CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Meloidogyne naasi Franklin 1965
Barley root knot nematode

Current Pest Rating: B

Proposed Pest Rating: B

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

Comment Period: 01/04/2023 through 02/18/2023

Initiating Event:

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

History & Status:

Background:

Root-knot nematodes (*Meloidogyne* spp.) were first reported in California by E. A. Bessey in 1911. *Meloidogyne* is a name of Greek origin, meaning "apple-shaped female." It is one of the most extensively studied nematode genera in the state with six species of significant economic concern: *M. incognita, M. javanica, M. arenaria, M. hapla, M. chitwoodi,* and *M. naasi*. The host ranges of different species are variable but encompass most of the economically important agronomic and ornamental crops grown in California. Most, including *M. naasi*, are distributed widely in California's agricultural areas but show some differences in distribution and crop preferences.

Meloidogyne naasi was originally described from field crops (cereals, grasses, sugarbeet) in England and Wales (Franklin, 1965). It is known to be a serious pathogen on cereal crops and turfgrasses. The specific name *naasi* is derived from the initials of the UK National Agricultural Advisory Service. Today, *M. naasi* is found in temperate areas of the United States and Europe (EPPO, 2022). In California, *M. naasi* is most often associated with grasses and small grains (Chitambar et al., 2018; CDFA PDR database, 2022; Nemaplex, 2010).

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. The females are globose and sedentary at maturity. They establish a feeding site as juveniles and permanently remain within the plant root, exuding eggs out into the soil. The feeding site is a group of 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 serious nutrient sinks, producing large amounts of proteins that the nematode 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. *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, but they can mate with females. Eggs hatch in the soil and vermiform juveniles (mostly female sometimes male) swim to new roots (Mitkowski and Abawi, 2003; Sasser and Carter, 1985).

Hosts: Main hosts for this nematode are frequently grasses including cereal grains and commercial turfgrasses. Important host species include *Agrostis stolonifera* (creeping bentgrass), *Allium cepa* (onion), *Avena sativa* (oat), *Beta vulgaris* (beet), *Cynodon dactylon* (Bermuda grass), *Dactylis glomerata* (cat grass), *Digitaria sanguinalis* (hairy crabgrass), *Glycine max* (soybean), *Hordeum vulgare* (barley), *Medicago sativa* (alfalfa), *Pisum sativum* (pea), *Poa annua* (annual bluegrass), *Secale cereale* (rye), *Sorghum bicolor* (sorghum), *Trifolium repens* (white clover), *Triticum aestivum* (wheat), *T. durum* (durum), *Phaseolus vulgaris* (bean), and *Stellaria media* (chickweed) (Siddiqui et al., 1973; CABI, 2022).

Symptoms: Nematode feeding causes cell enlargement and proliferation and leads to the primary symptom of a galled root system. On some hosts such as tomatoes, galls are obvious and can be up to one inch in diameter. However, galled root systems should not be the only diagnostic test, as galls are not always formed or can be very small, spindle shaped, or in spirals. Galls induced by *M. naasi* on cereal roots are cylindrical, spindle-shaped, hooked, ring-shaped or, if terminal, club-shaped. Several females are often found in one gall. Feeding from mobile J2s is associated with necrosis, hyperplasia, and hypertrophy in the root cortex (Subbotin et al., 2021).

Root knot nematode galls can resemble nodules caused by nitrogen-fixing bacteria. Sometimes the primary symptom is a proliferation of lateral root branches rather than galls. On grasses and onions, galls are usually small swellings and barely noticeable (Chitambar et al., 2018; Mitkowski and Abawi, 2003). On barley grown in Siskiyou County, Allen et al. (1970), observed the typical formation of spindle-shaped galls, and roots were killed when there was a heavy infection. Heavily infected plants are stunted, becoming yellow and may die. Surviving plants tend to remain stunted and do not produce normal heads.

