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*This PRA document was amended in 2019 to remove inconsistencies on risk management measures with the PRA record (document 10-16243), and in 2021 to clarify the phytosanitary measures recommended*

# Report of a Pest Risk Analysis for: *Meloidogyne enterolobii*

This summary presents the main features of a pest risk analysis which has been conducted on the pest, according to EPPO Decision support scheme for quarantine pests.

**Pest:** ***Meloidogyne enterolobii***
**PRA area:** The PRA area is the EPPO region (see map www.eppo.org).

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## STAGE 1: INITIATION

**Reason for doing PRA**: The NPPOs of the Netherlands and Germany have detected *M. enterolobii* (syn. *M. mayaguensis*) in imported plant material. In 2008, an outbreak was detected in Switzerland. Within the tropical root-knot nematodes, this species can be considered as one of the most damaging species and several economically important species are host plants. Resistance to other tropical root-knot nematodes of important crop cultivars, such as the *Mi* -1 gene carrying tomato cultivars, is not effective against *M. enterolobii*. The Working Party on Phytosanitary Regulations recommended that a PRA should be performed.

**Taxonomic position of pest:** Taxonomic Tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Nematoda
Family: Meloidogynidae
Genus: *Meloidogyne*
Species: *enterolobii*

## STAGE 2: PEST RISK ASSESSMENT

### Probability of introduction

*Entry*

Geographical distribution:

**EPPO region:** France (reported once from Concarneau, Bretagne region), and Switzerland.

*Note*: in the Netherlands, *M. enterolobii* has been intercepted approximately 10 times (from 1991 to 2007) in imported plant material from Asia, South America and Africa. Findings before 2007 could only be confirmed in the second half of 2007 when full information needed for reliable identification became available. It has been intercepted once in Germany (but on a large volume of plants for planting). It has also been detected on *Vitis* spp. but no further information on this finding is available consequently the pest is not considered as present in the Netherlands.

**Africa**: Burkina Faso, Ivory Coast, Malawi, Senegal, South Africa, Togo.

**Asia**: China (Hainan), Vietnam.

**North America**: USA (Florida, first reported in 2002 on ornamentals and then in a commercial tomato field and a tropical fruit nursery).

**Central America and Caribbean**: Cuba, Guatemala, Martinique, Guadeloupe, Puerto Rico, Trinidad and Tobago.

**South America**: Brazil (Bahia, Ceara, Maranhao, Minais Gerais, Parana, Pernambuco, Piaui, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Sao Paulo), Venezuela.

A table indicating references for the pest distribution is presented in Appendix 1

Major host plants or habitats:

The host range of *M. enterolobii* includes a large number of horticultural and agricultural crops (Brito *et al*., 2004a b & c) (see Appendix 2). It is expected that many more plant species will be hosts of *M. enterolobii* than currently known, since this is the case also with other, closely related root knot nematodes. Host plant research has mainly been carried out in (sub) tropical countries. Consequently, many of the known host plants are of no or only minor commercial importance for the EPPO region nevertheless some of the host plants are major crops in the EPPO region (e.g. tomato) or major ornamental plants such as *Rosa* sp. Tropical root knot nematodes usually have a wide host range. The EWG considered that the host list for *M. enterolobii* is likely to be similar to that of *M. incognita*. *M. incognita* has a very wide host range, with nearly every higher *planta* known to be a host (Jepson, 1987) and including more than 200 plant genera (Krishnappa, 1985 referred to in CABI, 2007). Research would be needed to obtain more knowledge about the host plants of *M. enterolobii* among commercially important crops in the EPPO region.

Which pathway(s) is the pest likely to be introduced on:

*M. enterolobii* is most likely to enter the PRA area in infested plant material or infested soil. Since *M. enterolobii* only feeds on root tissue, plant material is likely to be infested only if roots are present. As with other *Meloidogyne* spp., infested soil may be associated with some commodities (potted plants) and international transport of equipment and machinery (Davis & Venette, 2004a and 2004b).

The EWG considered the following possible pathways

1) Host plants for planting (including cuttings) with roots (with or without soil);
2) Non host plants for planting with soil attached
3) Plant products that may have soil attached (such as potatoes tubers, bulbs or rhizomes);
4) Soil attached to equipment and machinery;
5) Travellers;

6) Soil as such.

