Nematode Threats in the NAQS Region

(Photo by Tesfa Mekete)

Mike Hodda, Natalie Banks & Sunil Singh

October, 2012
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<td>64</td>
</tr>
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<td>Calopogonium mucunoides</td>
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</tr>
<tr>
<td>Camellia sinensis (tea)</td>
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</tr>
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<td>Capsicum spp. (chilli, capsicum etc.)</td>
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<td>Carica papaya (pawpaw)</td>
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<td>Celosia argentea (cock's comb)</td>
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<tr>
<td>Citrullus lanatus (watermelon)</td>
<td>65</td>
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<tr>
<td>Citrus spp.</td>
<td>65</td>
</tr>
<tr>
<td>Cocos nucifera (coconut)</td>
<td>66</td>
</tr>
<tr>
<td>Coffea sp. (coffee)</td>
<td>66</td>
</tr>
<tr>
<td>Colocasia esculenta (taro)</td>
<td>66</td>
</tr>
<tr>
<td>Coriandrum sativum (coriander)</td>
<td>66</td>
</tr>
<tr>
<td>Cucurbitaceae spp. (cucumber, pumpkin, squash etc.)</td>
<td>66</td>
</tr>
<tr>
<td>Dimocarpus longan (longan)</td>
<td>67</td>
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<tr>
<td>Dioscorea spp.</td>
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<td>Dracaena spp.</td>
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<td>Elettaria cardamomum (cardamom)</td>
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<td>68</td>
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<td>Ipomoea spp.</td>
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<td>Lactuca spp.</td>
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<td>Litchi chinensis (lychee)</td>
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<td>Manihot esculenta (cassava)</td>
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<td>Manilkara zapota (sapodilla)</td>
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<td>Momordica charantia (bitter melon)</td>
<td>69</td>
</tr>
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<td>Morus spp. (mulberry)</td>
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<tr>
<td>Musa spp. (banana &amp; plantain)</td>
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<tr>
<td>Nephelium lappaceum (rambutan)</td>
<td>70</td>
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Abbreviations and Acronyms

ASEAN countries..................Association of Southeast Asian Nations: Myanmar, Cambodia, Lao PDR, Vietnam, Thailand, Brunei Darussalam, Malaysia, Singapore, Philippines, but herein excluding Indonesia because it is included in the NAQS countries.

NAQS countries ..................Indonesia, Timor Leste, & Papua New Guinea. For the purposes of this report the Solomon Islands are included because of data availability and proximity to the NAQs region.

CABI..................................Centre for Agricultural Bioscience International
EPPO...................................European and Mediterranean Plant Protection Organisation
IPPC ..................................International Plant Protection Convention
NAQS.................................Northern Australia Quarantine Strategy
NEMABASE.........................University of California Davis Department of Nematology Nematode Hosts Database
PNG....................................Papua New Guinea
SPC ....................................Secretariat of the Pacific Community
Summary

Nematode pests are of considerable economic importance but their status in the countries to the north of Australia is poorly known. In June, 2012, the Northern Australia Quarantine Strategy group (NAQS) of the Department of Agriculture, Fisheries and Forestry (DAFF) commissioned this review of available information on the nematodes from the countries bordering northern Australia to identify any agriculturally important nematodes present in the region which may represent threats to Australian biosecurity.

This review examines the following factors relevant to the risk of entry into Australia (especially into Northern Australia) by plant-parasitic nematodes:

- Presence in the NAQS region of interest as well as in the ASEAN region more broadly, together with absence from Australia;
- Commonly grown host plants in above regions;
- Pathways used to move; and
- Impact (defined here as causing documented economic damage).

The review is based on examination of formally- and informally-published, peer-reviewed and unreviewed literature, public databases from reputable centres of nematology expertise, opinions and data provided by national experts, as well as unpublished datasets.

Key findings

Records of nematodes from NAQS region countries are sparse, and certainly underrepresent the nematodes actually present. Records from the ASEAN countries are more extensive, but still omit species which may be of concern. Data on pathways and hosts in both regions are also sparse.

Nematode threats can be categorized into 4 groups based on currently available data.

- 8 species which fulfilled all criteria to be risks fully and thus were considered the **greatest threats**.
- 11 species which fulfilled all criteria except one, and hence were considered **probable threats**, because they:
  - have not been recorded in the NAQS region countries, but are present in the ASEAN region immediately to the north; or
  - have been recorded from Australia, but have very restricted distributions or only some host races present within Australia; or
  - have not been proven pathogenic to plants.
- 6 species which could fulfil all criteria if races currently recognised as differing in host range or pathogenicity are distributed differently in Australia and the NAQS countries, but where there have been no investigations of whether this is the case. Hence these species were considered **possible threats**.
- 75 species which are known from the ASEAN region countries but fulfilled only some criteria and hence were considered **low threats**.
The crops most likely to host nematodes which were identified as threats were *Solanum* spp., *Zea mays*, *Oryza* spp. and *Cucurbitaceae* spp. (Table 5, p18). Other crops hosting many of the nematode threats were *Capsicum* spp., *Citrus* spp. and *Sorghum* spp. Other crops hosting many of the nematodes identified as threats were *Allium cepa*, *Coffeea* spp. and *Saccharum officinarum*.

Many of the greatest threats had relatively narrow host ranges among the crops investigated, which may allow targeting for surveillance. Although the host ranges may have been narrow botanically, most of the hosts were widely distributed and common, meaning that potential spread and impact are great. Many of the other nematode threats identified had a wide range of crops as hosts, as well as widely distributed and common hosts.

Significantly, many of the nematodes identified as the greatest or probable threats had host ranges including *Triticum aestivum* (wheat) and *Glycine max* (soy bean). These species are commercial crops grown outside the NAQS region of Australia, and so are not considered in detail in this review, but the fact that they are damaged by some of the nematode threats identified increases the potential negative impact of introduction of the nematodes concerned. That is, their impact may be greatest in parts of Australia outside the NAQS region.

The pathways most likely to carry damaging nematodes in the region were soil and plants or plant parts.

**Nematode species identified as threats**

**Greatest proven threats:**


**Probable threats:**

- *Ditylenchus destructor*, *Meloidogyne enterolobii*, *Meloidogyne naasi*, *Meloidogyne thailandica*, and *Radopholus arabocoffeae* (recorded in ASEAN countries but not NAQS countries);
- *Globodera rostochiensis*, *Longidorus elongatus*, *Meloidogyne exigua*, *Radopholus similis*, and *Xiphinema americanum* sensu lato (restricted distribution or limited number of host races in Australia).
- *Radopholus bridgei* (pathogenicity not demonstrated).

