California Pest Rating Profile for

Benyvirus necrobetae (syn. Beet necrotic yellow vein virus)
Rhizomania of beet

Pest Rating: C

Kingdom: Viruses and viroids, Category: Riboviria,
Category: Orthornavirae, Phylum: Kitrinoviricota,
Class: Alsuviricetes, Order: Hepelivirales,
Family: Benyviridae

Comment Period: 08/30/2024 through 10/14/2024

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from *Benyvirus necrobetae* is described herein and a permanent rating is proposed. It is listed as a widely prevalent virus in the United States (https://www.prevalentviruses.org/) and is a pest of concern for export seed from California.

History & Status:

Background:

Sugar beets have been grown widely in California over the last 150 years but have been gradually replaced by other crops. Today, only Imperial County has significant sugar beet production and processing. In 2022, Imperial County reported a sugar beet crop valued at $54M used for beet sugar and co-products such as dried beet pulp and beet molasses (https://agcom.imperialcounty.org/).

Benyvirus necrobetae, syn. Beet necrotic yellow vein virus is the type species of the genus *Benyvirus* (Beny: from **Be**et **n**ecrotic **y**ellow vein virus. The genus holds multipartite rod-shaped viruses with positive-stranded RNA genomes. The natural host ranges of benyviruses are usually very narrow and sugar beet, *Beta vulgaris,* is the primary host of *B. necrobetae*. It is one of the most destructive pathogens of sugar beets and has been spread to most growing areas worldwide.

The disease caused by *B. necrobetae* is called “rhizomania” and describes the abnormal root and taproot system of infected plants. In 1973, Tamada and Baba demonstrated that rhizomania could be

---

induced by a virus they named Beet necrotic yellow vein. It was moved to the genus *Benyvirus* in the 9th report of the International Committee on Taxonomy of Viruses in 2009. The virus is transmitted by the infected spores of a soilborne protist, *Polymyxa betae* (Keskin, 1964).

Hosts: Beta vulgaris is the main host and all cultivated forms including sugar beet, fodder beat, garden beet, and chard are susceptible. Disease has also been reported on *Spinacia oleracea* (spinach). Additional hosts include *Amaranthus retroflexus* (redroot pigweed), *Blitum capitatum* (strawberry blite), *Chenopodium album* (white goosefoot), *C. quinoa* (goosefoot), *C. vulvaria* (stinking goosefoot), *Cichorium intybus* (chicory), *Cirsium arvense* (creeping thistle), *Datura stramonium* (Jimson weed), *Gomphrena globose* (globe amaranth), *Heliotropium europaeum* (European heliotrope), *Lipandra polysperma* (manyseed goosefoot), *Matricaria chamomilla* (chamomile), *Persicaria maculosa* (lady's thumb), *Plantago major* (broadleaf plantain), *Polygonum aviculare* (common knotgrass), *Portulaca oleracea* (little hogweed), *Solanum nigrum* (European black nightshade), S*onchus arvensis* (perennial sow-thistle), *S. asper* (spiny sowthistle), *Tribulus terrestris* (puncture vine), *Veronica hederifolia* (ivy-leaved speedwell), and *Xanthium strumarium* (common cocklebur) (CABI, 2024).

Symptoms: The first sign of rhizomania disease in a sugar beet crop appears as light green or yellow irregularly shaped patches in the field, early in the growing season. Beets grown in heavily infested fields show symptoms on developed roots: an uncoordinated proliferation of partially necrosed necrotized lateral roots (known as ‘salt and pepper beard’) gives the disease the name “rhizomania”. The root is often constricted (funnel or turnip-shaped) and cutting the root shows browning of the vascular ring, or even of the whole tip of the root. It is the damage to the roots that causes the foliar symptoms through reduced nutrient uptake (Stevens et al., 2006), but if the virus becomes systemic, the leaves show a variety of symptoms, including yellowing, crinkling, wilting and vein yellowing (Stevens et al., 2006).