Numerous aboveground symptoms can also be observed, but these are also not diagnostic. Severely affected plants wilt readily, even when soil moisture is sufficient, because galled roots have less ability to absorb and transport water. Nutrient deficiency symptoms including chlorosis can also be observed

because of a reduced ability of galled roots to absorb and transport nutrients, even when levels are adequate in the soil. Stunting is a frequent symptom. At high densities or with highly sensitive crops, root-knot nematodes can kill host plants, particularly if the high populations occur early in the growing season when root systems are small. Above ground, symptoms usually appear in clusters of plants or in patches of the field. Heavily infected roots are often badly discolored and rotted. This is due to the invasion of roots by fungi such as *Rhizoctonia, Fusarium* and *Pythium*, which cause necrosis, and due to the breakdown of galled tissue by bacteria (Mitkowski and Abawi, 2003; Chitambar et al., 2018).

Transmission: Root-knot nematodes move slowly through undisturbed soil, and in perennial crops, infestations will gradually radiate outward from an initial point of infection. Cultivation and other practices that move soil and plants will spread root-knot nematodes over longer distances. Golf course operations that allow movement of soil on carts, clubs and spiked shoes have been shown to transmit *Meloidogyne* spp. (McClure et al., 2012).

Damage Potential: The length of a root-knot nematode life cycle varies among species but can be as short as two weeks. Nematodes in cooler regions typically have longer life cycles. Eggs may remain inside root tissue or may be released into the soil matrix. Eggs hatch at random and hatching does not require exposure to root exudates. Second-stage juveniles move within the film of water that lines soil pores and are the infective stage. Stylets are used to penetrate root tips at the elongation zone. Once inside the plant root, nematodes migrate towards the vascular cylinder where they establish a feeding site. Once feeding is initiated, they become sedentary and undergo three additional moults to become pear or nearly spherical-shaped adults. The adult female lays 150–250 eggs in a gelatinous matrix on or below the surface of the root. The proportion of males in a population are typically low but may be found toward the end of the growing season, when populations are dense and host plants are under stress (McClure and Viglierchio, 1966).

Meloidogyne naasi was found causing economic damage to barley in the Klamath Basin near Tulelake (Siskiyou County) in 1964 (Allen et al., 1970). It was known to cause damage in England and Whales and has been reported from sugar beets in Belgium. It has also been recorded in Southern California on turf grass. In barley, Allen et al. (1970) reported a yield losses of 50-75% of the crop when nematode populations were high.

McClure et al. (2012) describe root-knot nematodes as a serious threat to both cool- and warm-season turfgrasses. The most common species, *Meloidogyne naasi*, was found in 41 golf courses in the coastal or cooler areas of California during their survey of golf course greens.

Worldwide Distribution: Africa: *Libya*, *Mozambique*. Americas: *Argentina, Canada, Chile, United States* (California, Illinois, Kansas, Kentucky, Maryland, Michigan, Nevada, Oregon, Utah, Washington); Asia: *Iran*, *India, Thailand.* Europe*: Belgium, Czech Republic, Denmark, France, Germany, Hungary, Ireland, Italy, Malta, The Netherlands, Norway, Poland, Portugal, Serbia, Sweden, United Kingdom*; Oceania: *New Zealand*. (CABI, CPC, 2022; Subbotin et al, 2021).

Official Control: *Meloidogyne naasi* is on the A1 list for Argentina, Brazil, East Africa, European Union, Kazakhstan, Paraguay, Turkey, Ukraine, and United Kingdom. It is on the A2 list for Asia and Pacific

Plant Protection Commission, China, Egypt, Eurasian Economic Union, European and Mediterranean Plant Protection Organization, Jordan, and Russia (EPPO, 2022). It is a Quarantine pest for Canada, Israel, Morocco, Mexico, Moldova, Norway, and Tunisia. *Meloidogyne naasi* is on the USDA PCIT's harmful organism list for Honduras, Indonesia, The Republic of Korea, and Timor-Leste (USDA- PCIT, 2022)

California Distribution: There are official records from as early as 40 years ago in Butte, Contra Costa, Fresno, Kern, Los Angeles, Madera, Monterey, Orange, Placer, San Diego, San Luis Obispo, Santa Cruz, Siskiyou, Tulare, Yolo, and Yuba counties on barley, bluegrass, bentgrass, and Bermuda grass (CDFA PDR database, 2022). A survey was done by McClure et al. (2012) to look for root knot nematodes in golf course greens. These authors report *M. naasi* from the following counties: Alameda, Contra Costa, Los Angeles, Marin, Monterey, Orange, Riverside, Sacramento, San Bernardino, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Stanislaus, and Ventura.

