California Pest Rating Proposal for

Aphelenchoides besseyi Christie, 1942 (Allen, 1952)

Strawberry summer dwarf nematode
Rice white tip nematode

Current Pest Rating: A

Proposed Pest Rating: A

Kingdom: Animalia, Phylum: Nematoda,
Class: Secernentea, Subclass: Diplogasteria,
Order: Aphelenchida, Superfamily: Aphelenchoidea,
Family: Aphelenchoididae, Subfamily: Aphelenchoidinae

Comment Period: 06/25/2021 - 07/25/2021

Initiating Event:

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

History & Status:

Background: A serious foliar disease of rice that is now called "White-tip" was originally described 1915 in Japan. In the United States, white-tip symptoms on rice were first attributed to iron or magnesium deficiency and/or an imbalance in the magnesium/calcium ratio. In 1949, Cralley showed that the disease symptoms on rice were caused by nematode feeding and like the symptoms on rice reported from Japan. Later it was found that the white tip nematode was identical to a foliar nematode of strawberry described by Christie in 1942 (Allen, 1952), already named *Aphelenchoides besseyi* with the common name of strawberry crimp or summer dwarf.

Nematodes in the genus *Aphelenchoides* feed ectoparasitically and endoparasitically on aboveground plant parts and are collectively known as foliar nematodes. The populations are predominately adult females with some males, and normally are amphimictic (reproduction in which sperm and eggs come from separate individuals and cross-fertilize), although parthenogenetic reproduction (egg develops into an embryo without being fertilized) has been reported (Sudakova and Stoyakov, 1967).

Hosts: Aphelenchoides besseyi attacks a wide range of plants including grasses, vegetables, and ornamentals including: *Allium cepa* (onion), *Allium sativum* (garlic), *Armoracia rusticana* (horse radish), *Asplenium nidus* (bird's nest fern), *Avena sativa* (oat), *Begonia* sp., *Brassica rapa* subsp. *pekinensis* (Chinese cabbage), *Cattleya* sp., *Chrysanthemum maximum* (Shasta daisy), *Chrysanthemum maximum* (chrysanthemum), *Chrysanthemum* sp. (chrysanthemum), *Chrysanthemum morifolium* (florist's chrysanthemum), *Chrysanthemum X morifolium* (chrysanthemum), *Coleus blumei* (painted nettle), *Colocasia esculenta* (taro), *Cyperus iria* (rice flatsedge), *Dahlia pinnata* (dahlia), *Dahlia variabilis, Dendrobium* sp., *Digitaria adscendens* (crab grass), *D. sanguinalis* (large crabgrass), *Dioscorea* (yam), *Dioscorea cayenensis* (yellow yam), *Dioscorea trifida* (cushcush yam), *Echinochloa crus-galli* (Japanese millet), *Erechtites praealta*, *Ficus elastica* var. *decora* (rubber plant), *Fragaria glandiglora* (strawberry), *Fragaria vesca* (strawberry), *Fragaria xananassa* (strawberry), *Gladiolus* sp. (sword lily), *Glycine hispida; Glycine max* (soybean), *Gossypium hirsutum* (upland cotton), *Hibiscus* sp. (rose mallows), *Hydrangea macrophylla, Impatiens balsamina* (garden balsam), *Ipomoea batatas* (sweet potato), *Jasminum volubile* (wax jasmine), *Lactuca sativa* (lettuce), *Nicotiana tabacum* (tobacco), *Oryza* sp., *Oryza breviligulata*, *Oryza glaberrima* (African rice), *Oryza sativa* (rice), *Panicum miliaceum* (millet), *P. maximum* (Guinea grass), *P. bisulcatum* (Japanese panicgrass), *Pennisetum typhoides* (pearl millet), *Phalenopsis* sp., *Phaseolus vulgaris* (bean), *Plectranthus scutellarioides* (painted nettles), *Polianthes tuberosa* (tuberose), *Pluchea odorata* (marsh fleabane), *Polianthes tuberosa* (tuberose), *Saccharum officinarum* (sugar cane), *Saintpaulia ionantha* (African violets), *Setaria italica* (foxtail millet), *Setaria viridis* (green foxtail), *Sorghum halepense* (johnson grass), *Sporobolus poiretti* (perennial bunch grass), *Stylosanthes hamata* (cheesytoes), *Tagetes* sp. (marigold), *Tithonia diversifolia* (mexican sunflower),*Torenia fournieri* (wishbone), *Vanda* sp., *Zea mays* (maize), *Zinnia elegans* (zinnia) (Nemaplex, 2010; CABI-ISC, 2021).

