

## California Pest Rating Proposal for

### *Heterodera sturhani* Subbotin 2015

#### Sturhan cereal cyst nematode

**Current Pest Rating: none**

**Proposed Pest Rating: A**

Kingdom: Animalia, Phylum: Nematoda,  
Class: Secernentea, Subclass: Diplogasteria,  
Order: Tylenchida, Superfamily: Tylenchoidea,  
Family: Heteroderidae, Subfamily: Heteroderinae

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**Comment Period: 04/26/2021 through 06/10/2021**

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#### Initiating Event:

A pest risk assessment of *Heterodera sturhani* is presented here, and a pest rating for California is proposed.

#### History & Status:

**Background:** Cereal cyst nematodes are important pests that limit production of small grain cereals. Extensive nematode feeding reduces root mass and saps plant nutrients and can result in greatly reduced crop yields. Cyst nematodes are biotrophic sedentary endoparasites that can establish prolonged parasitic interactions with their hosts. They are among the most challenging nematodes to control, because of the "cyst" stage, which is the body of a dead female nematode containing hundreds of eggs. Cysts with viable eggs can persist in dry soil for years, where they remain relatively resistant to chemical and biological stresses. Cysts are easily moved with soil.

There are many closely related cereal cyst nematode (CCN) species, and they are found in most regions of the world where small grains are grown. CCNs were first recognized in the 1940s and in the following decades were described in Russia, Ukraine, Latvia and other former republics of the U.S.S.R. Using morphological and molecular characteristics, the genus *Heterodera* has been divided into nine groups (Subbotin et al., 2010; Handoo and Subbotin, 2018). The Avenae group is one of the largest and contains species that parasitize monocots only. Molecular markers based on the internal transcribed

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spacer (ITS) region of the ribosomal RNA gene and the cytochrome oxidase I gene can be used to differentiate species in this complex. Currently there are ten published species in the *H. avenae* complex: *H. arenaria*, *H. avenae*, *H. aucklandica*, *H. australis*, *H. filipjevi*, *H. mani*, *H. pratensis*, *H. riparia*, *H. sturhani*, and *H. ustinovi*. Five species from this group are considered as nematode pests and are collectively known as cereal cyst nematodes (CCN) (Smiley et al., 2017). Four are of major economic importance in cereal growing areas: the European CCN *H. avenae*, the Filipjev CCN *H. filipjevi*, the Sturhan CCN *H. sturhani* and the Australian CCN *H. australis*. The other six species in the complex parasitize grass species but have less importance to agriculture (Subbotin et al., 2018).

In 2003 and 2010, Subbotin et al. noted samples identified as *H. avenae* from China were a distinct group within the *H. avenae* complex. The isolates they studied were morphologically and genetically closer to *H. pratensis* or *H. riparia* than to *H. avenae*, suggesting they may be another species. Sturhan and Rumpfenhorst in 1996 had shown that Chinese cereal cyst nematode populations had a different IEF protein profile from *H. avenae* but did not separate them further. In 2015, Subbotin published an analysis of *CoxI* gene sequences which was evidence of a Chinese *H. 'avenae'* as separate from other species of the *H. avenae* complex. He formally described isolates from China previously identified as *H. 'avenae'* (type C) as a new species, *H. sturhani*, and gave it the common name Sturhan cereal cyst nematode. Surveys have shown that this nematode is widely distributed in provinces, autonomous regions, and cities in China, including Hubei, Shanxi, Henan, Hebei, Beijing, Inner Mongolia, Qinghai, Anhui, Shandong, Shaanxi, Gansu, Jiangsu, Tianjin, Tibet, and Xinjiang (Cui et al., 2015; D. L. Peng et al., 2009).

Ongoing research recognizes *H. avenae* as a species complex and a dozen distinct species have been separated out (Subbotin et al., 2018). Precise species identification is important for implementing effective management practices as selection of resistant or tolerant cereal cultivars requires knowledge of individual species distributions, as cultivars are not necessarily resistant or tolerant to both (Yan et al., 2023). *Heterodera sturhani* is closely related to *H. pratensis*, but *H. sturhani* parasitizes cereals including wheat, barley, wild and cultivated oat, whereas *H. pratensis* is presently known only as a parasite of grasses (Subbotin et al., 2010).

**Hosts:** The major cereal hosts are wheat (*Triticum aestivum*), oats (*Avena sativa*), and barley (*Hordeum vulgare*) but it also parasitizes grasses: *Festuca arundinacea*, *Dactylis glomerata*, *Phalaris tuberosa* and others (Subbotin, 2015; Smiley et al., 2017).

