CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Heterodera cruciferae Franklin, 1945

Cabbage cyst nematode

Current Pest Rating: C

Proposed Pest Rating: C

Kingdom: Animalia, Phylum: Nematoda,
Class: Chromadorea, Order: Rhabditida,
Family: Heteroderidae

Comment Period: 06/06/2023 through 07/21/2023

Initiating Event:

This nematode has not been through the pest rating process. The risk to California from *Heterodera cruciferae* is described herein and a permanent rating is proposed.

History & Status:

Background:

Schmidt (1871) established the genus *Heterodera* from Greek heteros = other, and deros = skin. *Heterodera* is the type and oldest genus for the family Heteroderidae, which holds nematodes with sexual dimorphism, in which the mature females become swollen, and lemon-shaped, while the males remain vermiform. *Heterodera cruciferae* is an amphimictic, sedentary endoparasite. After emerging from the egg, the J2s penetrate roots, become sedentary, swell, and establish a permanent feeding site in the root stele. Males are sedentary in the J3 and become active after reaching maturity. Adult females are swollen, and the posterior portions of their bodies protrude from the root. The female dies and becomes a cyst, each containing 500-600 embryonated eggs which can be extremely long lived in the soil, surviving decades of adverse conditions (Subbotin et al., 2010).

Heterodera cruciferae was first reported from the United Kingdom by Franklin (1945). It was found in California in Half Moon Bay, San Mateo County by Raski and Sciaroni (1954). When found in here, it

was described as well-established and estimated to have been present for many years. Today it is a widespread pest that can be found in most soils in which brassicas are frequently grown.

Some authors have not considered *H. cruciferae* to be a major pest of cabbage (Stone and Row, 1976) but others have reported significant crop losses (McCann, 1981; Sykes and Winfield, 1966; Chizhov et al., 2009). Both *Heterodera cruciferae* and the sugar-beet nematode, *H. schachtii*, apparently can infect most species of *Brassica*, including agricultural crops such as cabbage, Brussels sprouts, cauliflower, broccoli, and radish (Baldwin and Mundo-Ocampo, 1991). Sugarbeet (*Beta vulgaris*) very poor host of *Heterodera cruciferae* (Nemaplex, 2010). The sugar beet cyst nematode can occur together in the same fields with cabbage cyst nematode (Sikora and Fernandez, 2005).

This nematode survives for many years in the soil in the absence of a host crop as eggs in cysts. Two to three generations may be completed in one year on a long-growing crop (Stone and Rowe, 1976). Hatching of *H. cruciferae* eggs can be stimulated by exposure to root diffusates from *Brassica* spp., but not by the diffusates of other cruciferous hosts (Winslow, 1954).

Hosts: All species and varieties of *Brassica* and other Brassicaceae are hosts of or associated with this nematode, plus plants in some other families including lettuce and barley.

Alyssum alpestre, *A. argenteum*, *A. montanum*, *Alyssum* sp. (alyssum), *Arabis bellidifolia* (rock cress), *A. caucasica* (wall rock cress), *Barbarea longirostris* (winter cress), *B. vulgaris* (garden yellow rocket), *Beta vulgaris* (sugar beet), *Biscutella laevigata* (biscutella), *Brassica juncea* (brown mustard), *B. napus* (canola), *B. nigra* (black mustard), *B. oleracea* (broccoli), *B. rapa* (turnip), *Brassica* sp., *Capsella bursa-pastoris* (shepherd's purse), *Cardamine pratensis* (lady's smock), *Cheiranthus annuus* (cheiranthus), *C. cheiri* (wallflower), *Cochlearia glastifolia* (scurvy grass), *Coronopus didymus* (lesser-swine cress), *C. squamatus* (wart cress), *Crambe maritima* (sea kale), *Descurainia Sophia* (flixweed), *Diplotaxis erucoides* (rocket), *Erysimum allionii* (erysimum), *E. cheiranthoides* (wormseed wallflower), *E. hieraciifolium* (erysimum), *Hordeum vulgare* (barley), *Iberis amara* (rocket candytuft), *I. umbellata* (globe candytuft), *Isatis tinctoria* (isatis), *Lactuca sativa* (lettuce), *Lamium album* (dead nettle), *L. purpureum* (red deadnettle), *Lepidium sativum* (cress garden), *Lobularia maritima* (sweet alyssum), *Lunaria annua* (silver dollar), *L. redeviva* (honesty), *Moricandia arvensis* (moricandia), *M. sonchifolia* (moricandia), *Myagrum perfoliatum* (myagrum), *Nasturtium microphyllum* (nasturtium), *N. officinale* (watercress), *Raphanus maritimus* (wild radish), *R. sativus* (radish), *Rapistrum rugosum* (rapistrum), *Rorippa amphibia* (rorippa), *R. islandica* (yellowcress marsh), *Sinapis alba* (white mustard), *S. arvensis* (wild mustard), *Sisymbrium austriacum* (sisymbrium), *S. irio* (London rocket), *S. orientale* (sisymbrium), *Stachys annua* (stachys), *S. arvensis* (fieldnettle betony), *Thlaspi arvense* (penny cress), *Triticum aestivum* (wheat) (Nemaplex, 2010; Siddiqi et al., 1973).

