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Guava Root-Knot Nematode or Pacara Earpod Root-Knot Nematode *Meloidogyne enterolobii* (Yang and Eisenback, 1983) (Nematoda: Chromadorea: Rhabditida: Tylenchina: Tylenchomorpha: Tylenchoidea: Meloidogynidae)[1]

Chang Liu, Zane. J. Grabau, and Johan Desaeger[2]

The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

Meloidogyne enterolobii is an emerging tropical and subtropical pest. It was described by Yang and Eisenback (1983) but may have previously been misidentified as other root-knot nematode species. Guava root-knot nematode has the ability to overcome many resistant genes commonly deployed in crops and is particularly damaging, which makes it of particular concern for agricultural production.

Synonymy

Meloidogyne mayaguensis (Rammah and Hirschmann, 1988)

Distribution

Meloidogyne enterolobii was first described from the pacara earpod tree (*Enterolobium contortisiliquum*) in Hainan Island in China in 1983 (Yang and Eisenback, 1983), and is mainly found in tropical and subtropical areas including Africa (Benin, Burkina Faso, Congo, Kenya, Malawi, Mozambique, Niger, Nigeria, Senegal, South Africa, Togo); Asia (China, India, Thailand, Vietnam); Europe (Portugal, Switzerland); North America and the Caribbean (Costa Rica, Guadeloupe, Guatemala, Martinique, Mexico, Trinidad and Tobago, United States); and South America (Brazil, Venezuela (Castillo P and Castagnone-Sereno P, 2020). It has limited distribution but can be highly damaging. It was first reported in the United States in 2004 in Florida (Brito et al., 2004), and has been reported in most counties in Florida (Brito et al., 2008, 2010). It has since been reported in North Carolina (Ye et al., 2013), South Carolina (Overstreet et al., 2019) and Louisiana (Rutter et al., 2019).

Description

Morphologically, *Meloidogyne enterolobii* is very similar to other root-knot nematode species and requires training to differentiate nematodes morphologically. Second stage

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2. Johan Desaeger; Zane Grabau; and Johan Desaeger; Entomology and Nematology Department, UF/IFAS Extension, Gainesville, FL 32611.

juveniles are translucent white, vermiform (worm-shaped), and tapered at both ends. They have a long, narrow tail and a delicate stylet (Figure 1). Females are white, pear-shaped with prominent necks variable in size (Figure 2). Males are translucent white, vermiform, and rounded at both ends (Figure 3). They are larger than juveniles with a more robust stylet and head framework. Morphological characteristics used to differentiate *Meloidogyne enterolobii* from other *Meloidogyne* species include the female perineal pattern (oval shape, coarse or smooth striae, moderately high to high arch, anus and vulva size and position) as well as the morphology of the head, tail, and stylet in various life stages (Yang and Eisenback, 1983). Identification based on molecular techniques can also be done and is often preferred as this requires only knowledge of common molecular techniques and no morphological expertise. Differentiation of *Meloidogyne enterolobii* from other common root-knot nematode species is based on the presence/absence and/or size of the amplicons in PCR reactions (Hu et al., 2011). The UF/IFAS Nematode Assay Lab performs this diagnosis by using molecular identification tools as do other professional diagnostic laboratories.

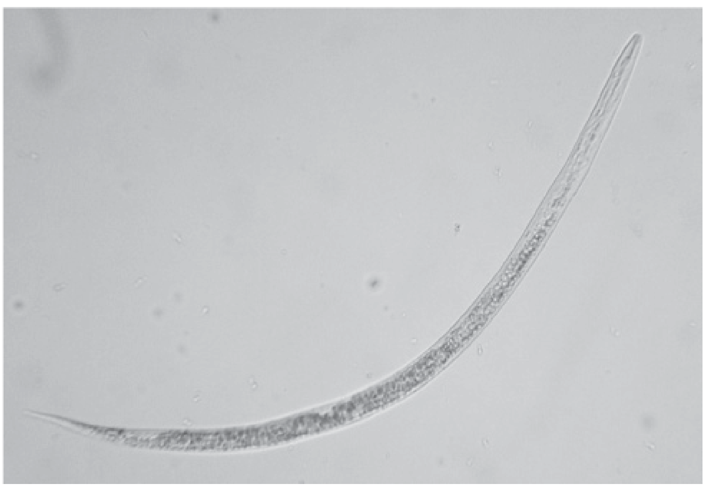

Figure 1. Second stage juvenile of Guava root-knot nematode *Meloidogyne enterolobii* at 400x magnification.
Credits: FIND*ME*

Figure 2. Guava root-knot nematode *Meloidogyne enterolobii* females are white and pear-shaped.
Credits: Will Rutter, USDA-ARS, used by permission