**Possible threats:**

- *Meloidogyne arenaria*, *Meloidogyne hapla*, *Meloidogyne incognita*, *Meloidogyne javanica*, *Pratylenchus coffeae*, and *Pratylenchus zeae* (recorded from NAQS countries and Australia, but have races or pathotypes differing in hosts and pathogenicity which are of biosecurity significance although these have not been investigated and hence their distributions in the NAQS countries and Australia are unknown).

**Low threats:**

- 73 species as listed in Table 4.
Table 1. Greatest nematode threats.

<table>
<thead>
<tr>
<th>Species</th>
<th>Country</th>
<th>Common crop hosts</th>
<th>Pathways</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ditylenchus angustus</em></td>
<td>Indonesia</td>
<td><em>Oryza</em> spp. (rice)</td>
<td>Plants or Plant Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Corns, Rhizomes &amp; Tubers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seedlings &amp; Nursery Stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flower &amp; Ornamental Plants</td>
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<td></td>
<td></td>
<td>Bulbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seeds</td>
</tr>
<tr>
<td><em>Globodera pallida</em></td>
<td>Indonesia</td>
<td><em>Solanum</em> spp. (potato, aubergine, tomato etc.)</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Plants or Plant Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Corns, Rhizomes &amp; Tubers</td>
</tr>
<tr>
<td><em>Heterodera glycines</em></td>
<td>Indonesia</td>
<td><em>Beta vulgaris</em> (beetroot)</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Cucurbitaceae</em> spp. (cucumber, pumpkin, squash etc.)</td>
<td>Roots and Rootstock</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Glycine max</em> (soybean)</td>
<td>Seedlings &amp; Nursery Stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Vigna</em> spp. (bean)</td>
<td>Plants or Plant Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Zea mays</em> (maize)</td>
<td></td>
</tr>
<tr>
<td><em>Heterodera zeae</em></td>
<td>Indonesia</td>
<td><em>Bambusa</em> spp. (bamboo)</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Capsicum</em> spp. (chilli, capsicum etc.)</td>
<td>Roots and Rootstock</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Citrus</em> spp.</td>
<td>Seedlings &amp; Nursery Stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Oryza</em> spp. (rice)</td>
<td>Plants or Plant Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Saccharum officinarum</em> (sugarcane)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Solanum</em> spp. (potato, aubergine, tomato etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Sorghum</em> spp. (sorghum)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Triticum</em> spp. (wheat)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Zea mays</em> (maize)</td>
<td></td>
</tr>
<tr>
<td><em>Hirschmanniella miticausa</em></td>
<td>PNG, Solomons</td>
<td><em>Colocasia</em> (taro)</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Plants or Plant Parts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Corns, Rhizomes &amp; Tubers</td>
</tr>
<tr>
<td><strong>Hirschmanniella oryzae</strong></td>
<td>Indonesia, Malaysia, Myanmar, Philippines, Thailand, Vietnam</td>
<td><em>Abelmoschus</em> spp. (aibika, okra etc.)&lt;br&gt;<em>Oryza</em> spp. (rice)&lt;br&gt;<em>Saccharum officinarum</em> (sugarcane)&lt;br&gt;<em>Solanum</em> spp. (potato, aubergine, tomato etc.)&lt;br&gt;<em>Sorghum</em> spp. (sorghum)&lt;br&gt;<em>Triticum</em> spp. (wheat)&lt;br&gt;<em>Zea mays</em> (maize)</td>
<td>Plants or Plant Parts&lt;br&gt;Corms, Rhizomes &amp; Tubers&lt;br&gt;Seedlings &amp; Nursery Stock&lt;br&gt;Seeds</td>
</tr>
<tr>
<td><strong>Meloidogyne graminicola</strong></td>
<td>Indonesia</td>
<td><em>Allium cepa</em> (onion)&lt;br&gt;<em>Brassica</em> spp. (cabbage, broccoli etc.)&lt;br&gt;<em>Glycine max</em> (soybean)&lt;br&gt;<em>Oryza</em> spp. (rice)&lt;br&gt;<em>Solanum</em> spp. (potato, aubergine, tomato etc.)&lt;br&gt;<em>Sorghum</em> spp. (sorghum)&lt;br&gt;<em>Triticum</em> spp. (wheat)&lt;br&gt;<em>Zea mays</em> (maize)</td>
<td>Soil&lt;br&gt;Plants or Plant Parts&lt;br&gt;Flower &amp; Ornamental Plants&lt;br&gt;Roots and Rootstock</td>
</tr>
<tr>
<td><strong>Radopholus citri</strong></td>
<td>Indonesia</td>
<td><em>Citrus</em> spp.</td>
<td>Soil&lt;br&gt;Roots and Rootstock&lt;br&gt;Seedlings &amp; Nursery Stock&lt;br&gt;Plants or Plant Parts</td>
</tr>
</tbody>
</table>
Table 2. Probable nematode threats.

