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European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

EPPO Data sheets on quarantine pests
Fiches informatives sur les organismes de quarantaine

Meloidogyne enterolobii

Identity

Scientific name: *Meloidogyne enterolobii* Yang & Eisenback, 1983
Synonyms: *Meloidogyne mayaguensis* Rammah & Hirschmann, 1988
Taxonomic position: Nematoda: Tylenchida: Meloidogynidae
Common names: non-existent
Notes on taxonomy: *Meloidogyne enterolobii* was described by Yang & Eisenback (1983) from roots of pacara earpod trees (*Enterolobium contortisiliquum*), on Hainan Island in China. In 1988 Rammah and Hirschmann described *M. mayaguensis* from roots of eggplant (*Solanum melongena*) from Puerto Rico and indicated that this new species 'superficially resembles *M. enterolobii*', but shows 'several distinct morphological features and a unique malate dehydrogenase pattern (N3c)'. Karssen *et al.* (2012) re-studied the holo- and paratypes of both species and confirmed *M. mayaguensis* as a junior synonym for *M. enterolobii*.
EPPO code: MELGMY
Phytosanitary categorization: EPPO A2 list No. 361

Hosts

The root-knot nematode *Meloidogyne enterolobii* is polyphagous and has many host plants including cultivated crops and weeds. It attacks herbaceous as well as woody plants. The principal hosts are *Phaseolus vulgaris* (bean), *Coffea arabica*[1] (coffee), *Gossypium hirsutum* L. (cotton), *Solanum melongena* (eggplant), *Psidium guajava* (guava), *Solanum quitoense* (naranjilla), *Carica papaya* L. (papaya), *Capsicum annuum* (pepper), *Solanum tuberosum* (potato), *Glycine max* (soybean), *Ipomoea batatas* (sweet potato), *Nicotiana tabacum* (tobacco), *Lycopersicon esculentum* (tomato) and *Citrullis lanatus* (watermelon) (Rammah & Hirschmann, 1988; Brito *et al.*, 2007; Gomes *et al.*, 2008; Bitencourt & Silva, 2010; Silva *et al.*, 2010; Quénéhervé *et al.*, 2011; Crozzoli *et al.*, 2011; 2012; da Silva & Krasuski, 2012; Onkendi & Moleleki, 2013; Ye *et al.*, 2013). For *Gossypium hirsutum* (cotton), Brito *et al.* (2004) reported that four Florida isolates of *M. enterolobii* reproduced on this host, which confirmed the original description by Yang & Eisenback (1983).

Meloidogyne enterolobii has also been reported on *Ajuga*, *Angelonia*, *Aquilaria malaccensis*, *Brugmansia*, *Enterolobium contortisiliquum*, *Euphorbia punicea*, *Hibiscus*, *Maranta arundinasea*, *Morinda citrifolia*, *Ocimum basilicum*, *Paulownia elongate*, *Rosa*, *Syzygium aromaticum*, *Thunbergia*, *Tibouchina* and several weeds (Carneiro *et al.*, 2006; Kaur *et al.*, 2007; de Almeida *et al.*, 2011b; Han *et al.*, 2012). Experiments carried out in the Netherlands have also shown that *Cactus*, *Ficus*, *Syngonium* and *Vitis* can also be host plants of *M. enterolobii*. Only a few crops have been reported as non-hosts or very poor hosts for *M. enterolobii*, including *Brassica oleracea* (cabbage), *Allium sativum* (garlic), *Citrus* × *paradisi* (grapefruit), *Zea mays* subsp. *mays* (maize), *Arachis hypogaea* (peanut), *Citrus* × *aurantium* (sour orange) and *Allium fistulosum* (welsh onion) (Rammah & Hirschmann, 1988; Guimaraes *et al.*, 2003; Rodriguez *et al.*, 2003; Brito *et al.*, 2004; Bitencourt & Silva, 2010; Dias *et al.*, 2010a; Rosa *et al.*, 2012).

Geographical distribution

Meloidogyne enterolobii has been reported from several countries in North, Central and South America, Africa and Asia (CABI, 2000). Its present distribution in warmer climates suggests that this species will not survive outside greenhouses in northern countries of Europe, but it might be able to establish itself in the Mediterranean region. For Europe *M. enterolobii* was first recorded in a greenhouse in France (Blok *et al.*, 2002), but the pest is no longer present. It has also been reported from two greenhouses in Switzerland associated with severe damage on tomato and cucumber (Kiewnick *et al.*, 2008). *Meloidogyne enterolobii* has been intercepted in EPPO countries such as the Netherlands, Germany and the UK several times in imported plant material from Asia, South America and Africa (e.g. *Cactus* sp., *Syngonium* sp, *Ficus* sp., *Ligustrum* sp., *Brachychiton* sp., *Rosa* sp.).
EPPO region: Switzerland (Kiewnick *et al.*, 2008).
Africa: Burkina Faso, Côte d'Ivoire, Malawi, Senegal, South Africa (Fargette *et al.*, 1996; Willers, 1997; Onkendi & Moleleki, 2013).

