CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Meloidogyne fallax Karssen, 1996

False Columbia root-knot nematode

Current Pest Rating: none

Proposed Pest Rating: A

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

Comment Period: 07/10/2023 through 08/24/2023

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from *Meloidogyne fallax* is described herein and a permanent pest rating is proposed.

History & Status:

Background:

*Meloidogyn*e spp. are obligate, sedentary endoparasites that feed within host plant roots. The effect of root-knot nematodes on plants can be dramatic. As a result of their feeding, large galls or “knots” are formed on the root systems, which impairs the plant’s ability to take up water and nutrients from the soil (Chitambar et al., 2018).

Meloidogyne is a name of Greek origin, meaning "apple-shaped female." Adult females, globose and sedentary, are found embedded in their host’s roots. They produce eggs within a mass either on the surface of, or within roots. *Meloidogyne* spp. generally reproduce by mitotic parthenogenesis, meaning that males are not necessary and viable eggs can be produced by females alone in the absence of fertilization. Vermiform males are rare and are only found when the population is subjected to an environmental stress. Eggs hatch in the soil and vermiform juveniles (mostly female sometimes male) swim to new roots (Mitkowski and Abawi, 2003).

The first stage juvenile develops within the egg and molts to develop into the second stage. The second-stage juveniles (J2) are the infective stage that hatch from eggs and migrate in rhizosphere soil to host roots where they reinfest the same roots they were originally associated with or are attracted to other nearby host roots. The J2s penetrate the host roots and establish a specialized feeding site that is formed at the head end of the nematode in response to its feeding. They become sedentary while feeding at the specialized site, increase in size and undergoing two more molts and non-feeding stages before developing into mature adult females or vermiform males and completing the life cycle.

The feeding site is a group of plant cells known as "giant-cells", created when the nematode injects secretory proteins that stimulate changes within the parasitized cells. The injected cells rapidly become multinucleate when division occurs without cell wall formation. Giant-cells can be very large and act as significant nutrient sinks, producing large amounts of proteins that the nematodes can use. Increases in the production of plant growth regulators from nematode feeding also plays a role in this increase in cell size and division. Root cells next to the giant-cells enlarge and divide rapidly, resulting in gall formation. Once a female establishes a feeding site as a juvenile, she permanently remains within the plant root, exuding her eggs out into the soil (Perry and Moens, 2013).

Meloidogyne fallax was detected for the first time in 1992 in the Netherlands. Initially it was thought to be a new race of *M. chitwoodi*, the Columbia root knot nematode, because it looked very similar yet had a different host range. Later, it was described as a new species, with the type strain derived from naturally infected black salsify (*Scorzonera hispanica*) and named by Karssen (1996). Several molecular diagnostic techniques have been developed for the identification of *M. fallax*. It can be distinguished from *M. chitwoodi* and other species by the ITS rRNA and COI gene sequence (Subbotin et al., 2021). The name 'fallax' is from Latin, meaning "deceptive" and refers to the misleading morphological resemblance to *M. chitwoodi.* New Zealand is the only known country where *M. fallax* is widely distributed (North and South Island) and it has been detected in crops and pasture fields (Rohan et al., 2016). This strongly suggests that New Zealand could be the place of origin of this nematode.

In recent years, root-knot nematodes have emerged as important pests on golf course greens in the Western USA. During a research survey carried out by Nischwitz et al., (2013) samples were collected from 238 golf courses in 7 states. In one sample from San Francisco County, they identified *M. fallax*. This was the first record of this nematode species in the U.S. In response to this report, CDFA conducted an extensive turf survey. Hundreds of samples were collected from golf courses in 25 California counties (including San Francisco County) leading to nearly 600 nematode detections. *Meloidogyne fallax* was not found in any of the survey samples (CDFA PDR Database, 2023). USDA-APHIS classifies *M. fallax* as not occurring in the U.S. (CABI, 2023).

Hosts: Meloidogyne fallax can parasitize a wide range of dicotyledonous plant species and some monocotyledons, including economically important crops such as carrot (*Daucus carota*), black salsify (*Scorzonera hispanica*) and strawberry (*Fragaria × ananassa*) (Nemaplex, 2010). *Oenothera erythrosepala, Phacelia tanacetifolia, Hemerocallis* 'Rajah' and *Dicentra spectabilis* are considered good hosts for *M. fallax* (Goossens, 1995; Brinkman et al., 1996). Hairy nightshade (*Solanum physalifolium*)

and white clover (*Trifolium repens*) were infected by this nematode in pastures in New Zealand (Shah et al., 2010; Rohan et al., 2016).

Symptoms: Visible signs of severe plant infestation can be observed both above and below ground. Affected plants often exhibit stunted growth and yellowing leaves. Below ground, the presence of galls is a common indicator of nematode infestation. The root galls caused by *M. fallax* resemble those formed by *M. chitwoodi*, typically appearing as relatively small galls without secondary roots emerging from them (in contrast to *M. hapla*, where secondary roots are visible). In the case of potato tubers, *M. chitwoodi* and *M. fallax* create numerous raised areas on the surface resembling small pimples (unlike *M. hapla*, which does not cause such swellings). Interestingly, certain potato cultivars may show no external symptoms despite heavy infestation, yet the internal tissue just beneath the peel may exhibit necrosis and a brownish coloration (EPPO, 2016).