**The most relevant traded pathway was considered to be host plants or cuttings with roots (with or without soil) and non host plants with soil attached**.

**Establishment**

Plants or habitats at risk in the PRA area:

Not all known host plants are present in the EPPO region, but those that are present are widespread, such as rose, cucumber, tomato, pepper, egg plants, broccoli and bean. An illustration of the area occupied by tomato and cucumber and their relative importance is presented in Table 3.

**Table 3**. Vegetable production data from FAO datasets for vegetable production. The figures are derived from mean production values over the years 2004 – 2006.

| | Tomato | Cucumber |
|---|---|---|
| Total production in the PRA area (ha) | 1 123 826 | 345 767 |
| Proportion of total vegetable production area | 16.0 % | 4.9 % |

Climatic similarity of present distribution with PRA area (or parts thereof):

Based on the present knowledge of distribution of *M. enterolobii*, this species needs a relatively high temperature to develop. These conditions are present outside in the southern part of the EPPO region and in greenhouses in the entire EPPO region. The precise temperature requirements of *M. enterolobii* have not been studied. It is assumed that this species has similar climatic condition requirements as other tropical root knot nematode species. The following tropical root knot nematode species are known to occur in the EPPO region: *M. javanica*, *M. incognita* and *M. arenaria* (CABI, 2002a, 2002b; CABI 2003) and have been recorded many times outdoors in the southern part of the region.
In the northern parts of the EPPO region, tropical root-knot nematode species have been detected under protected cultivation. A recent study has shown that *M. incognita* is able to survive outdoors (overwinter) in the Northwest of Germany (pers. comm., J. Hallmann, 2009). *M enterolobii* has been found together with *M. hapla* (a northern root knot nematode) in Switzerland (Kiewnick, pers. comm. 2009). This indicates that *M. enterolobii* has similar temperature requirements than *M. hapla*.

Based on these facts, it can be assumed that suitable climatic conditions can be found in all parts of the EPPO region.

Characteristics (other than climatic) of the PRA area that would favour establishment:

The pest occurs on a wide range of soil but association with crop damage is mainly observed in sandy soils. Such soils are present mainly in the southern and central parts of the PRA area (see Appendix 3). Establishment is not affected by competition, co-existence of two or more *Meloidogyne* species on the same host in the field is well known, and suggests strongly that competition between these nematode species is not an issue (Karssen, 2002).

Which part of the PRA area is the endangered area:

As the pest can be present under protected conditions the whole EPPO region is considered to be the endangered area, the Mediterranean part is considered as being most at risk as the pest is more likely to establish outdoors than in the northern part of the region.

**POTENTIAL ECONOMIC CONSEQUENCES**

**How much economic impact does the pest have in its present**

All available literature refers to *M. enterolobii* as a highly virulent and damaging nematode species, when compared to the other tropical root-

**distribution:**

knot nematodes. Brito *et al*. (2004b) state that *M. enterolobii* is highly virulent to many vegetables.
Only few detailed studies have been made so far on yield losses. In tomato trials the strongest reduction in fruit yield was caused by *M. enterolobii* compared to other tropical root-knot nematodes i.e. the yield was 0.9 kg in a microplot infested with *M enterolobii* compared to 2.6 kg in the control, i.e. 65% reduction (Cetintas *et al.*, 2007).
In fact this nematode produces bigger galls (which can be correlated with reduction of crop yields).
Results for the other nematodes is shown in the table below (based on Cetintas *et al.*, 2007)

| | Fruit yield | % of losses |
|---|---|---|
| *M. arenaria* | 1.5 | 42 % |
| *M. floridensis* | 1.5 | 42 % |
| *M. incognita* | 1.4 | 46 % |
| *M. javanica* | 1.4 | 46 % |
| *M. enterolobii* | 0.9 | 65 % |
| Control plot | 2.6 | |

In two greenhouses in Switzerland yield losses of up to 50% and severe stunting of tomato rootstocks, resistant to *M. incognita*, *M. javanica* and *M. arenaria*, and cucumber were observed (Kiewnick *et al*., 2008).