[1]It is noted that while coffee can be a good host some cultivars are resistant (see details in the control paragraph).

Asia: China (Hainan, Guangdong, Liaoning) (Yang & Eisenback, 1983), Vietnam (Iwahori *et al.*, 2009).
North America: USA (Florida, North Carolina) (Brito *et al.*, 2004; Ye *et al.*, 2013), Mexico (Ramirez-Suarez *et al.,* 2013).
Central America and Caribbean: Costa Rica (Humphreys *et al.*, 2012), Cuba (Decker & Rodriguez Fuentes, 1989), Martinique (Carneiro *et al.*, 2001), Puerto Rico (Rammah & Hirschmann, 1988), Trinidad and Tobago.
South America: Brazil (Alagoas, Bahia, Ceara, Goias, Mato Grosso, Maranhao, Minais Gerais, Parana, Pernambuco, Piaui, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina, Sao Paulo, Tocantins) (Carneiro *et al.*, 2001, 2006; de Torres *et al.*, 2004, 2005, 2007; da Silva *et al.*, 2006, 2008; de Oliveira *et al.*, 2007; de Almeida *et al.*, 2008, 2011b; Gomes *et al.*, 2008; Charchar *et al.*, 2009; de Siqueira *et al.*, 2009; Castro & Santana, 2010; de Almeida & Santos, 2011; dos Reis *et al.*, 2011; dos Paes *et al.*, 2012), Venezuela (Lugo *et al.*, 2005; Perichi & Crozzoli, 2010).

Biology

Meloidogyne enterolobii is a sedentary endoparasite. Second-stage juveniles (J2) hatch from eggs in the soil or root debris and migrate towards the root tip of candidate host plants. Using their stylet or wounds, juveniles enter the unsuberized epidermal cells near the root tip and migrate within the cortical tissue until they initiate a permanent feeding site in close proximity to the vascular tissue. Juveniles soon lose their mobility and become sedentary. At the same time, feeding of the J2 on root cells induce those cells to differentiate into multinucleate nursing cells, so-called giant cells. At the same time the surrounding tissue starts to divide giving rise to a typical root gall or root-knot. During their further development juveniles swell to become sausage-shaped and undergo three moults before they reach adult stages. Adult females are pear-shaped and found almost completely embedded in the host tissue. Eggs are laid by the female in a gelatinous sac near the root surface. Adult males are vermiform and found free in the rhizosphere or near the protruding body of the female. As for other *Meloidogyne* species, reproduction is nearly almost parthogenetic. The life cycle of *M. enterolobii* takes 4–5 weeks under favourable conditions and females produce around 400–600 eggs.

Detection and identification

Symptoms

Meloidogyne enterolobii affects growth, yield, lifespan and tolerance to environmental stresses of infested plants. Typical above-ground symptoms include stunted growth, wilting and leaf yellowing. Typical root galls are found below-ground which can be large in size and numbers (Cetintas *et al.*, 2007). Overall, damage due to *M. enterolobii* may consist of reduced quantity and quality of yield. Plant infection with secondary plant pathogens might be enhanced following *M. enterolobii* infestation, such as being described for *Fusarium solani* on guava (Gomes *et al.*, 2011).

Morphology

Second-stage juveniles are vermiform, annulated, tapering at both ends, 250–700 µm long, 12–18 µm wide, tail length 15–100 µm and hyaline tail part 5–30 µm in length (Yang & Eisenback, 1983; Rammah & Hirschmann, 1988). Females are characteristically globular to pear-shaped, pearly-white and sedentary. Their body is annulated, 400–1300 µm long, 300–700 µm wide and shows lateral fields each with 4 incisures. The stylet is dorsally curved, 10–25 µm long, with rounded to ovoid stylet knobs, set off to sloping posteriorly. The perineal pattern is round to ovoid; the arch is moderately high to high and usually rounded. The vermiform males are annulated, slightly tapering anteriorly, bluntly rounded posteriorly, 700–2000 µm long and 25–45 µm wide. The stylet is 13–30 µm long, with stylet knobs, variable in shape.

Meloidogyne enterolobii closely resembles other tropical root-knot nematodes such as *M. incognita*, *M. arenaria* and *M. javanica*. In general, it can be separated from other species within the genus by perineal pattern shape, male and female stylet morphology; morphology of the male; body length and morphology of the lip region, as well as tail and hyaline tail part in second-stage juveniles according to EPPO Standard PM 7/103 (EPPO, 2011). The other two *Meloidogyne* species which are on the EPPO lists of pest recommended for regulation, namely *M. chitwoodi* and *M. fallax*, are usually not associated with *M. enterolobii* and can also be clearly distinguished by their demarcated hyaline tail end.