<table>
<thead>
<tr>
<th>Species</th>
<th>Basis of Threat Rating*</th>
<th>Location in Region</th>
<th>Common Hosts in Region</th>
<th>Pathways</th>
</tr>
</thead>
</table>
| *Ditylenchus destructor*     | A                       | Malaysia**         | *Solanum* spp. (potato, aubergine, tomato etc.)  
Ipomoea batatas (sweet potato)  
Bulbs                                                                | Soil  
Plants or Plant Parts  
Corms, Rhizomes & Tubers  
Bulbs  
Seeds                                                                |
| *Globodera rostochiensis*    | RD                      | Indonesia          | *Solanum* spp. (potato, aubergine, tomato etc.)                                        | Soil  
Plants or Plant Parts  
Corms, Rhizomes & Tubers                                                                |
| *Longidorus elongatus*       | D                       | Vietnam            | *Allium cepa* (onion)  
*Arachis hypogaea* (peanut)  
*Beta vulgaris* (beetroot)  
*Brassica* spp. (cabbage, broccoli etc.)  
*Cucurbitaceae* spp. (cucumber, pumpkin, squash etc.)  
*Ficus* spp. (figs)  
*Lactuca* spp.  
*Phaseolus vulgaris* (haricot bean)  
*Rosa* spp. (rose)  
*Solanum* spp. (potato, aubergine, tomato etc.)  
*Vitis* spp. (grape)  
*Zea mays* (maize)                                                                | Soil  
Plants or Plant Parts  
Corms, Rhizomes & Tubers  
Bulbs  
Flower & Ornamental Plants                                                                |
| *Meloidogyne enterolobii*    | A                       | Vietnam            | *Capsicum* spp. (chilli, capsicum etc.)  
* Coffea* spp. (coffee)  
*Cucurbitaceae* spp. (cucumber, pumpkin, squash etc.)  
*Psidium guajava* (guava)  
*Solanum* spp. (potato, aubergine, tomato etc.)                                                                | Soil  
Plants or Plant Parts  
Roots and Rootstock  
Flower & Ornamental Plants                                                                |
<table>
<thead>
<tr>
<th>Nematode</th>
<th>Scale</th>
<th>Country</th>
<th>Plants or Plant Parts</th>
<th>Soil Plants or Plant Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meloidogyne naasi</td>
<td>A</td>
<td>Thailand</td>
<td><em>Allium cepa</em> (onion) <em>Beta vulgaris</em> (beetroot) <em>Oryza</em> spp. (rice) <em>Solanum</em> spp. (potato, aubergine, tomato etc.) <em>Sorghum</em> spp. (sorghum)</td>
<td>Plants or Plant Parts Roots and Rootstock Flower &amp; Ornamental Plants</td>
</tr>
<tr>
<td>Meloidogyne thailandica</td>
<td>A</td>
<td>Thailand</td>
<td><em>Zingiber officinale</em> (ginger)</td>
<td>Plants or Plant Parts Roots and Rootstock Flower &amp; Ornamental Plants</td>
</tr>
<tr>
<td>Radopholus arabocoffeae</td>
<td>N</td>
<td>Vietnam</td>
<td><em>Coffea</em> spp. (coffee)</td>
<td>Plants or Plant Parts Seedlings &amp; Nursery Stock</td>
</tr>
<tr>
<td>Radopholus bridgei</td>
<td>P</td>
<td>Indonesia</td>
<td><em>Curtica zedoaria</em> (turmeric)† <em>Anubias</em> sp., <em>Echinodores</em> sp., <em>Ophiopogon</em> sp (Aquarium plants)‡</td>
<td>Plants or Plant parts Roots and Rootstock Flower and Ornamental Plants Aquarium plants</td>
</tr>
</tbody>
</table>
| Radopholus similis | PNG, Solomon Islands, Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand | Abélmoschus spp. (aibika, okra etc.)
Ananas comosus (pineapple)
Arachis hypogaea (peanut)
Bambusa spp. (bamboo)
Beta vulgaris (beetroot)
Brassica spp. (cabbage, broccoli etc.)
Camellia sinensis (tea)
Capsicum spp. (chilli, capsicum etc.)
Citrullus lanatus (watermelon)
Citrus spp.
Cocos nucifera (coconut)
Coffeea sp. (coffee)
Cucurbitaceae spp. (cucumber, pumpkin, squash etc.)
Dioscorea spp.
Ficus spp. (figs)
Gardenia sp.
Glycine max (soybean)
Heliconia spp.
Hibiscus spp.
Ipomoea spp.
Lactuca spp.
Litchi chinensis (lychee)
Mangifera spp. (mango)
Momordica charantia (bitter melon)
Musa spp. (banana & plantain)
Persea americana (avocado)
Petroselinum crispum (parsley)
Phaseolus vulgaris (haricot bean)
Pinus spp. (pine)
Piper spp. (pepper)
Psidium guajava (guava)
Saccharum officinarum (sugarcane)
Solanum spp. (potato, aubergine, tomato etc.)
Sorghum spp. (sorghum)
Theobroma cacao (cacao)
Triticum spp. (wheat)
Vigna spp. (bean)
Zea mays (maize)
Zingiber officinale (ginger) | Soil
Plants or Plant Parts
Corms, Rhizomes & Tubers
Bulbs |
<table>
<thead>
<tr>
<th>Xiphinema americanum s.l.</th>
<th>R</th>
<th>Philippines, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allium cepa</strong> (onion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Arachis hypogaea</strong> (peanut)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bambusa</strong> spp. (bamboo)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Beta vulgaris</strong> (beetroot)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bougainvillea</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brassica</strong> spp. (cabbage, broccoli etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capsicum</strong> spp. (chilli, capsicum etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Citrus</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cocos nucifera</strong> (coconut)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coffeea</strong> sp. (coffee)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cucurbitaceae</strong> spp. (cucumber, pumpkin, squash etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ficus</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gardenia</strong> sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Glycine max</strong> (soybean)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hibiscus</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lactuca</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Litchi chinensis</strong> (lychee)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mangifera</strong> spp. (mango)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manilkara zapota</strong> (sapodilla)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Morus</strong> spp. (mulberry)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Musa</strong> spp. (banana &amp; plantain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nicotiana tabacum</strong> (tobacco)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oryza</strong> spp. (rice)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Passiflora</strong> spp. (passion fruit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Persea americana</strong> (avocado)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phaseolus vulgaris</strong> (haricot bean)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pinus</strong> spp. (pine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Psidium guajava</strong> (guava)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rhododendron</strong> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rosa</strong> spp. (rose)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Saccharum officinarum</strong> (sugarcane)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solanum</strong> spp. (potato, aubergine, tomato etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sorghum</strong> spp. (sorghum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Triticum</strong> spp. (wheat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vigna</strong> spp. (bean)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vitis</strong> spp. (grape)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Zea mays</strong> (maize)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Soil
Plants or Plant Parts
Corms, Rhizomes & Tubers
Bulbs
Flower & Ornamental Plants
*—A: present in ASEAN countries only; R: only some host or pathogenicity races present in Australia; D: Distribution very restricted in Australia; P: pathogenicity not proven

**—unconfirmed report (EPPO)

†— not on main crop host list, but included because native and widespread in Indonesia

‡—not on main crop host list, but included because of unusual pathway
Table 3. Possible nematode threats in NAQS countries.