Besides the above-mentioned damage, *M. enterolobii* is of particular concern because it can reproduce on cultivars with the *Mi* resistance gene (Fargette, 1987; Cetintas *et al.*, 2008; Brito *et al.*, 2007b; Brito *et al.*, 2007a; Carneiro *et al*., 2006; Berthou *et al.*, 2003). The *Mi* resistance gene confers resistance to the three major tropical-subtropical nematode species, such as *M. incognita*, *M. javanica* and *M. arenaria* (Zoon *et al*., 2004).

**Describe damage to potential hosts in PRA area:**

*M. enterolobii* is highly virulent and produces more root galls compared to other root-knot nematodes (Cetintas *et al.*, 2007; Fargette, 1987).

(Gall on tomato roots (Courtesy S. Kiewnick)

**How much economic impact would the pest have in the PRA area:**

As the correlation between root galling and yield loss is well known (Ploeg & Phillips, 2001; Kim & Ferris, 2002), it is expected that *M. enterolobii* will cause yield losses similar to *M. incognita*, *M. javanica* and *M. arenaria* which are well established in large parts of the PRA-area (CABI, 2007). For example, the potential effect of *M. incognita* on field crop yield is large (usually about 20% but crop losses up to 100% have been noted) as shown by various experiments (e.g. CABI, 2007; Russo *et al.*, 2007).

In southern parts of the EPPO region, where the outdoor climate is suitable for development and survival of *M. enterolobii*, damage levels as a result of *M. enterolobii* infestations in field crops may be similar to those noted in the pest's current area of distribution (see above). It should also be noted that the *Mi*-resistance gene, which has been introduced in many cultivated tomato varieties (Zoon *et al.*, 2004), would be of no use against *M. enterolobii* infestations. It should be noted that at higher temperatures the *Mi* resistance gene is also not effective against root-knot nematodes.

In general plant-parasitic nematodes are very difficult to control.
In production places where resistant cultivars are used to control other root-knot nematodes, or in places of production where no root-knot nematodes occur and no chemical treatment is carried out, the increase in production costs is likely to be major.
When chemical treatments are already applied to control other root-knot nematode species, increase in production costs is likely to be minimal.

Considering the broad host range including economically important crops like tomato, sweet pepper and eggplant, and the impact of *Meloidogyne* infestations in general, the economic impact of establishment of *M. enterolobii* is assessed to be large for the entire EPPO region.

## CONCLUSIONS OF PEST RISK ASSESSMENT

| | |
|---|---|
| **Summarize the major factors that influence the acceptability of the risk from this pest:** | The pest can establish in the PRA area and cause economic damage. Nematodes are difficult to control. |
| **Estimate the probability of entry:** | Probability of entry is considered high taking into account the likelihood of association and concentration of the pest at origin with the pathway, the volumes of trade and frequency, the likelihood to survive and to remain undetected. Almost all component of entry potential have been rated high.<br>If imported infested plants are subsequently grown in a (greenhouse or field) nursery, this will aid transfer to a suitable host. If plants are for final consumers as pot plants the risk of transfer to suitable hosts is lower. Outbreaks of the pest have been recorded in the PRA area (Switzerland, France) demonstrating that entry is possible. |
| **Estimate the probability of establishment:** | The pest presents a risk of establishment in the EPPO region. Outdoor establishment is likely in the southern part of the region. The pest may also survive in the northern part of the region but temperature is less favourable for tropical root-knot nematodes. Establishment under protected conditions is possible in all parts of the region. |
| **Estimate the potential economic impact:** | Economic impact is likely to be higher than for other root-knot nematodes as it produces bigger galls (which can be correlated with reduction of crop yields). An important economic impact is noted in two glasshouses in Switzerland where it has been detected in tomato and cucumber production Also the ability of this nematode species to overcome root-knot nematode resistance genes in economically important crops may increase its economic impact. |
| **Degree of uncertainty** | Major uncertainties<br>– Origin of the pest (this is being investigated)<br>– Host range of the pest, in particular the importance of |

monocotyledon hosts (this is being investigated) and potato.
- How the pest was introduced in Brittany and Switzerland
- Transfer from ornamental plants (considered by the EWG to be the most likely pathway) to vegetable crops such as tomato and cucumber.