Symptoms: When the host is rice, during early growth, *A. besseyi* is found in low numbers within the folded leaf sheaths where it feeds ectoparasitically around the apical meristem, on buds, at leaf tips and growing points (Todd and Atkins, 1958). They coil and aggregate together in the glume axis. They can also feed endoparasitically, entering the leaf mesophyll. During early growth, the most conspicuous symptom is that the new leaves have chlorotic tips as they grow out of the leaf sheath. These tips later dry and curl, while the rest of the leaf may appear normal, and this is why it's called "white tip". The young leaves of infected tillers can be speckled with a white splash pattern or have distinct chlorotic areas. Leaf margins may be distorted and wrinkled but leaf sheaths are symptomless. In severe infections, the flagleaf is shortened and twisted, and this prevents the panicle from emerging properly (Yoshii and Yamamoto, 1950a; Todd and Atkins, 1958).

A rapid increase in nematode numbers takes place at late tillering and correlates with the reproductive phase of the rice plant. The nematodes enter the spikelets before anthesis (the flowering period of a plant, from the opening of the flower bud onward). As the grains fill and seed maturation proceeds, nematode reproduction ceases, although the juveniles continue to molt until they are adults. The grain produced by infested plants is small and distorted (Todd and Atkins, 1958), with kernels that are discolored and cracked (Uebayashi et al., 1976). Infected plants mature late and have sterile panicles borne on tillers produced from high nodes. The viability of infected seed is lower and germination is delayed (Tamura and Kegasawa, 1959). Infected panicles are shorter, with fewer spikelets and a smaller proportion of filled grain; plants are reduced in vigor and height (Todd and Atkins, 1958). *Aphelenchoides besseyi* slowly desiccate as kernel moisture is depleted.

Strawberries infested with *A. besseyi* will have aboveground symptoms which can include stunted growth, reddened leaves, small curled or crinkled leaves (crimp), deformed buds and flowers, and a reduction in flowering and fruiting. In the early stage of infection, the cells of the vein sheath stop the extension of the nematodes and leaf necrosis across the veins, which gives a clear pattern on the leaves. A reduction in flowering and fruiting distinguishes a foliar nematode infestation from insect infestations, which also produce leaf symptoms similar to those described above. In advanced stages of infection, even the leaf veins break down, and the nematodes and leaf necrosis spread over the entire leaf. Heavily infected leaves fall to the ground. There are no reported belowground symptoms from foliar nematodes (Ploeg and Westerdahl, 2018).

Transmission: The principal way that *A. besseyi* moves over long distances with rice is with infected seed. It can be transmitted in flood water in lowland rice and swim short distances to reach new seedlings (Tamura and Kegasawa, 1958). When rice seed infected with *A. besseyi* is planted, the nematodes become active and are attracted to the meristematic areas of the emerging seedlings. At 30° C, the life cycle is only 8-12 days, with a minimum temperature that supports development of 13° C (Sudakova, 1968).

With strawberries or other plants that are vegetatively propagated, this nematode moves long distances with infected daughter plants, and shorter distances within a field by splashing or with people handling the plants. The nematodes overwinter in buds, growing points, and dead leaves on the ground. In the spring they become active and can climb up the stems by swimming in films of water. Once at the growing points, they attack leaves by entering through the stomata and moving between cells. The eggs, juveniles and adults all develop in the leaves. The leaf cells turn brown and collapse, shrink and die, prompting the nematodes to exit and find new leaves to invade (Agrios, 2005). This nematode is not thought to survive long periods in the soil between crops (Cralley and French, 1952).

When feeding on rice, at the end of the growing season many of the nematodes will be in a state of cryptobiosis under the hulls of seed. Cryptobiosis is a physiological state where metabolic activity is reduced to an undetectable level. This allows them to survive periods of extremely dry conditions. They can survive in an anhydrobiotic state under hulls of rice grains without moisture and still be viable after three years (Taylor, 1969).