<table>
<thead>
<tr>
<th>Species</th>
<th>Country</th>
<th>Percentage of hosts among crops investigated*</th>
<th>Pathways</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Meloidogyne arenaria</em></td>
<td>Indonesia, PNG, Solomons</td>
<td>60</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Flower and Ornamental Plants Seeds &amp; Nuts Sea-swept Plant Debris</td>
</tr>
<tr>
<td><em>Meloidogyne hapla</em></td>
<td>Indonesia, PNG</td>
<td>43</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Flower and Ornamental Plants Sea-swept Plant Debris</td>
</tr>
<tr>
<td><em>Meloidogyne incognita</em></td>
<td>Indonesia, PNG, Solomons</td>
<td>78</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Flower and Ornamental Plants Sea-swept Plant Debris</td>
</tr>
<tr>
<td><em>Meloidogyne javanica</em></td>
<td>Indonesia, PNG, Solomons</td>
<td>68</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Flower and Ornamental Plants Sea-swept Plant Debris</td>
</tr>
<tr>
<td><em>Pratylenchus coffeae</em></td>
<td>Indonesia, PNG, Solomons</td>
<td>55</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Seedlings and Nursery Stock Flower and Ornamental Plants Sea-swept Plant Debris</td>
</tr>
<tr>
<td><em>Pratylenchus zeae</em></td>
<td>Indonesia, PNG, Solomons</td>
<td>27</td>
<td>Soil Plants or Plant Parts Corms, Rhizomes &amp; Tubers Roots and Rootstock Flower and Ornamental Plants Seedlings and Nursery Stock Sea-swept Plant Debris</td>
</tr>
</tbody>
</table>

*—all nematode species identified as possible threats had a wide host range outside the crops investigated
Table 4. Low nematode threats.

| Aphelenchoides besseyi | Pratylenchus crenatus |
| Aphelenchoides fragariae | Pratylenchus delattrei |
| Aphelenchoides ritzemabosi | Pratylenchus flakkenensis |
| Aphelenchoides subtenuis | Pratylenchus goodeyi |
| Bitylenchus brevisetosus | Pratylenchus hexincisus |
| Bitylenchus dadius | Pratylenchus loosi |
| Bursaphelenchus mucronatus | Pratylenchus neglectus |
| Bursaphelenchus rainulfi | Pratylenchus penetrans |
| Bursaphelenchus singaporensis | Pratylenchus pinguicaudatus |
| Bursaphelenchus thailandiae | Pratylenchus pratensis |
| Cactodera cacti | Pratylenchus pseudopratensis |
| Ditylenchus dipsaci | Pratylenchus sudanensis |
| Helicotylenchus dihystera | Pratylenchus teres |
| Helicotylenchus microcephalus | Pratylenchus vulnus |
| Helicotylenchus multicinctus | Quinsulcius acutus |
| Helicotylenchus pseudorobustus | Quinsulcius capitatus |
| Helicotylenchus varicaudatus | Quinsulcius curvus |
| Heterodera avenae | Radopholus dariophilus |
| Heterodera cruciferae | Radopholus histrio |
| Heterodera fici | Rotylenchulus parvus |
| Heterodera oryzae | Scutellonema brachyurum |
| Heterodera sacchari | Scutellonema clathricaudatum |
| Heterodera schachtii | Scutellonema minutum |
| Heterodera trifolii | Trichodora cylindricus |
| Hemicriconemoides cocophilus | Tylenchorhynchus annulatus |
| Hemicriconemoides mangiferae | Tylenchorhynchus clarus |
| Hemicriconemoides strictathecatus | Tylenchorhynchus rudus |
| Hoplolaimus galeatus | Xiphinema basiri |
| Hoplolaimus indicus | Xiphinema brasiliense |
| Hoplolaimus pararobustus | Xiphinema brevicollum |
| Hoplolaimus seinhorsiti | Xiphinema index |
| Meloidogyne fallax | Xiphinema insigne |
| Meloidogyne thamesi | Xiphinema italica |
| Meloidogyne trifolii | Xiphinema pachtaicum |
| Merlinius brevidens | Xiphinema rivesi |
| Pratylenchus alleni | Xiphinema vuittenzei |
| Pratylenchus brachyurus | |
Introduction

Background

Nematodes are microscopic round worms which occupy every ecosystem on earth, living freely or in association with plants or animals. Of the approximately 25,000 known species, about 15% (3,600 species) are plant-parasitic but of these, only a few are considered major economic pests, causing severe crop losses under certain conditions (Singh, unpublished data). In developing nations, yield losses due to nematode damage amount to about 15% of crop production per annum; in developed nations, this figure is 8.8% (Nicol et al., 2011). Documented damage from plant-parasitic nematodes in Australia is over AUS$600 million annually (Hodda & Cook, 2009).

Only 15% of species of plant-parasitic nematodes are known from Australia (Hodda & Nobbs 2008, Hodda & Singh 2010, Singh unpublished). Many exotic species have potential to become invasive and damaging (Singh et al. in press). Because of the considerable cost and difficulty in managing damaging nematodes once established, quarantine forms a major part of minimising the impact of plant-parasitic nematodes in Australia.

Considering the potential economic importance of plant-parasitic nematodes, the Northern Australia Quarantine Strategy group (NAQS) of the Department of Agriculture, Fisheries and Forestry (DAFF) in June 2012 commissioned CSIRO to review the biosecurity threats posed by plant-parasitic nematodes in the NAQS region.

Scope

Within Scope

This review examines the following factors relevant to the risk of entry by plant-parasitic nematodes:

- Presence in the NAQS countries as well as the ASEAN countries immediately to the north;
- Commonly grown host plants in above countries and northern Australia;
- Pathways used to move (regulated or unregulated); and
- Impact (geographic range and level of damage to plant hosts)

Beyond Scope

This review does not consider the following:

- crops grown exclusively commercially (many hosts are grown both commercially and domestically);
- native or wild plant hosts;
- countries outside the ASEAN region (north of South East Asia and East of the Solomon Islands);
- risk management measures to mitigate the hazard posed by these nematodes;
• detailed climatic or environmental preferences of nematode species (the subject of current research by the third author);
• detailed investigation and analysis of pathways and networks by which the nematodes might move (the subject of current research by the second author); and
• systematic uncertainties regarding the delimitation of nematode species (the subject of current research by the first author).
Methodology

Data collection
Information on the nematodes present in the NAQS and ASEAN countries was compiled from available national checklists, consultations with national experts and information from published articles to July 2012.

Nematode distributions were compiled from the published sources listed in the bibliography, the Australian Faunal Directory, the CABI Crop Protection Compendium, and EPPO publications.

Host lists were assembled from the CABI Crop Protection Compendium, NEMABASE, the published sources listed in the bibliography and the comprehensive dataset compiled from all published sources by the third author as part of his graduate studies (Singh submitted). Common hosts only were investigated: defined as recorded in more than 3 NAQS or ASEAN countries (excluding Australia). Lists of common crops were compiled from local experts and NAQS staff, published lists, unpublished nematode host information from the ASEAN-NAQS region and the unpublished dataset of the third author. Potential hosts grown primarily commercially or in other parts of Australia were not investigated in detail, except for wheat (*Triticum aestivum*) and soy bean (*Glycine max*), which, where included in the host list of the greatest or probable threats, were used to assess the threats posed.