**Symptoms:** The diagnostic symptoms of cyst nematodes are usually the presence of cysts on the roots, the proliferation of roots, and shallow root systems. When there are population of *Heterodera* in the soil, patches of stunted seedlings (three- to five-leaf stage) can appear first. Stunted seedlings will exhibit chlorotic or necrotic lower leaves, with healthy younger leaves, few or no tillers, rotting of lower culms and crowns, and light brown roots with branching (Smiley et al., 2008). Plants produce smaller heads with shriveled grain kernels (Smiley et al., 2017). *Heterodera sturhani* differs from *H. avenae* by having smaller average cyst sizes and a smaller average fenestral length (Subbotin, 2015).

**Transmission:** *Heterodera sturhani* completes one generation per year. A low temperature chill factor seems not to be involved in hatching, and the rate of hatch can be increased by cereal root exudates

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(but exudates are not required). Juveniles begin to emerge from cysts during the autumn (October) and continue through spring (April) even in areas with cold winter climates. It does not seem to have a diapause requirement and can hatch anytime when hosts are available.

Mobile, second-stage juveniles leave the cysts in the spring and burrow into the host roots just behind the growing point. They rest parallel to the main axis with their heads in the endodermis. The juveniles induce the formation of unique syncytial feeding structures as their sole nutrient resources within the vascular cylinder of the roots. After growing and molting for approximately 3 weeks, mobile, vermiform males are released back into the soil. The sedentary female matures 6 to 9 weeks after invasion. Her body breaks through the root surface but remain attached to the root. Males mate with adult females on the root surface. Females can lay and release 50-100 eggs into the soil. Near the end of her life, the female holds her eggs inside her body. The egg-filled female dies, and her body wall hardens to form a tough, leathery-skinned cyst around her eggs. The cysts are released into the soil as roots die (Willmott, 1972).

The main way this nematode spreads locally is as cysts in the soil. Thus, anything that moves soil is a potential pathway including agricultural equipment and containers, tools, vehicle tires, and workers clothing or boots. Adults, juveniles, eggs, and cysts can be found in association with infected or contaminated planting stock. Cysts can also move in the soil with water from rainfall or irrigation. Cysts can persist in dry soil for months to years, protecting the eggs, until there is adequate water for hatching (Smiley et al., 2017).

*Damage Potential:* Cereal cyst nematodes are among the most important nematode pests that limit production of small grain cereals worldwide, and *Heterodera spp.* are major pests of wheat, barley, and oat. Yield losses in China were previously attributed only to *H. avenae* could be from *H. avenae*, *H. filipjevi*, *H. australis* or *H. sturhani*, as all are present. Yield losses in three provinces of China, caused by '*H. avenae*,' were estimated at 1.2 Mt, based on an infestation of 22% of the production area and an overall yield reduction of 10% in those areas (Peng et al. 2009).

**Worldwide Distribution:** China (Subbotin et al., 2015).

**Official Control:** *Heterodera spp.* is on the USDA's harmful organism list for Australia, Chile, Jordan, Madagascar, Namibia, Nauru, Oman, South Africa, Syrian Arab Republic, and United Arab Emirates (USDA PCIT, 2021).

**California Distribution:** None.

**California Interceptions:** None

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

## **Consequences of Introduction:**

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- 1) Climate/Host Interaction:** *Heterodera sturhani* has been found in diverse climates around the world and it is likely to become established wherever suitable hosts can grow. Wheat is the predominant small grain crop in California, grown on over 500,000 acres, with small grains serving as important rotational crops (UC Agronomy Research and Information Center: Small Grains; Chitambar et al., 2018).

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 contains cereals and grasses in the family Poaceae.

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:** Tens to hundreds of eggs can be produced while the female is alive, with an additional ten to hundreds retained within her cyst after her death. For long and short distance dispersal these nematodes are dependent on movements of cysts, cyst-infested soils, and cyst-infested seed lots.

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:** Infestations of Sturhan cereal cyst nematode impacts small grain production resulting in direct plant loss and shriveled, unmarketable grains. Cysts in soil could be spread by movements of soil and irrigation water requiring changes in normal cultural practices. It is also a quarantine pest.

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

**Economic Impact: A, B, C, D, 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.
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- 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:** Infestations of Sturhan cereal cyst nematode could significantly affect other hosts in the family Poaceae outside of agricultural crops, potentially including native species.

**Environmental Impact: A, 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: 3**

- 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 *Heterodera sturhani*: High**

Add up the total score and include it here. **13**

- 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 'not established'**. There have been no detections of *H. sturhani* in California.

**Score: 0**

- Not established (0) Pest never detected in California or known only from incursions.**
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-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 = 13*

### Uncertainty:

Although there have been no detections of *H. sturhani* in the United States, there is of a lack of widespread nematode surveys (Yan et al., 2013).

### Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Heterodera sturhani* is A.

### References:

Chen, P. S., Wang, M. Z. and Peng, D. L. 1992. A study of cereal cyst nematode (*Heterodera avenae* Wollenweber) in China. *Acta Phytopathologica Sinica* 22: 339-343 (in Chinese).

