cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Aphelenchoides fragariae (Ritzema - Bos, 1891) Christie, 1932
Strawberry crimp nematode, Strawberry spring dwarf nematode, Foliar nematode.

Current Pest Rating: C

Proposed Pest Rating: C

Domain: Eukaryota, Kingdom: Metazoa,
Phylum: Nematoda, Order: Aphelenchida,
Family: Aphelenchoididae

Comment Period: 10/27/2021 through 12/11/2021

Initiating Event:

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

History & Status:

Background: California strawberries lead the nation, with nearly 88% of the US production and a value of over $2B. There are five distinct areas of strawberry production: Watsonville/Salinas, Santa Maria, Oxnard, Orange County/San Diego. The export value of strawberries was over $400M in 2019/20 (CDFA Agricultural Statistics, 2019/2020).

There are two important phytopathogenic genera in the nematode family Aphelenchoididae: *Aphelenchoides* (bud and leaf nematodes) and *Bursaphelenchus* (the pine wilt and red-ring nematodes). They survive inside the tissues of the plants they infect, and *Bursaphelenchus* also survives inside its insect vectors. They are unique among plant parasitic nematodes in that they seldom, if ever, enter the soil. The genus *Aphelenchoides* contains species that feed on plants, fungi, and insects, and the plant parasitic species have a very wide host range compared to other types of plant-pathogenic nematodes (Kohl, 2011). As the name suggests, it is an important pest of strawberry (Fragaria) and many flowering ornamentals including anemone, begonia, lily, violet, primula and azalea. Its host range also includes a wide range of ferns.

Aphelenchoides fragariae was proposed as a new species in the genus *Aphelenchus* by Bastian (1865) and Rizema Bos (1891). Christie (1932) transferred it to *Aphelenchoides*. The type host is strawberry, collected from Kent, United Kingdom. The neotype was proposed and described by UC Berkeley

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Nematologist M. W. Allen (1952) from strawberry in Escalon, California (San Joaquin County). Now this nematode is widespread in the United States, Europe and Asia as a pest of many plants and seems well adapted to tropical and temperate climates. It should not be confused with *A. ritzemabosi*, C-rated Chrysanthemum foliar nematode, or A- rated *A. besseyi*, which causes strawberry crimp disease and white tip of rice. *Aphelenchoides besseyi,* commonly called strawberry summer dwarf nematode, is a pest of quarantine significance in California.

Hosts: There are more than 250 recorded hosts in 47 families for this nematode; most hosts are in Liliaceae, Primulaceae and Ranunculaceae (Nemaplex, 2010). Confirmed hosts in California are *Anemone hupehensis* (Japanese anemone), *Asplenium bulbiferum* (hen and chickens fern), *Asplenium nidus* (bird's nest fern), *Athyriam felix* (lady fern), *Beta vulgaris* subsp. *vulgaris* convar. *vulgaris* var. *altissima* (sugar beet), *Codiaeum cariegatum* (croton), *Fragaria × ananassa* (strawberry), *Saintpaulia* spp. (African violet), *Salvia chiapensis* (Chiapas sage), and *Woodwardia fimbriata* (giant chain fern) (CDFA PDR Database, 2021).

Symptoms: Disease symptoms on strawberry are called spring dwarf, spring crimp and red plant. Endoparasitic activity of *A. fragariae* causes shoot malformations including twisting and puckering of leaves, discolored areas with a hard and rough surface, undersized leaves with crinkled edges, reddening of petioles, tight aggregation of crowns, shortening of internodes on runners, reduced flower trusses with only one or two flowers or flowers aborted, and death of the crown bud (Maas, 1998; Ploeg and Westerdahl, 2018). Ectoparasitic feeding on folded crown and runner buds causes small dry, brown areas that are seen on expanded leaves usually near the mid-rib. Occasionally the nematodes are found in strawberry fruit pulp (Tacconi, 1972).

On flowering ornamentals such as violets, anemone and begonia, the feeding areas of foliar nematode appear as irregular, water-soaked patches later turning brown, violet, or black. The affected areas are limited by the leaf veins. The nematode causes die-back disease of lilies; leaves, flower buds and fruits turn brown and die (Daughtrey et al., 1995). Ferns develop water-soaked, often chevron-like stripes on fronds as movement of the nematodes seems to be delimited by vein. The stripes turn brown in summer when the fern is the driest (Sandeno and Jensen, 1962).