Other uncertainties
- Distribution of the pest in the EPPO region
- Uncertainty on the prevalence and cultivation practices in nurseries or production areas in the countries where the pest is present.
- Temperature requirements of the pest (being investigated) and adaptability
- Actual use of root-knot nematode resistant cultivars (this is important given that is not an option to control this nematode)
- Crop rotation possibilities
- Interception of Meloidogyne species (could they be *M. enterolobii?)*
- Efficacy of nematicides against *M. enterolobii*
- Yield losses on crops of importance in the EPPO region
- Economic data (costs for control, crop losses…)

**OVERALL CONCLUSIONS** **The pest is an appropriate candidate for the management stage.**

## STAGE 3: PEST RISK MANAGEMENT

### IDENTIFICATION OF THE PATHWAYS

**Pathways studied in the pest risk management**

- Host plants for planting (including cuttings) with roots (with or without soil)
- Non-host plants for planting with soil attached
- Plant products that may have soil attached (such as tubers, bulbs or rhizomes);
- Soil attached to equipment and machinery;
- Travellers;
- Soil as such.

Plants for planting are the most important pathway.
In case importation of soil would be allowed this could also be an important pathway.

The following pathways present a low risk:
- Plant products that may have soil attached (such as tubers, bulbs or rhizomes);
- Equipment and machineries;
- Passengers.

**Other pathways identified but not studied** None

**Pathway 1: Host plants for planting (including cuttings) with roots (with or without soil);**

*Measures related to consignments:*

No measures identified (testing of plants a standalone measure was not considered practical)

*Measures related to the crop or to places of production:*

The plants should be grown for their whole life in protected conditions meeting the following growing conditions:

- artificial or disinfested growing medium should be used and no direct contact of the plant growing media with the soil should be guaranteed
- plants for planting free from the nematode should be used as a start
- exclusion of reinfestation by controlling irrigation water
- visual inspection of plants root.

The plants should have been grown in a pest-free area following ISPM No. 4 *Requirements for the establishment of pest-free areas* or in a pest-free place of production following ISPM No.10 *Requirements for the establishment of pest-free places of production and pest-free production sites*.
For pest free places of production, hygienic measures should be applied to avoid reinfestation.

- **Pathway 2: Non host plants for planting with soil attached**

*Measures related to consignments:*
Freedom from soil.

*Measures related to the crop or to places of production:*
The plants should have been grown in a pest-free area following ISPM No. 4 *Requirements for the establishment of pest-free areas* or in a pest-free place of production following ISPM No.10 *Requirements for the establishment of pest-free places of production and pest-free production sites*.

- **Pathway 3: Plant products that may have soil attached (such as tubers, bulbs or rhizomes)**

*Measures related to consignments:*
Tubers, bulbs or rhizomes should be cleaned (brushing or washing) in order to be practically free from soil.

*Measures related to the crop or to places of production:*
The plants should be grown for their whole life in protected conditions meeting the following growing conditions:

- artificial or disinfested growing medium should be used
- exclusion of reinfestation by controlling irrigation water

The plants should have been grown in a pest-free place of production or pest-free area. For crop freedom and pest-free places of production, hygienic measures should be applied to avoid reinfestation.

- **Pathway 4: Soil as such**

Note: the import of soil is prohibited in many countries of the EPPO region
*Measures related to consignments:*
Testing of soil or soil sterilization is in principle possible but was not considered practical.

*Measures related to the crop or to places of production:*
Soil should originate from a pest-free place of production or a pest-free area.
Pest freedom can be verified by testing the site of production from where the soil will be taken.

- **Pathway 5: Soil attached to equipment and machinery**

Cleaning of equipment and machinery

- **Pathway 6: Passengers**

Publicity to enhance public awareness on pest risks, fines or incentives. Treatments may also be possible (cleaning of shoes).

***Other possible measures***
No effective measures were identified in the importing country (*M. enterolobii* is very likely to survive eradication programmes outdoors).

**EVALUATION OF THE MEASURES IDENTIFIED IN RELATION TO THE RISKS PRESENTED BY THE PATHWAYS**
Pest-free areas or pest-free place of productions are common phytosanitary measures for plants for planting, which are required for other nematodes.