The plant genus *Solanum* contains over 1500 species, including the potato, tomato and aubergine as well as many wild relatives (Frodin 2004). Two species of nematodes considered in this review—*Globodera rostochiensis* and *Globodera pallida*—parasitize the genus *Solanum* almost exclusively. In this review, the genus was considered as a single "host". In considering the threat posed by the nematodes and host, the size and wide distribution of the genus mean that biosecurity threats may be considerably greater than may appear from the apparently small host list. The plant genera *Piper* (2000 species), *Dioscorea* (800 species) and *Ipomoea* (600 species) are others considered in the present review which contain many species but are listed as a single "host".

Pathway categories follow Centre for Agricultural Bioscience International (2012), as modified by de la Peña *et al.* (2011) and Singh *et al.* (in press). Pathways were categorized as NAQS and non-NAQS pathways based on whether or not they fit within a NAQS pathway and loosely by what is permitted to be traded under the Torres Strait Treaty ([http://www.dfat.gov.au/geo/torres_strait/index.html](http://www.dfat.gov.au/geo/torres_strait/index.html)). The plant species moving via the various pathways were not considered in detail because there have been few studies of this phenomenon. Plant movements are a part of current studies by the second author.

Pathways were determined from the published sources listed in the bibliography, the unpublished dataset of the third author, and consultation with local experts. Feasibility of pathways was inferred from distances between hosts as inferred from frequency of occurrence data, mostly unpublished or informal from local experts or NAQS.
Data Filters
More than 1200 species of nematodes have been reported as damaging plants (Singh unpublished). Investigation of all was beyond the scope of this review, and in any case they are being investigated as part of graduate studies by the third author. Hence a series of filters was used to select the species most likely to be threats for detailed investigation (see below).

The following filters were applied: only species passing all filters were investigated in detail.

Filter 1: Recorded in NAQS or ASEAN countries.
Filter 2: Common crop hosts present in NAQS or ASEAN countries as well as in Northern Australia.
Filter 3: Pathway present.

Likewise, many plant species are known as hosts for many of the nematode species considered. For example, more than 3000 plant species are recorded as hosts for *Meloidogyne incognita* and a similar number for *M. javanica*. Indeed, the hosts for most of the nematode species investigated in detail include many native and non-crop plants which may act as reservoirs or dispersal pathways for the nematodes identified as posing threats. Detailed studies of dispersal are part of separate graduate studies by the second author. The large numbers of hosts made investigation of all recorded hosts beyond the scope of this review, so only 60 of the common crop hosts were investigated in detail (Table 13, p39).

Additional criteria for assessing threat posed
The threat posed by the species passing the above filters was assessed using the following criteria. Whether species met each criterion was assessed using the data sources cited above, and a level of threat estimated as the number of criteria met. If criterion 3 was not met, then one of the secondary criteria had to be met.

Criterion 1: Pathogenicity to crops proven.
Criterion 2: Recorded in NAQS countries.
Criterion 3: Absent from Australia. A secondary criterion was that if recorded in Australia, the species was restricted in distribution or range of races such as to be a biosecurity threat: the races have been shown to vary in host range and/or pathogenicity and there is evidence that not all races occur in Australia.

The process is outlined in Figure 1.
Figure 1. Process for identification of nematode threats.

Evaluation criteria
1. Damage to plants proven
2. Recorded in NAQS countries
3. Absent from Australia

--Plant-parasitic nematodes--

Present in ASEAN or NAQS regions? → Yes → Hosts present in NAQS & ASEAN countries & Australia? → Yes → Pathway present? → Yes → List of 99 species

All criteria met? → Greatest threats

Criterion 1 not met: Damage to plants not proven → Probable threat

Criterion 2 not met: not recorded in NAQS countries → Probable threat

Criterion 3 not met: present in Australia → Host or pathogenicity races known?

Yes → Certain races absent from Australia

No → Very restricted distribution in Australia

Yes → Probable threat

Low threat

Low threat

Low threat

Low threat

Possible threat

--Plant-parasitic nematodes--

List of 99 species

Evaluation criteria
1. Damage to plants proven
2. Recorded in NAQS countries
3. Absent from Australia

--Plant-parasitic nematodes--
Results

Nematodes

A total of 98 nematode species were considered in detail as having passed filters 1-3. They are listed according to their level of threat in Table 1, Table 2, Table 3 and Table 4 (pages 3, 5, 10 and 11), and consolidated in Table 12 (p37).

Seven species met all the criteria to be considered threats. They are listed in Table 1 (p3), with full details presented in Appendix C—Detailed nematode profiles (p37).

An additional 11 species met all criteria except one. They are listed in Table 2 (p5), with full details presented in Appendix C—Detailed nematode profiles (p37).

- Five of these species have not been recorded in the NAQS region. Surveying for nematodes within the NAQS countries have been limited (see Limitations of review, p26), meaning that these species may be present, but unrecorded. This is more likely if the species is widespread in the immediately adjacent area.

- Five of these species have been recorded from Australia. Two of these have very restricted distributions within Australia, being restricted to single localities in NSW and SA, meaning that introduction to new areas is of concern. Three are known to have races differing in hosts and pathogenicity (which under IPCC means that the distributions of the races can be considered for biosecurity). The races present in NAQS countries are mostly not known, however to be included in this group there had to be some evidence that not all the races were currently present in Australia. All the species in this group are known major pathogens, so introduction of new races would be a concern.

- The pathogenicity of one species has not been demonstrated. Neither has the species been shown to cause no damage, but few studies are available.

Races differing in host ranges and pathogenicity are recognised for four species of the genus *Meloidogyne* (Root-Knot Nematodes) and two species of the genus *Pratylenchus* (Root Lesion Nematodes) found in both the NAQS countries and Australia. All cause large losses in many parts of the world. None are listed as probable threats because there is no evidence that only particular races are present in Australia, however there have been very few investigations, either in Australia or the NAQS countries. Should future studies suggest that few races are present in Australia, or that the races in the NAQS countries are different, then the threats posed by these species should be re-assessed.

Of the nematode species identified as greatest or probable threats, most had relatively narrow host ranges (Table 5, p18). By contrast, many of the probable threats and all of the possible threats had very wide host ranges. However, the study was limited to crop hosts and many non-crop hosts are not listed (see Limitations of review, p26). For example, *Heterodera zeae*
and *Meloidogyne graminicola* occur on many graminaceous plants, and the single genus *Solanum*, which is the host to *Globodera pallida*, contains over 1500 species.

Table 5. Number of the crops investigated which are hosts for nematode species identified as threats.