Figure 3. *Meloidogyne* male at 400x magnification. Males are worm-shaped with rounded heads and tails.
Credits: Zane Grabau, UF/IFAS

Life Cycle

Meloidogyne enterolobii is very similar to other root-knot nematodes in respect to life cycle. The eggs hatch into 2nd-stage juveniles in the soil, which migrate through the soil in search for a susceptible host root. J2 stage is the only infective stage, and they invade the root tip and establish a permanent feeding site, from which the juvenile and adults feed. The root cells surrounding the feeding site enlarge and multiply, giving rise to a gall in which the juveniles are embedded. Nematodes keep developing into J3 and J4 stages, and eventually develop into globose females or vermiform males. Females produce eggs out of their body and eggs are deposited into a gelatinous matrix called "eggmass". A single female can produce 500-1000 eggs. Mature males cease feeding and exit the roots. Males are not required for reproduction (mitotic reproduction).

Hosts

As an emerging pest, *Meloidogyne enterolobii* host tests are still ongoing, but itcan infect most horticultural, ornamental, and agronomic crops based on testing thus far (Table 1).

Meloidogyne enterolobii has a similar host preference to southern root-knot nematode *Meloidogyne incognita*, except that *Meloidogyne enterolobii* can reproduce on many plant cultivars carrying *Meloidogyne* resistance genes (Table 2). Thus far, sweetpotato production in the United States, guava production in Brazil, and horticultural production in the Caribbean are the industries that have been most affected by *Meloidogyne enterolobii.*Some crop species have been reported as poor or non-hosts for *Meloidogyne enterolobii* (Table 3), including grapefruit (*Citrus paradisi*), sour orange (*Citrus aurantium*), garlic (*Allium sativum*), coconut (*Cocos nucifera*), grape (*Vitis vinifera*), mango (*Mangifera indica*), mulberry (*Morus alba*), corn (*Zea mays*) and peanut (*Arachis hypogaea*) (Rodriguez et al., 2003;

European and Mediterranean Plant Protection Organization, 2014; Freitas et al., 2017; Schwarz et al., 2020).

Symptoms

Symptoms caused by *Meloidogyne enterolobii* are similar to those caused by other root-knot nematode species, although on certain crops symptoms of *Meloidogyne enterolobii* infection are generally more severe than that of other root-knot nematode species. The typical symptom is severe galling (knotty root growths stimulated by *Meloidogyne* infection) of the root system (Figures 4 and 5). *Meloidogyne enterolobii* also infects tubers and storage roots, such as potatoes and sweetpotatoes (Figure 6). Infected tubers can be severely deformed with large galls on the tuber, the tuber can be cracked and dark on the surface, and white round females can be discovered under the tuber surface upon inspection with a dissecting scope. Aboveground symptoms include reduced stand, chlorosis (yellowing of plant foliage), stunting and loss of vigor (Figure 7). Damage symptoms on cultivars resistant to common *Meloidogyne* species are an indication that *Meloidogyne enterolobii* may be responsible for the damage as it can infect many resistant cultivars. As with other plant-parasitic nematodes, *Meloidogyne enterolobii* symptoms typically have a patchy field distribution (Figure 8) corresponding to varying nematode populations and environmental conditions.

Figure 4. Root galling induced by *Meloidogyne enterolobii* on a pepper carrying the *N* gene for resistance to most *Meloidogyne* species.
Credits: Zane Grabau, UF/IFAS

Management

Management of *Meloidogyne enterolobii* relies largely on techniques that have been successful with other root-knot nematodes as relatively limited field research has been done with *Meloidogyne enterolobii*. Management options also vary by crop, particularly for chemical control. See UF/IFAS EDIS nematode management guides for information on specific crops including sweet potato, potato, cucurbits, tomatoes/peppers, cotton, and soybean among others.

Figure 5. Severe root galling induced by *Meloidogyne enterolobii* on tomato.
Credits: David Moreira Calix, UF/IFAS

Figure 6. *Meloidogyne enterolobii* infected sweet potato with extensive galling and deep cracks.
Credits: Charles Overstreet, LSU, used with permission

Cultural

Extreme plant quarantine methods have been implemented to restrict dispersal of *Meloidogyne enterolobii* within the United States. After this pest was found in the North Carolina sweet potato growing belt in 2013, a number of states issued internal or external quarantines. These quarantines required planting material to be certified free of *Meloidogyne enterolobii* or restricted distribution of sweet potato produced from states confirmed to have this pest. Quarantine is a critical step in preventing this species spreading in a certain area. Using qualified nematode free seedlings and planting in clean fields even in areas where quarantines are not in place are important measures as they will prevent introduction of *Meloidogyne enterolobii* into the field.