Damage Potential: Affected panicles show high sterility, distorted glumes and small and distorted kernels (Ou, 1972). In rice, emergence of severely infected seedlings is delayed, and germination rate is low. The severity of the disease varies with region, country, year, etc. and depends on the rice variety and cultural practices. The degree of damage in susceptible varieties depends largely on the number of infected seeds sown, as well as the number of *A. besseyi*-infected seed. Different varieties of rice are affected to different degrees of infection and some pathotypes of nematodes are more aggressive.

Yields have been reported to be reduced by 17-54% in susceptible varieties and 24% in resistant (Atkins and Todd, 1959). Up to 50% yield loss of upland rice was caused in Brazil (Silva, 1992)

Worldwide Distribution: *Aphelenchoides besseyi* has been reported from most rice-growing countries throughout the world. Its wide distribution has resulted from dissemination in seed (Ou, 1985), and it remains a quarantine pest in many countries because of the potential for movement and introduction into new areas of more virulent pathotypes.

Africa: *Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Democratic Republic of the, Côte d'Ivoire, Egypt, Gabon, Gambia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mali, Nigeria, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe.* Asia: *Afghanistan, Azerbaijan, Bangladesh, Cambodia, China, Georgia, India, Indonesia, Iran, Japan, Kyrgyzstan, Laos, Malaysia, Myanmar, Nepal, North Korea, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Tajikistan, Thailand, Turkey, Uzbekistan, Vietnam.* Europe: *Bulgaria, Hungary, Italy, Netherlands, Romania, Russia, Ukraine.* North America: *Cuba, Dominica, Dominican Republic, El Salvador, Guadeloupe, Mexico, Panama, United States* (Arkansas, California, Florida, Hawaii, Louisiana, Texas). Oceania: *Australia, Cook Islands, Fiji, Papua New Guinea.* South America: *Brazil, Ecuador*.

Official Control: This nematode is on the EPPO's A1 list for Azerbaijan, Bahrain, Comunidad Andina, Chile, Inter-African Phytosanitary Council, Jordan, Russia, Ukraine, Uruguay; on the A2 list for Comite Regional de Sanidad Vegetal del Cono Sur, Egypt, European plant protection organization, and Turkey; It is a quarantine pest for Israel, Mexico, Morocco, and Tunisia (EPPO, 2021).

It is listed on the USDA's harmful organism list for Albania, Algeria, Argentina, Cambodia, Chile, Colombia, Egypt, Eurasian Customs Union, European Union, French Polynesia, Georgia, Guatemala, Holy See (Vatican City State), Honduras, Indonesia, Israel, Jordan, Mexico, Monaco, Morocco, Namibia, New Caledonia, Nicaragua, Oman, Panama, Paraguay, Peru, Qatar, San Marino, Serbia, South Africa, Thailand, Timor-Leste, Tunisia, Turkey, United Arab Emirates, United Kingdom, Uruguay, and Viet Nam (USDA PCIT, 2021).

Status in California:
1963, *A. besseyi* was detected in a fungal culture of *Sclerotium oryzae*, which causes stem rot of rice. The fungus was collected from a rice field in Butte County that was used by a research facility that exchanged seed with areas in the southeastern United States. In 1997 in order to improve our ability to meet the export requirements of trading partners, 490,000 acres of commercial rice spread over 13 counties were surveyed and one confirmed and three suspect finds of *A. besseyi* were made from four composite samples representing 33 fields, collected from Colusa and Sutter counties.

California Distribution: In the last 20 years, there have been very occasional detections in Butte, Colusa, Sutter, Yolo, and Yuba counties during phytosanitary inspections of rice for export. CDFA has not implemented any formal quarantine regulations against this nematode as it as for burrowing and reniform nematodes, or golden nematodes (Chitambar, 1999). Strawberry summer dwarf disease on strawberry occurred sporadically in California from the 1930s until 1959, but is currently unknown in California (Chitambar, 1999).

California Interceptions: In 1959, a strawberry sample from Canby, Oregon, and intercepted at a nursery in Stanislaus County.

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

Consequences of Introduction:

1) **Climate/Host Interaction:** The limited presence and low detection rate of *A. besseyi* in California rice may indicate this species' struggle to widely establish within the state. *Aphelenchoides besseyi* needs a continuous supply of moisture on rice seedlings in order to migrate and feed on growing tips of plant stems, leaves, and panicles. Atmospheric humidity of at least 70% is required for nematode development. California rice is grown under low relative humidity through its growing season. Average rainfall during this season does not exceed one inch. Strawberries are mostly grown in cool, coastal areas where there is moisture from fog and condensation, but the foliage is not wet for long periods of time.