<table>
<thead>
<tr>
<th>Greatest threats</th>
<th>Probable threats</th>
<th>Possible threats</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species</strong></td>
<td><strong>hosts</strong></td>
<td><strong>hosts</strong></td>
</tr>
<tr>
<td><em>Heterodera zeae</em></td>
<td>8</td>
<td>Radopholus similis</td>
</tr>
<tr>
<td><em>Meloidogyne graminicola</em></td>
<td>6</td>
<td>Xiphinema americanum</td>
</tr>
<tr>
<td><em>Heterodera glycines</em></td>
<td>4</td>
<td>Longidorus elongates</td>
</tr>
<tr>
<td><em>Ditylenchus angustus</em></td>
<td>1</td>
<td>Meloidogyne exigua</td>
</tr>
<tr>
<td><em>Globodera pallida</em></td>
<td>1</td>
<td>Meloidogyne enterolobii</td>
</tr>
<tr>
<td><em>Hirschmanniella miticausa</em></td>
<td>1</td>
<td>Meloidogyne naasi</td>
</tr>
<tr>
<td><em>Hirschmanniella oryzae</em></td>
<td>1</td>
<td>Radopholus bridgei</td>
</tr>
<tr>
<td><em>Radopholus citri</em></td>
<td>1</td>
<td>Ditylenchus destructor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Geography
All but one of the species fulfilling all criteria as threats were reported from Indonesia, with one from PNG and the Solomon Islands. None were from Timor Leste. Only 21 species have been reported from PNG (SPC 2012): seven of these fulfil most but not all criteria as threats (Table 1, Table 2 and Table 3, pages 3, 5 and 10). Only twelve species have been reported from the Solomons (SPC 2012): seven of these fulfil most but not all criteria as threats (Table 1, Table 2 and Table 3, pages 3, 5 and 10). The species lists from both countries are almost certainly substantial underestimates resulting from lack of surveys. There have been no surveys or reports of plant-parasitic nematodes from Timor Leste.
Host Plants

Detailed lists of nematodes known to parasitize were available for 60 of the 66 common host plants identified (Table 13, p39). All nematodes known from each of these hosts are listed in Appendix C—Detailed nematode profiles (p37), with species identified as threats highlighted.

The crop with the highest numbers of nematode species which were the greatest or potential threats was *Solanum* spp. (Table 6, p21). Other crops with many nematode threats recorded from them were *Zea mays*, *Oryza* spp. and Cucurbitaceae spp. (Table 6, p21). *Capsicum* spp., *Citrus* spp., *Sorghum* spp., *Allium cepa*, *Coffea* spp. and *Saccharum officinarum* hosted fewer of the nematodes identified as threats, but still considerable numbers (Table 6, p21).

*Triticum aestivum* (wheat) and *Glycine max* (soybean) were both hosts for many of the greatest or probable threats (Table 7, p21). These species are commercial crops grown extensively in Australia, but outside the NAQS region. That these species are damaged by many of the nematode threats identified means that the potential negative impact from the nematodes includes other parts of Australia and other crops.
Table 6. Most frequent crop plant hosts for nematodes in the NAQS region and (number of nematode species recorded).

<table>
<thead>
<tr>
<th>Greatest threats (8)</th>
<th>Probable threats (11)*</th>
<th>Greatest &amp; Probable (19)*</th>
<th>All nematodes (98)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zea mays (4)</td>
<td>Capsicum spp. (5)</td>
<td>Zea mays (7)</td>
<td>Saccharum officinarum (60)</td>
</tr>
<tr>
<td>Sorghum spp. (2)</td>
<td>Citrus spp. (4)</td>
<td>Cucurbitaceae spp. (7)</td>
<td>Oryza spp. (58)</td>
</tr>
<tr>
<td>Abelmoschus spp. (2)</td>
<td>Coffea sp. (4)</td>
<td>Sorghum spp. (5)</td>
<td>Citrus spp. (58)</td>
</tr>
<tr>
<td>Allium cepa (1)</td>
<td>Allium cepa (3)</td>
<td>Citrus spp. (5)</td>
<td>Zea mays (58)</td>
</tr>
<tr>
<td>Bambusa spp. (1)</td>
<td>Brassica (3)</td>
<td>Capsicum spp. (5)</td>
<td>Musa spp. (50)</td>
</tr>
<tr>
<td>Citrus spp. (1)</td>
<td>Ipomoea spp. (3)</td>
<td>Allium cepa (4)</td>
<td>Sorghum spp. (49)</td>
</tr>
<tr>
<td>Cucurbitaceae (1)</td>
<td>Lactuca spp. (3)</td>
<td>Saccharum officinarum (4)</td>
<td>Pinus spp. (44)</td>
</tr>
<tr>
<td>Nicotiana tabacum (1)</td>
<td>Musa spp. (3)</td>
<td>Coffea sp. (4)</td>
<td>Brassica (43)</td>
</tr>
<tr>
<td>Phaseolus vulgaris (1)</td>
<td>Oryza spp. (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saccharum officinarum (1)</td>
<td>Phaseolus vulgaris (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigna spp. (1)</td>
<td>Saccharum officinarum (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum spp. (3)</td>
<td>Zea mays (3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*—partial list only.

Table 7. Major crop plant hosts outside the NAQS region for nematodes identified as threats.

<table>
<thead>
<tr>
<th>Greatest threats (8)*</th>
<th>Probable threats (11)*</th>
<th>Greatest &amp; Probable (19)*</th>
<th>All nematodes (98)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triticum aestivum (4)</td>
<td>Triticum aestivum (4)</td>
<td>Triticum aestivum (8)</td>
<td>Triticum aestivum (55)</td>
</tr>
<tr>
<td>Glycine max (2)</td>
<td>Glycine max (3)</td>
<td>Glycine max (5)</td>
<td>Glycine max (48)</td>
</tr>
</tbody>
</table>

*—partial list only.
Pathways
The pathways through which the greatest number of nematodes can move were plants or plant parts, and soil (Table 8, Table 9 and Table 10, pages 23, 24 and 25).
Table 8. Pathways for greatest nematode threats. Top row: coloured boxes= NAQS pathways and clear boxes= non-NAQS pathways.