Freedom from soil for plant products is also a common measure.
The measures envisaged interfere with trade but not unduly. It is not envisaged to close the pathway.

| | |
|---|---|
| **Degree of uncertainty** | Uncertainties in the management part are:<br>Potential for disruption in the plants for planting trade supply due to phytosanitary measures could not be estimated |

**CONCLUSION:**
**Recommendation for possible measures:**
**PC= Phytosanitary certificate, RC=Phytosanitary certificate of re-export**

| | |
|---|---|
| **Pathway 1: Host plants for planting (including cuttings) with roots (with or without soil)** | PC and, if appropriate, RC<br>• Plants should have been produced in a Pest free area for *M. enterolobii*<br>or<br>• Plants should have been produced in a Pest free place of production for *M. enterolobii*<br>*or*<br>• Plants should have been produced under protected cultivation |

| | |
|---|---|
| **Pathway 2: Non host plants for planting with soil attached** | PC and, if appropriate, RC<br>• Soil should be removed<br>or<br>• Plants should have been produced in a Pest free area for *M. enterolobii*<br>or<br>• Plants should have been produced in a Pest free place of production for *M. enterolobii* |

| | |
|---|---|
| **Pathway 3** Plant products that may have soil attached (such as tubers, bulbs or rhizomes) | PC and, if appropriate, RC<br>• Plant products should be practically free from soil<br>or<br>• Plant products should have been produced in a Pest free area for *M. enterolobii*<br>*or*<br>• Plant products should have been produced in a Pest free place of production for *M. enterolobii*<br>*or*<br>• Plants products should have been produced under protected cultivation (see above) |

| | |
|---|---|
| **Pathway 4:** Soil as such | PC and, if appropriate, RC<br>• Soil should originate from a pest-free area<br>or<br>• Soil should originate from a pest-free place of production |

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|---|---|
| **Pathway 5:** Soil attached to equipment and machinery | Cleaning of equipment and machinery |

| | |
|---|---|
| **Pathway 6:** Passengers | Publicity to enhance public awareness on pest risks, fines or incentives.<br>Cleaning of shoes |

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**Appendix 1**

**Distribution of *Meloidogyne enterolobii* Yang et Eisenback, 1983**

| Continent | Country | Location | Reference |
|---|---|---|---|
| **Africa** | **Senegal** | Bambylor | Diop, 1994; Trudgill *et al.*, 2000 |
| | | Keur Yerim | Diop, 1994 |
| | | Keur Ngoor | Diop, 1994 |
| | | Dakar | Diop, 1994 |
| | | Touba N'Diayc | Diop, 1994 |
| | | Mboro Nkage | Diop, 1994 |
| | | Fas Boye | Diop, 1994 |
| | | Mbodjene | Diop, 1994 |
| | | SE Gaouane | Diop, 1994 |
| | | ISRA St Louis | Diop, 1994 |
| | | Ndiol | Diop, 1994 |
| | | Ntiago | Diop, 1994 |
| | **South Africa** | Nelspruit | Willers, 1997a |
| | **Ivory Coast** | *Man**** | Fargette, 1987; Fargette *et al.*, 1994; Block *et al.*, 2002; |
| | **Burkina Faso** | *Bobo Dioulasso**** | Fargette *et al.*, 1994; Trudgill *et al.*, 2000; Block *et al.*, 2002; |
| | | *Ouagadougou**** | Fargette *et al.*, 1994; Trudgill *et al.*, 2000; Blok *et al.*, 2002 |
| | **Malawi** | Blantyre | Trudgill *et al.*, 2000 |
| | | Karonga | Trudgill *et al.*, 2000 |
| | | Kasungu | Trudgill *et al.*, 2000 |
| | | Lilongwe | Trudgill *et al.*, 2000 |
| | | Machinga | Trudgill *et al.*, 2000 |
| | | Mzuzu | Trudgill *et al.*, 2000 |
| | | Salima | Trudgill *et al.*, 2000 |
| | **Togo** | | Fargette, 1987 |
| **North America** | | | |
| | **USA** | | |
| | | **Florida** | |
| | | Alachua | Brito *et al.*, 2004(d); Brito *et al.*, 2007b |
| | | Broward | Brito *et al.*, 2004(a); Brito *et al.*, 2007(b); Cetintas *et al.*, 2007; Cetintas *et al.*, 2008; Kaur *et al.*, 2007 |
| | | Dade | Brito *et al.*, 2004(a) Brito *et al.*, 2004(d); Brito *et al.*, 2007(b); Brito & Inserra, 2008; Cetintas *et al.*, 2008 |
| | | Gilchrist | Brito *et al.*, 2004(d) |