Transmission: Meloidogyne fallax has limited ability to move in the field. Only second-stage juveniles can move within the soil, and their range is typically restricted to a few tens of centimeters per year at most. The most probable way for *M. fallax* to be introduced to a new area is through the transportation of infested or contaminated planting materials. Nematodes can easily be carried by infested host plants or host products such as bulbs or tubers. Additionally, the movement of non-host plants intended for planting, like seedling transplants or nursery stock, as well as non-host plant products such as bulbs, tubers, corms, and rhizomes, can contribute to the spread of *M. fallax* if they are contaminated with soil infested by the nematode. Another potential pathway for its spread is through the movement of bulk soil. The infective juveniles of this nematode species can survive for more than a year in the absence of host plants, and contaminated irrigation water can also facilitate nematode movement (Chitambar et al, 2018).

Damage Potential: The host range of this nematode includes significant agricultural crops like tomato, carrot, wheat, and barley, closely matching that of *M. chitwoodi*. During trials, *M. fallax* was found to produce similar symptoms as *M. chitwoodi* on potato tubers, black salsify, and carrots, including the formation of external galls and internal necrosis just below the skin (Brinkman et al., 1996; van Riel and Goossens, 1996). Natural outbreaks of *M. fallax* on potato crops have been reported, displaying these external symptoms (Karssen, 1996). In an experimental field infested with *M. fallax*, Goosens (1995) observed infected *Asparagus officinalis* and several ornamentals with root-knots. It has also been observed that *M. fallax* occasionally co-occurs with *M. chitwoodi* in mixed infestations (Wesemael et al., 2006).

Worldwide Distribution: Australia, Belgium, Chile, France, Indonesia, Netherlands, New Zealand, South Africa, Sweden, Switzerland, and United Kingdom (EPPO, 2023).

Official Control: *Meloidogyne fallax* is on the USDA PCIT's harmful organism list for Albania, Brazil, Egypt, Eurasian Customs Union, European Union, Holy See (Vatican City State), Japan, Monaco, Morocco, Norway, Oman, Peru, Qatar, Republic of North Macedonia, San Marino, Serbia, Republic of Korea, Republic of Moldova, United Arab Emirates, Uruguay, and Viet Nam.

Meloidogyne fallax is on the EPPO's A1 list for Argentina, Bahrain, Brazil, Eurasian Economic Union, Kazakhstan, Georgia, and Russia. It is on the A2 list for Switzerland, Comite de Sanidad Vegetal del Cono Sur, European and Mediterranean Plant Protection Organization, and European Union. It is a quarantine pest in Moldova and Norway and a regulated non-quarantine pest in the United Kingdom. It is a U.S. regulated pest (subject to rejection at the ports and borders), and on the alert list of the North American Plant Protection Organization (EPPO, 2023; USDA PCIT, 2023).

California Distribution: none (CDFA PDR database; Nemaplex, 2010).

California Interceptions: none

The risk *Meloidogyne fallax* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** *Meloidogyne fallax* has established in diverse climates including those found in Northern Europe, North Africa and the Middle East, New Zealand, and tropical parts of Asia. Its likely to survive wherever its hosts can grow.

   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 is large including plants from diverse 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:** A single female nematode can produce hundreds of eggs in her lifetime. Root-knot nematodes do not have a high dispersal potential unless moved by people. They can be moved accidentally with infected plants and soil.

   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:** The impact of *Meloidogyne fallax* is mainly manifested through cosmetic damage, resulting in quality losses for crops such as carrots and potatoes, and from quarantine actions. Damage potential of this nematode on other known host crops are currently limited (MacLeod et al., 2012). In countries where regulations exist for *M. fallax*, it may be necessary to destroy traded plants and plant products that are infested with this nematode to prevent its spread (EPPO, 2023; Ellings, 2013). Root-knot nematodes can be spread by the movement of water.

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

   Economic Impact: A, B, 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:** *Meloidogyne fallax* could trigger quarantines and treatment programs in California.

   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 *Meloidogyne fallax:* 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.

   There is an official published report of *M. fallax* from a San Francisco County golf course (Nischwitz et al., 2013), identified by experts from the USDA-ARS Nematology lab. It was not found during a nematode survey conducted by CDFA from October 2012 to March 2013.

   Evaluation is 'not established'.

   Score: 0
   -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* ***= 13***

Uncertainty:

Although officially considered 'not established' by the USDA, it's possible there are populations below our detection level in San Francisco County.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for ***Meloidogyne fallax*** **is A.**

References:

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Responsible Party:

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*Comment Period: 07/10/2023 through 08/24/2023

*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: A