<table>
<thead>
<tr>
<th>Nematode species</th>
<th>Soil</th>
<th>Plants or Plant Parts</th>
<th>Corms, Rhizomes &amp; Tubers</th>
<th>Roots and Rootstock</th>
<th>Seedlings &amp; Nursery Stock</th>
<th>Flower &amp; Ornamental Plants</th>
<th>Bulbs</th>
<th>Seeds and Nuts</th>
<th>Sea-swept Plant Debris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ditylenchus angustus</td>
<td>☒</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Globodera pallida</td>
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<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Heterodera glycines</td>
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<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Heterodera zeae</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Meloidogyne graminicola</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Hirschmanniella miticausa</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Hirschmanniella oryzae</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Radopholus citri</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Nematode species</td>
<td>Soil</td>
<td>Plants or Plant Parts</td>
<td>Corms, Rhizomes &amp; Tubers</td>
<td>Roots and Rootstock</td>
<td>Seedlings &amp; Nursery Stock</td>
<td>Flower &amp; Ornamental Plants</td>
<td>Bulbs</td>
<td>Seeds &amp; Nuts</td>
<td>Sea-swept Plant Debris</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>-----------------------</td>
<td>---------------------------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>---------------------------</td>
<td>-------</td>
<td>-------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><em>Ditylenchus destructor</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
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<td>✗</td>
</tr>
<tr>
<td><em>Globodera rostochiensis</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><em>Longidorus elongatus</em></td>
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<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><em>Meloidogyne enterolobii</em></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><em>Meloidogyne exigua</em></td>
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<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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<td><em>Meloidogyne naasi</em></td>
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<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><em>Meloidogyne thailandica</em></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><em>Radopholus arabocoffeae</em></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><em>Radopholus bridge</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><em>Radopholus similis</em></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><em>Xiphinema americanum</em></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
Table 10. Pathways for possible nematode threats. Top row: coloured boxes= NAQS pathways and clear boxes= non-NAQS pathways.

<table>
<thead>
<tr>
<th>Nematode species</th>
<th>Soil</th>
<th>Plants or Plant Parts</th>
<th>Corms, Rhizomes &amp; Tubers</th>
<th>Roots &amp; Rootstock</th>
<th>Seedlings &amp; Nursery Stock</th>
<th>Flower &amp; Ornamental Plants</th>
<th>Bulbs</th>
<th>Seeds &amp; Nuts</th>
<th>Sea-swept Plant Debris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meloidogyne arenaria</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>¨</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Meloidogyne hapla</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>¨</td>
<td>×</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Meloidogyne incognita</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>¨</td>
<td>×</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Meloidogyne javanica</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>¨</td>
<td>×</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Pratylenchus coffeae</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pratylenchus zeae</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Limitations of review

Assessing threat

The international definition of a quarantine pest is “a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled” (FAO 2011a). Organisms which meet this definition can be regulated (FAO 2011b). These criteria are not very specific and results in long lists of potential threats, investigation of all of which was beyond the resources available for the present review. There are several more detailed methods for assessing the threats posed by biological organisms which discriminate threats (Singh et al. in press). Most include parameters such as climatic suitability, pathways, hosts, and economic impact, but how these parameters are evaluated differs among methods. A best method has yet to emerge (Singh 2013).

In the present review all the common parameters cited above were included using a simple dichotomous classification. (Presence of hosts was used as a surrogate climatic suitability.) This produced manageable—but still substantial—lists of nematodes. Detailed investigations of improved methods may yield some different evaluations (Singh 2013).

Verification of material

Many of the nematode and host records used were unverified. Voucher material is extremely sparse. Many nematodes are misidentified as major crop pests because pests are the best known species, and hence have information and identification guides available, or be listed in widely-available keys. However, the reverse also occurs, most particularly with introduced pests being misidentified as local species, or major pests not being recognised on the basis of causing different symptoms in different situations or hosts.

The nematode fauna of Australia's north, the NAQS and ASEAN countries are generally very poorly characterised. There are undoubtedly many more species present than are currently recorded. How many of these will be of significance to biosecurity is unknown.

Uncertainty of identifications

Several national lists contained nematodes identified to genus level only (notably PNG and the Solomon Islands). Altogether 18 genera contain unidentified species (Table 11, p29). Two genera (Bursaphelenchus and Dolichotaurus) were only recorded from unidentified species. These records were not included in this review although most of the genera contain recognised major crop pests: this may have lead to some underestimation of the nematode threats. The unidentified species are included in the lists of nematodes recorded by crop for reference (Appendix D—Nematodes recorded on host crop, p62).

Limited survey data

No records of plant-parasitic nematodes could be located for several countries (e.g. Myanmar and Timor Leste). Records from other countries were extremely old and in need of updating (e.g PNG, Thailand).
Uncertainty over damage caused
Lack of information on damage caused by plant-parasitic nematodes is a major uncertainty in assessing their biosecurity threats (Singh et al. in press). Many of the species investigated in detail passed all filters, and are known to parasitise crop plants, but the damage caused has not been investigated or documented. The threats posed by some of these species may need reassessing should more information become available.

Climatic suitability for establishment
The suitability of the environment in Northern Australia for establishment of nematodes (eg climate or soil types) was not included in this review because information on preferences and limits is limited for many nematode species. Environmental conditions can be important determinants of nematode abundances and the damage they inflict, as well as their success in establishing. The suitability of the different parts of Australia for different nematode pests of plants is the subject of separate studies by the third author. These studies should add considerably to the present review and should be available early in 2013.

Host races or pathotypes
Under the IPPC, races or pathotypes must differ in hosts or pathogenicity to be considered significant for biosecurity. Such races have been studied and accepted in many nematode species. Many have been found in both Australia and the NAQS countries (and the ASEAN countries, too). Whether the races are a biosecurity threat depends on their distribution in the countries being considered. Although the races have been known for many years in some cases (Swanson & Van Gundy, 1984 for Meloidogyne, Kort et al., 1974 for Globodera, Mizukubo 1995, Mizukubo & Sano 1997 and Kumar 1991 for some species of Pratylenchus), the particular races present in Australia and the NAQS countries remain inadequately known, particularly for then nematode genera Meloidogyne and Pratylenchus. Studies in several countries have found that nematode races often vary substantially between countries, with significant implications for how nematodes are managed (eg Hodda 2004, Rammah and Hirschmann 1990, Moritz et al., 2003, Robertson et al., 2009). It is thus entirely likely that the races of Meloidogyne and Pratylenchus present differ between Australia and the NAQS or ASEAN countries. However, this has not been demonstrated to date, so the species involved were only regarded as possible threats in the present review. More research is needed to clarify the situation.

By contrast with Meloidogyne and Pratylenchus, there is evidence that only a very limited number of races of Globodera rostochiensis and Radopholus similis are present in Australia (Hodda 2004, Quader et al. 2008, Gafur unpublished). Although the races in the NAQS and ASEAN countries are yet to be characterised, they are likely to be different, so these species were regarded as probable threats in the present review. A very limited number of races of Ditylenchus dipsaci seem present as well, but there have been no reports from the NAQS countries, so this species is only regarded as a low threat via these countries.