Transmission: The nematode may live its entire life inside leaves or on the surfaces of the plant hosts. Nematodes enter leaves through stomata or through wounds and they can swim rapidly. The female lays her eggs in the intercellular spaces of leaves. The eggs hatch and produce the four juvenile stages and adults all inside the leaf. The life cycle can be completed in as little as two weeks, and both males and females occur. They spread short distances by swimming when there is moisture on the leaves (from rain or irrigation) but they can also be splashed to new plants or to distant parts of the same plants by falling rain or overhead watering. The nematodes overwinter as adults in dead leaves or between the scales of buds of infected tissues. In the spring the nematodes become activated and feed ectoparasitically on the epidermal cells of the organs in their vicinity. Thus, stem areas, petioles, and leaves near infested buds show brown scars consisting of groups of cells killed by the nematodes. Adults and forth-stage juveniles can overwinter in an anhydrobiotic state within dried plant tissue and

can survive that way for up to three years (Daughtrey et al., 1995). It can be easily moved with infected but asymptomatic planting stock.

Damage Potential: Aphelenchoides spp. feed ectoparasitically and endoparasitically on aboveground plant parts. They can reach high populations and can result in severe losses. With low numbers they are asymptomatic and can spread undetected through vegetative propagation with cuttings from infected mother plants (Chitambar et al., 2018). Because ornamentals are sold for their aesthetic value, there is little to no tolerance for foliar or flower damage from nematode feeding and tunneling (Daughtrey et al., 1995).

Aphelenchoides fragariae can severely impact the yield of strawberry, as heavily infected plants do not grow normally or produce fruit (Maas, 1998). In a study by Bohmer, (1981), the weight of strawberry crowns was reduced 41% by *A. fragariae*. Fruit yield in the first year was reduced 54%, and the number of runners was reduced by 15%. *Aphelenchoides fragariae* can become a serious pathogen in strawberry nurseries where environmental conditions such as warm temperatures and high humidity favor a rapid buildup of the population.

Worldwide Distribution: Asia: *China, India, Israel, Japan, Kyrgyzstan, South Korea,* and *Turkey*. Europe: *Belgium, Bulgaria, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Latvia, Moldova, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine,* and *United Kingdom*. North America: *Canada, United States* (California, Connecticut, Delaware, Florida, Georgia, Hawaii, Illinois, Maryland, Massachusetts, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Virginia). Oceania: *Australia, New Zealand, Papua New Guinea* (CABI-CPC, 2021).

Official Control: *Aphelenchoides fragariae* is on the USDA PCIT's harmful organism list for Chile, China, Colombia, Costa Rica, Cuba, Dominican Republic, Egypt, French Polynesia, Guatemala, Honduras, India, Indonesia, Israel, Jordan, Lebanon, Mexico, Morocco, Namibia, Nicaragua, Norway, Oman, Panama, Peru, Qatar, South Africa, Svalbard and Jan Mayen, Taiwan, Turkey, and United Arab Emirates (USDA, 2021), It is on the EPPO A1 list for Argentina, Bahrain, Chile, Egypt, Inter-African Phytosanitary Council, and Jordan; A2 list for Turkey and the Comite de Sanidad Vegetal del Cono Sur, and a Quarantine pest in Mexico, Morocco and Tunisia (EPPO, 2021).

Freedom from parasitic nematodes is part of the California Strawberry Registration & Certification Program. Run by CDFA and Foundation Plant Services at UC Davis, it is a voluntary, multi-step clean stock system adopted in 1949. Foundation, registered, and certified nursery stock is inspected and tested for viral, fungal, and bacterial pathogens, nematodes, and varietal purity.

California Distribution: Humboldt, Lassen, Mendocino, Merced, Monterey, Orange, Sacramento, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Shasta, and Sonoma counties, on strawberries and ornamentals.

California Interceptions: None

The risk *Aphelenchoides fragariae* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** *Aphelenchoides* are dependent on water for movement and dispersal. *Aphelenchoides fragariae* is less likely to occur in the more arid parts of the state, but conditions in greenhouses or other structures with higher humidity are ideal.

   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 host range is extremely large including many ornamentals and strawberries

   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 has a relatively short generation time when conditions are favorable and can survive for years in anhydrobiosis when conditions are unfavorable. It spreads with water.

   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:** This nematode directly affects yield of strawberries and the value of ornamentals including ferns. It is on the harmful organism list for many countries

   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.
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 is a pest that needs to be kept out of strawberry nurseries. There are few curative treatments making sanitation and prevention key programs for many crops

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

Environmental Impact: D, 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 *Aphelenchoides fragariae:* 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.

This nematode has been found in many parts of the state and is in the nursery trades on ornamentals.

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* ***= 10***

Uncertainty:

Aphelenchoides fragariae feeding can increase the incidence and severity of some bacterial plant pathogens, including *Xanthomonas* spp. and *Clavibacter* spp., making it difficult to separate the damage caused by each (CABI-CPC, 2021).

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Aphelenchoides fragariae* is C.

References:

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Responsible Party:

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***Comment Period: 10/27/2021 through 12/11/2021**

***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[@]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