| Continent | Country | Location | Reference |
|---|---|---|---|
| | | Hendry | Brito *et al.*, 2004(d); Brito *et al.*, 2007(a) Centintas *et al.*, 2008 |
| | | Hillsborough | Levin, 1995 |
| | | Lee | Levin, 1995 |
| | | Martin | Brito *et al.*, 2004(a) |
| | | Nassau | Brito *et al.*, 2004(a); Brito *et al.*, 2007(b) |
| | | Palm Beach | Brito *et al.*, 2004(a); Brito *et al.*, 2007(a); Cetintas *et al.*, 2008 |
| | | Putman | Brito & Inserra, 2008 |
| | | St. Lucie | Brito *et al.*, 2004(d) |
| | | **Puerto Rico** | |
| | | Jobos | Ramah et Hirschmann, 1988; |
| | | Isabella | Ramah et Hirschmann, 1988; |
| **Central America** | | | |
| | **Cuba** | Oriente | Decker & Rodriguez Fuentes, 1989, Rodrigues *et al.*, 1995 b; Rodrigues *et al.*, 2003 |
| | | Franco | Molinari *et al.*, 2005 |
| | Guadeloupe*** | | IRD, 2006; Rammah & Hirschmann, 1988; |
| | **Guatemala** | Don Bosco, Coban | Decker & Rodriguez Fuentes, 1989; Carneiro *et al.*, 2000; Hernandes *et al.*, 2004 |
| | **Martinique** | *Le Lamentin* | Carneiro *et al.*, 2000; IRD, 2006; |
| | **Trinidad and Tobago** | St George | Trudgill *et al.*, 2000 |
| | | St Andrew | Trudgill *et al.*, 2000 |
| | | Caroni | Trudgill *et al.*, 2000 |
| | | Nariva | Trudgill *et al.*, 2000 |
| | | Mayaro | Trudgill *et al.*, 2000 |
| | | Victoria | Trudgill *et al.*, 2000 |
| | | St Patrick | Trudgill *et al.*, 2000 |
| | | Tobago | Trudgill *et al.*, 2000 |
| **South America** | | | |
| | **Brazil** | **Bahia** | |
| | | Curaçá | Carneiro *et al.*, 2001 |
| | | Maniçoba | Carneiro *et al.*, 2001 |
| | | **Ceará** | |
| | | Limoeiro do Norte | Torres *et al.* 2005 |
| | | **Maranhão** | |
| | | Vila Maranhão | Silva *et al.* 2008 |
| | | **Mato Grosso** | |
| | | Chapada dos Guimães | Almeida *et al.* 2008 |
| | | **Paraná** | |
| | | Santa Mariana | Carneiro *et al.*, 2006 |