Symptoms: There are no specific above ground symptoms in plants that can be attributed to, or used to diagnose, infection by cabbage cyst nematodes. General symptoms include stunting with leaves appearing yellowish red then turning necrotic in the older parts. In fields, poor and patchy plant growth is apparent in small, circular areas that extend to the entire field resulting in complete loss of crop. For cole crops, symptoms include patches of stunted or dying plants, yellowing of foliage, and reduction in head size or curds (Chitambar et al., 2018; Westerdahl and Ploeg, 2018). Cabbage cyst

nematodes establish permanent feeding sites in cabbage roots, which causes cellular alterations in the root cortex, endodermis, pericycle, and vascular cylinder by inducing typical multinucleate syncytia. Syncytial cytoplasm is granular and dense, with variously sized vacuoles and hypertrophied nuclei with nucleoli (Sasanelli et al., 2013).

Seedlings infested by cabbage cyst nematode may have longer petioles than normal, with green or yellow leaves depending on the severity of infestation. Plants are likely to be stunted and wilted. Typically, storage roots such as radishes and turnips will not be well developed and will have excessive fibrous roots. Mature female nematodes can be seen on the root surface as tiny, pinhead size, lemon-shaped bodies that are white in the earlier stages and turn into brown, egg-filled cysts on aging. These are distinct from the galls formed by root knot nematodes (Westerdahl and Ploeg, 2018).

Transmission: Infected nursery stock, infected plants, soil contaminated with cysts, cysts moving with wind, nematode-infested soil, or irrigation water.

Damage Potential: Stone and Rowe (1976) did not consider *H. cruciferae* to be a major pest. Lear et al. (1965), however, reported on considerable yield losses induced by *H. cruciferae* in Brussels sprouts in California. Sykes and Winfield (1967) noticed measurable crop damage due to a high level of populations of this species in 20% of the surveyed fields in the UK. In Russia, Chizhov et al. (2009) described infected plants with delayed formation of heads and the death of many plants from this nematode.

In heavily infested soils, seedling emergence may be delayed, or seedlings may be killed before emergence, reducing the stand. Seedlings infested with cyst nematodes may be predisposed to secondary infection by soilborne fungi. Infestations of cabbage cyst nematode may be localized or spread over an entire field. This nematode can also severely damage cole crops in any type of soil (Westerdahl and Ploeg, 2018).

Worldwide Distribution: Europe: Belgium, Bulgaria, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, The Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK, Ukraine, Yugoslavia (former); Asia: Armenia, Azerbaijan, Iran, Pakistan, Turkey; Africa: Libya; North America: USA; Oceania: Australia (Subbotin et al., 2010).

Official Control: *Heterodera cruciferae* is on the UDA PCIT's harmful organisms list for Honduras, Indonesia, and Timor-Leste (2023).

California Distribution: widespread in areas where brassicas are grown, especially along the coast.

California Interceptions: none

The risk *Heterodera cruciferae* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** *Heterodera cruciferae* thrives in temperate regions. In California it has been established for decades in cooler coastal temperate areas (Raski and Sciaroni, 1954).

   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 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 hosts for cabbage cyst nematodes are mainly in the family Brassicaceae

   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:** This nematode can have several generations per year. It spreads slowly in undisturbed sites but spreads easily with normal farming practices including flood irrigation and soil cultivation.

   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:** When abundant, cyst nematodes can cause yield reductions and even the death of plants. It is a quarantine pest in a few countries. Cysts can spread with water.

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

   Economic Impact: A, C, 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:** This nematode can significantly impact cultural practices, home/urban gardening, or ornamental plantings.

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: E

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*:* 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.

This nematode has been established in California for at least 75 years without being under regulatory control and it is widespread in the state.

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:

None

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Heterodera cruciferae*** **is C.**

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Responsible Party:

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***Comment Period: 06/06/2023 through 07/21/2023**

***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