Detection and inspection methods

The presence of *M. enterolobii* in infested soil and planting material can be determined by sampling of suspected material and subsequent extraction of second-stage juveniles using standard methods described in the EPPO Standard PM 7/119 on Nematode Extraction (EPPO, 2013a). Microscopic examination at 800–1000 times magnification is necessary for correct identification of the nematode species. Presence of females and males can assist in identification. However, as morphological characters of *M. enterolobii* are often similar to other *Meloidogyne* species, identification to species level is usually based on a combination of morphological/morphometrical characters and biochemical or molecular methods (isozymes or PCR). For details see the EPPO Diagnostic Protocol (EPPO, 2011).

Means of movement and dispersal

As is the case for other plant-parasitic nematodes *M. enterolobii*'s own movement is limited at most to a few tens of centimetres in the soil. The main routes for

nematode dissemination are by infested planting material and soil, such as traded host plants or cuttings with roots, traded soil bearing products such as potatoes, soil attached to equipment and machinery and irrigation water.

Pest significance

Economic impact

Meloidogyne enterolobii is considered as very damaging due to its wide host range, high reproduction rate and induction of large galls (Castagnone-Sereno, 2012). Severe damage caused by *M. enterolobii* has been reported for *Psidium guajava* (guava; da Silva & Krasuski, 2012; Martins *et al.*, 2013), *Lycopersicon esculentum* (tomato) and *Citrullis lanatus* (water melon; Cetintas *et al.*, 2007; Kiewnick *et al.*, 2009; Ramirez-Suarez *et al.*, 2014) and *Enterolobium contortisiliquum* (pacara earpod tree, Yang & Eisenback, 1983). Compared with other root-knot nematode species, *M. enterolobii* displays virulence against several sources of root-knot nematode-resistance genes and therefore is considered particularly aggressive. For example, *M. enterolobii* develops on crop genotypes carrying resistance to the major species of *Meloidogyne*, including resistant cotton, sweet potato, tomatoes (*Mi-1* gene), potato (*Mh* gene), soybean (*Mir1* gene), bell pepper (*N* gene), sweet pepper (*Tabasco* gene) and cowpea (R_k gene) (summarized in Castagnone-Sereno, 2012). In countries where *M. enterolobii* is regulated, traded plants and plant products infested with *M. enterolobii* may need to be destroyed.

Control

General management strategies for root-knot nematodes have been recently reviewed by Coyne *et al.* (2009) and Nyczepir & Thomas (2009). Taking into account the banning of most chemical nematicides, growing non host crops or black fallow are the most efficient methods for reducing *M. enterolobii* populations. Unfortunately, the list of non host plants is very small, including cabbage, garlic, grapefruit, maize, peanut, sour orange and welsh onion. Brito *et al.* (2007) reported on two carrot cultivars and collard allowing very little or no nematode reproduction. Of various selections of *Phaseolus vulgaris*, *P. lunatus*, *Vigna radiata*, *V. unguiculata* and *Canavalia ensiformis* being tested for their susceptibility to *M. enterolobii* only *P. vulgaris* cv. Alabama was resistant (Crozzoli *et al.*, 2012). Squash and lettuce showed some resistance towards *M. enterolobii* (Bitencourt & Silva, 2010) and eight genotypes of soybean turned out to be tolerant to *M. enterolobii* while 60 genotypes were susceptible (Dias *et al.*, 2010b). Compared to annual crops, more sources of resistance towards *M. enterolobii* have been reported for perennial crops such as the *R Mia* resistance gene in peach rootstocks (Claverie *et al.*, 2004; Nyczepir *et al.*, 2008), the *Ma* gene in Myrobolan plum (Rubio-Cabetas *et al.*, 1999) and some newly detected resistance in wild *Psidium* sp. accessions that might serve in the future as rootstock for guava (Carneiro *et al.*, 2007; de Almeida *et al.*, 2009). Although coffee has been reported as a principal host for *M. enterolobii* (Decker & Rodriguez Fuentes, 1989), all seven coffee cultivars tested by Alves *et al.* (2009) turned out to be resistant, thus leaving the host status of coffee unresolved.

Phytosanitary risk

Recent reports of *M. enterolobii* in glasshouses in the EPPO region clearly demonstrate that it has the potential to enter Europe (Blok *et al.*, 2002; Kiewnick *et al.*, 2008). It was also recently detected in the USA during routine regulatory sampling at ornamental nurseries in South Florida which has a comparable climate to Southern Europe (Han *et al.*, 2012). It is very likely that this species can survive in the warmer parts of the EPPO region and in glasshouses throughout the EPPO region. In addition, this species was detected on roses (plants for planting) originating from China (see EPPO RS 2008/107), thus suggesting that it can also survive slightly cooler temperatures. Once root-knot nematodes have been introduced, it is in general difficult to control or eradicate them.

Phytosanitary measures

No specific quarantine requirements for *M. enterolobii* are yet in force. However, measures similar to those recommended by EPPO for *Meloidogyne chitwoodi* and *M. fallax* (EPPO, 2013b) seem to be relevant, i.e. that consignments of rooted plants should come from areas where the pest does not occur or from fields found to be free of *M. enterolobii*.

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