| Continent | Country | Location | Reference |
|---|---|---|---|
| | | **Pernambuco** | |
| | | Petrolina | Carneiaro *et al.*, 2001 |
| | | **Piaui** | |
| | | Distrito Irrigado | Silva *et al.*, 2008 |
| | | **Rio Grande do Norte** | |
| | | Touros | Torres *et al.*, 2004 |
| | | **Rio Grande do Sul** | |
| | | Roca sales | Gomes *et al.*, 2008 |
| | | **Rio de Janeiro** | Carneiro, 2003 |
| | | Campos dos Goyatacaces | Lima *et al.*, 2005 |
| | | São João da Barra | Lima *et al.*, 2003; Souza *et al.*, 2006 |
| | | **Santa Catarina** | |
| | | Santa Rosa do Sul | Gomes *et al.*, 2008 |
| | | Içara | Gomes *et al.*, 2008 |
| | | **São Paulo** | |
| | | Garça | Buenno *et al.*, 2007 |
| | | Pirajui | Carneiro *et al.*, 2006 |
| | | Santa Cruz do Rio Pardo | Carneiro *et al.*, 2006 |
| | | Campos Novos Paulista | Carneiro *et al.*, 2006 |
| | | **Minas Gerais** | Torres *et al.*, 2005 |
| | **Venezuela** | **Lara State**** | Perichi *et al.*, 2006 |
| | | **Zulia State** | |
| | | Mara | Molinari *et al.*, 2005; Lugo *et al.*, 2005 |
| **Asia** | **China** | Hainan | Yang & Eisenback, 1983; Xu *et al.*, 2004 |
| | **Vietnam** | Southern Vietnam*** | Iwahori *et al.*, 2009 |
| **Europe** | | | |
| | **France** | Concarneau* | Blok *et al.*, 2002; |
| | **Switzerland** | **Aargau**+ | Kiewnick *et al.*, 2008 |
| | | **Lucerne**+ | Kiewnick *et al.*, 2008 |

*Plastic tunnel    **Capital of the States    ***no detailed information on location

+ Glasshouse

**Appendix 2**

The currently known (experimental) host plants for *M. enterolobii* include the following (those in bold are present in the EPPO region; *indicates species known to be introduced as an ornamental plant):

| Scientific name | Common name | Reference(s) |
|---|---|---|
| ***Angelonia angustifolia**** | Monkey face | Kaur *et al.*, 2006 |
| *Acacia seyal* | Whistling thorn | Duponnois *et al.*, 1997 |
| *Acacia holosericea* | Candelabra wattle | Duponnois *et al.*, 1997 |
| ***Ajuga reptans*** | Ajuga | Brito *et al.*, 2004a |
| ***Apium graveolens var. dulce*** | Celery | Brito *et al.*, 2004c |
| ***Beta vulgaris*** | Beet | Brito *et al.*, 2004c |
| ***Bidens alba*** | Spanish needle | Brito *et al.*, 2004c |
| ***Bidens pilosa*** | Spanish needle | Willers, 1997a |
| *Brachychyton sp.* | | NPPO of the Netherlands, finding 2006 |
| ***Brassica oleracea* var. *botrytis*** | Broccoli | Brito *et al.*, 2004c |
| ***Brugmansia* 'Sunray'** | Angel trumpet | Brito *et al.*, 2004a |
| ***Cactus sp.**** | Crimson Cactus | Brito *et al.*, 2004c NPPO of the Netherlands, finding 1991 |
| ***Callistemon citrinus*** | Bottlebrusth | Brito *et al.*, 2004a |
| ***Callistemon viminalis*** | Weeping bottlebrush | Levin, 2005 |
| *Canavalia ensiformis* | Horsebean | Brito *et al.*, 2004c |
| ***Capsicum annuum*** | Bell pepper | Brito *et al.*, 2004a; Yang & Eisenback, 1983, Kiewnick *et al.*, 2009 |
| ***Citrullis lanatus*** | Watermelon | Rammah & Hirschmann, 1988 |
| ***Citrullis vulgaris*** | Watermelon | Yang & Eisenback, 1983 |
| ***Clerodendrum ugandense**** | Glorybower | Brito *et al.*, 2004a |
| *Coffea arabica* | Coffee | Rodriguez *et al.*, 1995a & b; Decker & Rodriguez Fuentes, 1989 |
| *Crotalaria juncea* | Sunn hemp | Guimaraes *et al.*, 2003 |
| ***Cucumis sativus*** | Cucumber | Kiewnick *et al.*, 2008 |
| ***Cucurbita sp.*** | Pumpkin | Brito *et al.*, 2004c |
| *Enterolobium contortisiliquum* | Pacara earpod tree | Yang & Eisenback, 1983 |
| *Faidherbia albida* | Ana tree | Duponnois *et al.*, 1997 |
| *Fatoua villosa* | Hairy crabweed | Brito *et al.*, 2004a |
| ***Ficus sp.*** | Ficus | NPPO of the Netherlands, finding 1999 |
| ***Gossypium hirsutum* L.** | Cotton | Yang & Eisenback, 1983 |
| ***Ipomoea batatas*** | Sweet potato | Brito *et al.*, 2004c |
| ***Lantana sp.*** | Lantana | Brito *et al.*, 2004a |
| ***Ligustrum sp.*** | | NPPO of the Netherlands, finding 2004 |
| ***Lycopersicon esculentum*** | Tomato | Brito *et al.*, 2004a, 2004b, 2004c; Guimaraes *et al.*, 2003; Yang & Eisenback, 1983; Kiewnick *et al.*, 2008 |
| ***Maranta arundinacea* L.** | arrowroot | Zhuo et al., 2009 |
| ***Myrica cerifera*** | Wax myrtle | Brito *et al.*, 2004a |
| ***Nicotiana tabacum*** | Tobacco | Rammah & Hirschmann, 1988, Yang & Eisenback, 1983 |
| ***Ocimum sp.*** | Basil | Brito *et al.*, 2004a |
| ***Petroselinum crispum*** | Parley | Brito *et al.*, 2004c |
| ***Phaseolus vulgaris*** | Bean | Guimaraes *et al.*, 2003 |
| ***Poinsettia cyathophora*** | Wild poinsettia | Brito *et al.*, 2004a |
| *Psidium guajava* | Guave | Torres *et al.*, 2004 & 2005; |