Figure 7. *Meloidogyne* infected tomato exhibiting yellowing, stunting and wilting.
Credits: Chang Liu, UF/IFAS

Figure 8. Patchy distribution of *Meloidogyne* symptoms (reduced stand, stunting of foliar) in a napa cabbage field.
Credits: Zane Grabau, UF/IFAS

Figure 9. Reduced stand and stunting caused by *Meloidogyne enterolobii* in pepper production.
Credits: Johan Desaeger, UF/IFAS

Biological

Once *Meloidogyne enterolobii* is established in fields, it is generally not feasible to eradicate this pest and management relies on limiting the abundances of the nematode to alleviate crop damage. Crop rotation with poor- or non-hosts is a common and very successful method for managing other *Meloidogyne* species. The limited number of poor- or non-hosts for *Meloidogyne enterolobii*, particularly among high value crops, is the main factor that limits use of this practice. Biological control using fungal or bacterial agents may also be a useful tool for integrated pest management of *Meloidogyne enterolobii*. The fungus *Trichoderma harzianum* has shown value for managing *Meloidogyne enterolobii* on guava (Jindapunnapat et al, 2013), and the fungi *Pochonia chlamydosporia* and *Purpureocillium lilacinum* have had some efficacy in laboratory tests (Silva et al., 2017). Due to its ability to infect most known *Meloidogyne* resistant cultivars, use of resistant cultivars is currently unavailable to growers for managing this pest.

Chemical

There are both fumigant and non-fumigant nematicides registered for root-knot nematode management in Florida (Grabau, 2019). However, vegetables and ornamentals still largely rely on fumigation. Nematicides should be effective against *Meloidogyne enterolobii*, but more research on chemical control of this emerging pest is needed.

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Table 1. List of common agronomic, horticultural and ornamental crops know to be good hosts to *Meloidogyne enterolobii*.

Common name	Scientific name	Reference
Agronomic crops		
Cotton	*Gossypium hirsutum L.*	Ye et al., 2013
Soybean	*Glycine max*	Ye et al., 2013
sweet potato	*Ipomoea batatas*	Rutter et al., 2019
Tobacco	*Nicotiana tabacum*	Filho et al., 2016
Potato	*Solanum tuberosum*	Edward & Meleleki, 2013
Horticultural crops		
Thai basil	*Ocimum basilicum*	Gu et al., 2021
Bell pepper	*Capsicum annuum*	Assoumana et al., 2017
Cabbage	*Brassica oleracea*	Brito et al., 2007
Coffee	*Coffea*	Alves et al., 2009
Cucumber	*Cucumis sativus*	Kiewnick et al., 2008
Eggplant	*Solanum melongena*	Brito et al., 2007
Okra	*Abelmoschus esculentus*	Brito et al., 2007
Squash	*Cucurbita*	Brito et al., 2007
Tomato	*Solanum lycopersicum*	Kiewnick et al., 2008
Broccoli	*Brassica oleracea*	Brito et al., 2007
Banana	*Musa*	Silva et al., 2017
Guava	*Psidum guajava*	Gomes et al., 2008
Watermelon	*Citrullus lanatus*	Brito et al., 2007
Ornamental crops		
Angelonia	*Angelonia angustifolia*	Kaur et al., 2006
False daisy	*Eclipta prostrata*	Brito et al., 2008
Jamaican poinsettia	*Euphorbia punicea*	Han et al., 2012
Japanese blue berry	*Elaeocarpus decipiens*	Moore et al., 2020
Mulberryweed	*Fatoua villosa*	Brito et al., 2008
Poinsettia	*Poinsettia cyathophora*	Brito et al., 2008

Table 2. List of *Meloidogyne* resistance genes that *Meloidogyne enterolobii* is known to overcome. Crop listed under each resistance gene have cultivars that incorporate the given gene.

Resistance gene	Crop common name	Crop scientific name	Reference
Mi1	cotton	*Gossypium hirsutum*	Ye et al., 2013
Mi1	sweet potato	*Ipomoea batatas*	Rutter et al., 2019
Mi1	tomato	*Solanum lycopersicum*	Kiewnick et al., 2009
N	pepper	*Capsicum annuum*	Kiewnick et al., 2009
Rk	tobacco	*Nicotiana tabacum*	Ye et al., 2013

Table 3. List of common agronomic, horticultural, and ornamental crops known to be poor or non-hosts of *Meloidogyne enterolobii*.

Common name	Scientific name	Reference
Agronomic crops		
corn	*Zea mays*	Rosa, J.M.O et al., 2011
peanut	*Arachis hypogaea*	Rodriguez et al., 2003
Horticultural crops		
garlic	*Allium sativum*	Rodriguez et al., 2003
grape	*Vitis*	Freitas et al., 2016
strawberry	*Fragaria ananassa*	Freitas et al., 2016
sour orange	*Citrus aurantium*	Freitas et al., 2016
passion fruit	*Passiflora edulis*	Freitas et al., 2016