Transmission: Benyvirus necrobetae is vectored by a plasmodiophorid parasite, *Polymyxa betae* (Keskin, 1964). *Polymyxa betae* is widely distributed across Europe, Asia, and North America wherever sugar beets are grown. It has not always been documented, but in areas where rhizomania is spreading, the presence of its vector can be reasonably assumed.

The plasmodiophorid parasite survives in the soil as resting spores or cysts, which can be resistant and long-lived, surviving in the soil for up to 30 years. *Polymyxa betae* is an obligate intracellular parasite of *Beta vulgaris* roots, allowing the virus to survive in soils inside spores for decades. The individual cysts fuse together into cystosori to form large groups. They are dark brown when mature and can be easily seen in the root cortex cells of sugar beet lateral roots. When in the proximity of a sugar beet root, the cysts germinate to produce flagellated zoospores. The zoospores attach to the beet roots and their contents are injected into the host cytoplasm. After injection, the zoospore contents grow to form a multinucleate plasmodium. Sporangial plasmodia produce many thin-walled zoosporongia and secondary zoospores. These are released from the root cells and cause secondary infections. Sporogenic plasmodia develop into cystosori containing many unicellular resting spores (cysts) which are then returned to the soil as the roots degrade at the end of the growing season. *Polymxya betae* is

also a vector for other beet RNA viruses, namely, beet soil-borne mosaic virus, and beet soil-borne virus (Decroës, et al., 2022; CABI, 2024).

This virus is not seed-borne but it can be mechanically transmitted. Spread of the virus occurs mainly with infected plant parts or with the movement of soil containing infections *P. betae* (CABI, 2024).

Damage Potential: Rhizomania is a highly destructive disease of sugar beets. In infested fields, most sugar beet roots are usually small, sugar yields are poor, and losses can be as high as 100%. Sugar levels and the storability of the beets are reduced.

The severity of the damage depends on when in the growing season the plants are infected. Early infections can cause more severe stunting and greater yield reductions, while later infections may only result in slightly reduced root quality (Mcgrann et al., 2009). Studies suggest that additional losses in fields with infected beets may be the result of secondary invasion by other root pathogens, such as *Phytophthora* or *Pythium*.

Disease development is influenced by the population density of *Polymyxa betae*, which is enhanced by saturated soil conditions from rain, irrigation, or poor soil drainage and warm soil temperatures (Kaffka et al., 2010). Disease control depends on the use of resistant varieties. The virus can persist in infested soil for many years and in practical terms, once a field becomes contaminated with rhizomania, it remains permanently infested (Wisler and Duffus, 2000).

Worldwide Distribution: Africa: *Egypt, Morocco, South Africa and Tunisia*. Americas: *Brazil* and *The United States of America* (California, Colorado, Idaho, Michigan, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oregon, Texas, Washington, and Wyoming). Asia: *China, Iran, Japan, Kazakhstan, Kyrgyzstan, Lebanon, Mongolia, Pakistan*, and *Syria*. Europe: *Belgium, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Ukraine* and *United Kingdom* (EPPO, 2024).

Official Control*: Benyvirus necrobetae* is on the EPPO's A1 list for Bahrain, Jordan, and Kazakhstan. It is on the A2 list for Egypt, Russia, Türkiye, Ukraine, the Eurasian Economic Union, and the European Plant Protection Organization. It is a quarantine pest in Israel and Morocco (EPPO, 2024). It is on the USDA's Harmful Organisms list for Eurasian Customs Union, Chile, Colombia, Ecuador, Egypt, European Union, Guatemala, Holy See (Vatican City State), Israel, Japan, Jordan, Monaco, Morocco, Oman, Panama, San Marino, Taiwan, The Republic of Korea, The Republic of Türkiye, Tunisia, United Arab Emirates (USDA PCIT, 2024).

California Distribution: Official samples have been collected from Monterey, San Benito, Santa Barbara, Riverside, San Joaquin, and Yolo counties (CDFA PDR Database, 2024). It is assumed that all commercial sugar beet fields in California now have rhizomania (Kaffka et al., 2010).

California Interceptions: none

The risk that *Benyvirus necrobetae* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** The virus, inside its protist vector, can survive in climates suitable for the production of sugar beets including on the central coast and in the deserts.