Chitambar, J. J., Westerdahl, B. B., and Subbotin, S. A. 2018. Plant Parasitic Nematodes in California Agriculture. In Subbotin, S., Chitambar J., (eds) *Plant Parasitic Nematodes in Sustainable Agriculture of North America. Sustainability in Plant and Crop Protection*. Springer, Cham.

Cui, J. K., Huang, W. K., Peng, H., Liu, S. M., Wang, G. F., Kong, L. A., and Peng, D. L. 2015. A new pathotype characterization of Daxing and Huangyuan populations of cereal cyst nematode (*Heterodera avenae*) in China. *J. Integr. Agric.* 14:724-731.

Handoo, Z. A. 2002. A key and compendium to species of the *Heterodera avenae* group (Nematoda: Heteroderidae). *J. Nematol.* 34:250-262.

Handoo, Z.A. and Subbotin, S.A. 2018. Taxonomy, identification, and principal species. In: Perry, R.N., Moens, M. and Jones, J.T. (Eds). *Cyst nematodes*. Wallingford, UK, CAB International, pp. 365-397

Ferris, H. 1999. Nemaplex. Nematode plant expert information system. University of California. <http://nemaplex.ucdavis.edu/>

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- Kirjanova, E. S., and Krall, E. L. 1971. Parasitic nematodes of plants and their control. Vol. II. Nauka, Leningrad, U.S.S.R. (in Russian)
- McDonald, A. H. and Nicol, J. M., 2005. Nematode parasites of cereals. Plant parasitic nematodes in subtropical and tropical agriculture, (Ed. 2), pp.131-191.
- Peng, D. L., Nicol, J. M., Li, H. M., Hou, S. Y., Li, H. X., Chen, S. L., Ma, P., Li, H. L., and Riley, I. T. 2009. Current knowledge of cereal cyst nematode (*Heterodera avenae*) on wheat in China. Pages 29-34 in: Cereal Cyst Nematodes: Status, Research and Outlook. I. T. Riley, J. M. Nicol, and A. A. Dababat, eds. CIMMYT, Ankara, Turkey.
- Smiley, R.W., Dababat, A.A., Iqbal, S., Jones, M.G., Maafi, Z.T., Peng, D., Subbotin, S.A. and Waeyenberge, L., 2017. Cereal cyst nematodes: A complex and destructive group of *Heterodera* species. Plant Disease, 101(10), pp.1692-1720.
- Sturhan, D. and Rumpfenhorst, H.J. 1996. Untersuchungen über den *Heterodera avenae* – Komplex. Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft BerlinDahlem 317: 75-91
- Subbotin, S.A., Rumpfenhorst, H.J. and Sturhan, D., 1996. Morphological and electrophoretic studies on populations of the *Heterodera avenae* complex from the former USSR. Russian Journal of Nematology, 4(1), pp.29-38.
- Subbotin, S.A., Sturhan, D., Rumpfenhorst, H.J and Moens, M. 2003. Molecular and morphological characterization of the *Heterodera avenae* complex species (Tylenchida: Heteroderidae). Nematology 5:515-538.
- Subbotin, S.A., Mundo-Ocampo, M. and Baldwin, J.G. 2010. Systematics of Cyst Nematodes (Nematoda:Heteroderinae). Nematology Monographs and Perspectives, Volume 8B (D.J. Hunt & R.N. Perry Series Eds). The Netherlands, Brill. 512 pp.
- Subbotin, S. A. 2015. *Heterodera sturhani* sp. n. from China, a new species of the *Heterodera avenae* species complex (Tylenchida: Heteroderidae). Russ. J. Nematol. 23:145-152. ISI
- Subbotin, S.A., Toumi, F., Elekçioğlu, I.H., Waeyenberge, L. and Maafi, Z.T., 2018. DNA barcoding, phylogeny and phylogeography of the cyst nematode species of the *Avenae* group from the genus *Heterodera* (Tylenchida: Heteroderidae). Nematology, 20(7), pp.671-702.
- USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PEXD) Harmful Organisms Database Report. *Heterodera* spp. Accessed 3/22/2021
- Willmott, S., 1972. Commonwealth Institute of Helminthology and. CIH descriptions of plant-parasitic nematodes. Commonwealth Agricultural Bureaux.
- Yan, G., Smiley, R.W., Okubara, P.A. and Skantar, A.M., 2013. Species-specific PCR assays for differentiating *Heterodera filipjevi* and *H. avenae*. Plant Disease, 97(12), pp.1611-1619.
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## Responsible Party:

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**\*Comment Period: 04/26/2021 through 06/10/2021**

## **\*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 [a] cdfa.ca.gov.

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## 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.
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**Proposed Pest Rating: A**

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