California Interceptions: none

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

Consequences of Introduction:

1) **Climate/Host Interaction:** *Meloidogyne naasi* is widespread in temperate areas. It has been detected in areas representing a variety of climates in California, including the coastal and hot, dry valleys.

   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 includes many types of grasses, small grains, and weeds

   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 species can reproduce with females only, and populations can increase exponentially. They disperse slowly on their own, with juveniles moving through 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: Damage can be direct, from nematode feeding and gall formation on the roots, or indirect, as plants become more susceptible to attack from other types of pathogens. They can be moved with irrigation 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: This nematode parasitizes many types of grasses, some of which are native in the state. Cultural practices which involve movement of large amounts of soil can spread this nematode.

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

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 *Meloidogyne naasi:* High

Add up the total score and include it here.14
-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 is already widespread in California, likely moving with infected planting material and infested soils in the major agricultural areas along the Coast and in the Inland Valleys

   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* ***= 11***

Uncertainty:

Distinguishing between the species of *Meloidogyne* is often difficult and many species can co-occur. Cultural management techniques such as crop rotation and trap cropping, rely on knowing the species present in a field. The ability to analyze DNA has progressively led to more advanced and accurate methods of species identification and this is likely to continue to improve in the future.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Meloidogyne naasi* is B.

References:

Allen, M., Hart, W. and Baghott, K., 1970. Crop rotation controls barley root-knot nematode at Tulelake. California Agriculture, 24(7), pp.4-5.

CABI CPC 2022. *Meloidogyne naasi*. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.33250

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.

Dong, K., Chitambar, J., Subbotin, S., Alzubaidy, M., Luque-Williams, M., Romero, J., Kosta, K., and Luna, R. 2007. Significant records in Nematology: California statewide nematode survey project for 2006. California Plant Pest and Damage Report., (July 2005 through December 2006), 23, 45–71.

EPPO Database 2022. *Meloidogyne naasi*. https://gd.eppo.int/taxon/MELGNA

Franklin, M.T., 1965. A root-knot nematode, *Meloidogyne naasi* n.sp. on field crops in England and Wales. Nematologica 11: 75-86.

McClure, M.A. and Viglierchio, D.R., 1966. The influence of host nutrition and intensity of infection on the sex ratio and development of *Meloidogyne incognita* in sterile agar cultures of excised cucumber roots 1. Nematologica, 12(2), pp.248-258.

McClure, M.A., Nischwitz, C., Skantar, A.M., Schmitt, M.E. and Subbotin, S.A., 2012. Root-knot nematodes in golf course greens of the western United States. Plant disease, 96(5), pp.635-647.

Mitkowski, N. A. and Abawi, G. S. 2003. Root-knot nematodes. The Plant Health Instructor. DOI:10.1094/PHI-I2003-0917-01. Revised 2011.

Nemaplex UC Davis Nemabase 2010. http://Nemaplex.ucdavis.edu. Accessed 12/8/22

Sasser, J. N, Carter, C. C., 1985. An Advanced Treatise on Meloidogyne. Vol. I. Biology and Control. Raleigh, North Carolina State Graphics

Siddiqui, I. A., Sher, S. A., and French, A. M. 1973. Distribution of Plant Parasitic Nematodes in California. State of California Department of Food and Agriculture, Division of Plant Industry. 324p.

Subbotin S.A., Palomares-Rius J.E. and Castillo P. 2021. Systematics of Root-Knot Nematodes (Nematoda: Meloidogynidae). Nematology Monographs and Perspectives, Volume 14 (Series Editors: Hunt, D.J. & Perry, R.N.). Leiden, The Netherlands, Brill, 857 pp.

Triantaphyllou, A. C., 1973. Environmental sex differentiation of nematodes in relation to pest management. Annual Review of Phytopathology, 11:441-462

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. *Meloidogyne naasi*. Accessed 12/8/2022

Responsible Party:

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***Comment Period: 01/04/2023 through 02/18/2023**

***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: B