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

   Score: **2**
   - 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 main host is sugar beet, however, other beets and spinach, along with some weeds, are confirmed hosts.

   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:** The virus is dependent on *Polymyxa betae* for its reproduction and dissemination. *Polymyxa betae* has multiple forms in the soil and forms long-lasting survival structures that are highly resistant to degradation.

   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:** Rhizomania is a devastating disease to susceptible sugar beet cultivars.

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

   Economic Impact: A, B, C, D, 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: None have been identified

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

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 *Benyvirus necrobetae:* 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'.

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* ***= 7***

Uncertainty:

Rhizomania disease has been effectively controlled by cultivars harboring the Rz1 resistance gene, which has been introduced widely (Lewellen et al., 1987). The development of resistance-breaking strains has been favored by high selection pressure from resistant varieties on the soil-borne virus population. Re-emergence of this disease is possible as the virus evolves to overcome host resistance.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Benyvirus necrobetae*** **is C.**

References:

Decroës, A., Mahillon, M., Genard, M., Lienard, C., Lima-Mendez, G., Gilmer, D., Bragard, C. and Legrève, A., 2022. Rhizomania: hide and seek of *Polymyxa betae* and the Beet necrotic yellow vein virus with *Beta vulgaris*. Molecular plant-microbe interactions, 35(11), pp.989-1005.

EPPO Database. https://gd.eppo.int/taxon/BNYVV0 Accessed 7/29/2024

Kaffka, S., Turini, T. A. and Wintermantel, W. M. 2010. Agriculture: Sugarbeet Pest Management Guidelines Rhizomania- Beet necrotic yellow vein virus (BNYVV)UC IPM Pest Management Guidelines: Sugarbeet UC ANR Publication 3469

Keskin B, 1964. *Polymyxa betae* n. sp. ein Parasit in den Wurzeln von Beta vulgaris Tournefort, besonders wahrend der Jugendenwicklung der Zuckerrube. Archiv fur Mikrobiologie, 49:348-374.

Koenig, R., and Lesemann, D.-E. 2000. Genus Benyvirus. Pages 917-922 in: Virus Taxonomy. 7th Report of the International Committee on Taxonomy of Viruses. M. H. V. Van Regenmortel, C. M. Fauquet, and D. H. L. Bishop, eds. Academic Press, San Diego, CA.

Lewellen R. T., Skoyen I. O., Erichsen A. W. 1987. “Breeding sugar beet for resistance to rhizomania: Evaluation of host-plant reactions and selection for and inheritance of resistance,” in 50. Winter Congress of the International Institute for Sugar Beet Research, Bruxelles (Belgium), IIRB. Secretariat General, 11-12 Feb 1987.

Lindsten K, 1989. Investigations concerning soil-borne viruses in sugarbeet in Sweden. Bulletin OEPP/EPPO Bulletin, 19:531-537.

McGrann, G.R., Grimmer, M.K., MUTASA‐GÖTTGENS, E.S. and Stevens, M., 2009. Progress towards the understanding and control of sugar beet rhizomania disease. Molecular plant pathology, 10(1), pp.129-141.

Peltier, C., Hleibieh, K., Thiel, H., Klein, E., Bragard, C. and Gilmer, D., 2008. Molecular biology of the Beet necrotic yellow vein virus. Plant viruses, 2(1), pp.14-24.

Stevens, M., Liu, H.-Y. and Lemaire, O. (2006) Virus diseases. In: SugarBeet (Draycott, A.P., ed.), pp. 256–285 Oxford: Blackwell Publishing Ltd

Tamada, T. and Baba, T., 1973. Beet necrotic yellow vein virus from rhizomania-affected sugar beet in Japan. Japanese Journal of Phytopathology, 39(4), pp.325-332_1.

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. Accessed 7/29/2024.

Wisler, G.C. and Duffus, J.E. 2000. A century of plant virus management in the Salinas Valley of California, ‘East of Eden’. Virus Res. 71, 161–169

Responsible Party:

Heather J. Martin, 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: 08/30/2024 through 10/14/2024**

***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.

Pest Rating: C