   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 large with plants from multiple families

   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:** Seed-borne nematodes, and those that attack vegetatively propagated plants such as strawberries, always have a high potential for artificial spread. Under ideal conditions, this nematode has a very short lifecycle leading to high populations.

   Evaluate the natural and artificial dispersal potential of the pest.

   Score: 3

   - 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:** Currently, there is no record of rice yield losses caused by *A. besseyi* in California, which has only recorded low degrees of infection. However, the nematode has been a phytosanitary target species to California by many countries. There is no threat to California's strawberry and garlic industry due to *A. besseyi*. CDFA's certification programs for those hosts would detect the nematode species if it were present. Since 1989, *A. besseyi* has never been detected in tens of thousands of strawberry samples and garlic samples processed by CDFA's Nematology Laboratory. However, new pathotypes are possible and this nematode is a quarantine pest in other countries.

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

Economic Impact: A, C

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:** Seed from areas where *A. besseyi* occurs should be treated before planting to prevent spread to new areas (CABI-ISC, 2021).

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

Environmental Impact: D

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 *Aphelenchoides besseyi:* 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.

   Over decades of testing, this nematode is found only very occasionally from rice in Northern CA.

   Evaluation is 'low'.

   Score: -1
   -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* ***= 11***

Uncertainty:

Comprehensive surveys of rice production areas have not been done in more than 20 years, and some rice varieties can support nematodes but be asymptomatic, leading to an underestimation.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Aphelenchoides besseyi* is A.

References:

Agrios, G. N. 2005. Plant Pathology, 5th Edition. Elsevier Academic Press. 922 pg

CABI Invasive Species Compendium 2021. *Aphelenchoides besseyi*. https://www.cabi.org/isc/datasheet/6378 Accessed 5/13/2021

Chitambar, J. 1999. The White-Tip of Rice Nematode in California. California Plant Pest and Disease Report. California Department of Food and Agriculture. January -May pg 28-40

Christie JR, 1942. Proc. Helminth. Soc. Wash., 9:82-84

Cralley EM, 1949. White tip of rice. Phytopathology, 39:5

EPPO Global Database. 2021. *Aphelenchoides besseyi*. https://gd.eppo.int/taxon/APLOBE Accessed 5/13/2021

Nemaplex UC Davis Nemabase 2010. *Aphelenchoides besseyi*. Accessed 5/13/21

Ou, S.H., 1985. Rice diseases. Wallingford, UK; CAB International, 380 pp.

Ploeg, A., and Westerdahl, B. B. Strawberry nematodes. 2018. UC IPM Pest Management Guidelines: Strawberry. UC ANR Publication 3468

Silva, G. S. 1992. lnforme Agropecurio, 16:57-59, (English Summary).

Sudakova, M. I., and Stoyakov, A. V. 1967. Reproduction and duration of life of *Aphelenchoides besseyi* Christie, 1942. Zoologicheski Zhurnal, 46:1079-1099

Tamura I, Kegasawa K, 1958. Studies on the ecology of the rice nematode, *Aphelenchoides besseyi* Christie. II. On the parasitic ability of rice nematodes and their movement into hills. Japanese Journal of Ecology, 8:37-42

Taylor DP, 1972. Distribution and magnitude of *Aphelenchoides besseyi* infestation in rice in East Africa. International Symposium of Nematology (11th), European Society of Nematologists, Reading, UK, 3-8 September, 1972. Abstracts., 74-75

Todd, E. H., and Atkins, J. G. 1958. White tip disease of rice. I. Symptoms, laboratory culture of nematodes, and pathogenicity tests. Phytopathology, 48:632-637

Uebayashi Y, Amano T, Nakanishi I, 1976. Studies on the abnormal rice kernel "Kokutenmai". Mechanism of the symptom's development. Japanese Journal of Nematology, 6:67-72

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. *Aphelenchoides besseyi*. Accessed 5/13/2021

Yoshii H, Yamamoto S, 1950a. A rice nematode disease 'Senchu Shingare Byo'. I. Symptom and pathogenic nematode. Journal of the Faculty of Agriculture, Kyushu University, 9:209-222

Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 2800 Gateway Oaks Suite 200, Sacramento, CA 95833 Phone: (916) 654-1017, permits[@]cdfa.ca.gov.

***Comment Period:** **06/25/2021 - 07/25/2021**

***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: A