| | | |
|---|---|---|
| | | Guimaraes *et al.*, 2003; Brito *et al.*, 2004a; Carneiro *et al.*, 2001 |
| *Psidium guineense* | Brazilian guave | Maranhao *et al.*, 2003 |
| ***Rosa sp.*** | Rose | NPPO of the Netherlands, finding 2006 + 2007 |
| ***Solanum americanum*** | American black nightshade | Brito *et al.*, 2004a |
| ***Solanum melongena*** | Egg plant | Brito *et al.*, 2004a; Rammah & Hirschmann, 1988; Kiewnick, 2009 (unpublished) |
| ***Solanum tuberosum**** | Potato | Rodriguez *et al.* (2003) |
| ***Solenostemon scutellarioides*** | Coleus | Levin 2005 |
| *Syagrus romanzoffiana* | Queen palm | Levin, 2005 |
| *Syngonium sp.* | Syngonium | NPPO of the Netherlands, finding 1993 + 1994 |
| *Tecomaria capensis* | Cape honeysuckle | Brito *et al.*, 2004a |
| *Tibouchina* 'Compacta' | Glory bush | Brito *et al.*, 2004a |
| *Tibouchina elegans* | Glory bush | Brito *et al.*, 2004a |
| ***Vigna unguiculata*** | Cowpea | Guimaraes *et al.*, 2003 |
| ***Vitis sp.*** | Grape | NPPO of the Netherlands, finding 2007 |

*never observed on tubers

The experimental host plants being present in the EPPO region for *M. enterolobii* include the following

| | | |
|---|---|---|
| *Brassica oleracea* var. *sylvestris* | Broccoli | Brito *et al.*, 2004c; Kiewnick, 2009 unpublished |
| *Brassica oleracea* var. *botrytis* | Cauliflower | Kiewnick, 2009 unpublished (poor host) |
| *Brassica oleracea* L. convar. *Acephala* | German Turnip | Kiewnick, 2009 unpublished (poor host) |
| *Brassica oleracea* L. convar. *capitata* L. | Chou de Milan (Wirsing) | Kiewnick, 2009 unpublished |
| *Brassica rapa ssp. pekinensis* (Lour.) | Chinese cabbage | Kiewnick, 2009 unpublished (poor host) |
| *Curcurbita pepo ssp. pepo* | Zucchini, Courgette | Kiewnick, 2009 unpublished |
| *Lactuca sativa L.* | Iceberg Lettuce | Kiewnick, 2009 unpublished |
| *Lactuca sativa var. crispa* | Baby leaf lettuce | Kiewnick, 2009 unpublished |
| *Lactuca sativa var.longifolia (LAM.) Helm* | Lattich | Kiewnick, 2009 unpublished |

**Appendix 4**

Distribution of sandy soils such as arenosols (beige) and calcisols (yellow).