No races are known for Xiphinema americanum sensu lato, but in many ways the situation is similar to the three species discussed in the preceding paragraph. Xiphinema americanum
s.l. is a species complex, with many very closely related species extremely difficult to differentiate by any means, morphological or molecular (Gozel et al. 2006, Hunt 1993). Hence, nematodes identified as *Xiphinema americanum* s.l.—particularly older records (see above)—could be any one of up to about 40 species (Hunt 1993). Although there are records of *Xiphinema americanum* s. l. from both Australia and the NAQS countries, the differences in hosts and locations make it unlikely that they refer to the same species within the complex. Hence *Xiphinema americanum* s. l. was regarded as a probable threat.

**Impacts outside the NAQS region**

The potential of nematodes to damage crop plants other than those common in the NAQS region of Australia was mostly not considered in this review. Of these crops, only two very important species were investigated briefly: wheat (*Triticum aestivum*) and soy bean (*Glycine max*). Both crops were hosts to many of the nematode threats identified. The threat posed by the nematodes to other hosts outside the NAQS region was beyond the scope of this review, and remains to be investigated.
Table 11. Genera with unidentified species from NAQS or ASEAN countries.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Only record in genus?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphelenchoides</td>
<td></td>
</tr>
<tr>
<td>Bursaphelenchus</td>
<td>X</td>
</tr>
<tr>
<td>Dolichodorus</td>
<td>X</td>
</tr>
<tr>
<td>Ditylenchus</td>
<td></td>
</tr>
<tr>
<td>Globodera</td>
<td></td>
</tr>
<tr>
<td>Helicotylenchus</td>
<td></td>
</tr>
<tr>
<td>Heterodera</td>
<td></td>
</tr>
<tr>
<td>Hemicriconemoides</td>
<td></td>
</tr>
<tr>
<td>Hoplolaimus</td>
<td></td>
</tr>
<tr>
<td>Longidorus</td>
<td></td>
</tr>
<tr>
<td>Meloidogyne</td>
<td></td>
</tr>
<tr>
<td>Pratylenchus</td>
<td></td>
</tr>
<tr>
<td>Radopholus</td>
<td></td>
</tr>
<tr>
<td>Rotylenchulus</td>
<td></td>
</tr>
<tr>
<td>Rotylenchus</td>
<td></td>
</tr>
<tr>
<td>Scutellonema</td>
<td></td>
</tr>
<tr>
<td>Trichodorus</td>
<td></td>
</tr>
<tr>
<td>Tylencyphorhynchus</td>
<td></td>
</tr>
<tr>
<td>Xiphinema</td>
<td></td>
</tr>
</tbody>
</table>
References


Secretariat of the Pacific Community (SPC) (2012) Pacific Island Pest List Database http://pld.spc.int/pld/


Appendix A—List of nematode species evaluated
Table 12. List of all nematode species considered as part of this review.

| Aphelenchoides besseyi               | Pratylenchus flakkensis       |
| Aphelenchoides fragariae             | Pratylenchus goodeyi          |
| Aphelenchoides ritzemabosi          | Pratylenchus hexincisus       |
| Aphelenchoides subtenuis             | Pratylenchus loosi            |
| Bitylenchus brevilleiattes          | Pratylenchus neglectus        |
| Bitylenchus dabiis                  | Pratylenchus penetrans        |
| Bursaphelenchus macronatus          | Pratylenchus pinguicaudatus   |
| Bursaphelenchus rainulfi            | Pratylenchus pratensis        |
| Bursaphelenchus singaporensis       | Pratylenchus pseudoprotensis  |
| Bursaphelenchus thailandiae         | Pratylenchus scribneri        |
| Cactodera cacti                     | Pratylenchus sudanensis       |
| Ditylenchus angustus                | Pratylenchus teres            |
| Ditylenchus destructor               | Pratylenchus thornei          |
| Ditylenchus dipsaci                 | Pratylenchus vulnus           |
| Globodera pallida                  | Pratylenchus zeae             |
| Globodera rostochiensis             | Quinisulcius acutus           |
| Helicotylenchus dihystera           | Quinisulcius capitatus        |
| Helicotylenchus microcephalus       | Quinisulcius curvus           |
| Helicotylenchus multicinctus        | Radopholus arabocoffeae       |
| Helicotylenchus pseudorobustus      | Radopholus bridgei            |
| Helicotylenchus varicaudatus        | Radopholus citri              |
| Heteroderia avenae                 | Radopholus duriophilus        |
| Heteroderia cruciferae              | Radopholus nauticus           |
| Heteroderia fici                    | Radopholus similis            |
| Heteroderia glycines               | Rotylenchus parvus            |
| Heteroderia oryzae                 | Rotylenchus reniformis        |
| Heteroderia sacchari               | Rotylenchus robustus          |
| Heteroderia schachtii              | Scutellonema brachyurum       |
| Heteroderia trifolii                | Scutellonema clathricaudatum  |
| Heteroderia zeae                    | Scutellonema minutatum        |
| Hemicriconemoides cocophilus        | Trichodora cylindricus        |
| Hemicriconemoides mangiferae        | Tylenchorhynchus annulatus    |
| Hemicriconemoides strictathecatus   | Tylenchorhynchus brassicae    |
| Hirschmanniella miticausa           | Tylenchorhynchus clarus       |
| Hirschmanniella oryzae             | Tylenchorhynchus claytoni     |
| Hoplolaimus galeatus               | Tylenchorhynchus mashhoodi    |
| Hoplolaimus indicus                 | Tylenchorhynchus nudus        |
| Hoplolaimus pararobustus           | Xiphinema americanum          |
| Hoplolaimus seinhorsti             | Xiphinema basiri              |
| Longidorus elongatus               | Xiphinema brasiliense         |
| Meloidogyne arenaria               | Xiphinema brevicollum         |
| Meloidogyne enterolobii            | Xiphinema index               |
| Meloidogyne exigua                 | Xiphinema insigne             |
| Meloidogyne fallax                 | Xiphinema italica             |
| Meloidogyne graminicola            | Xiphinema pachtaicum          |
| Meloidogyne hapla                   | Xiphinema rivesi              |
| Meloidogyne incognita              | Xiphinema vuittenezi          |
| Meloidogyne javanica               |                            |
| Meloidogyne naasi                   |                            |
| Meloidogyne thailandica            |                            |
| Meloidogyne thamesi                |                            |
| Meloidogyne trifoliophila          |                            |
| Merlinius brevidens                |                            |
| Pratylenchus alleni                |                            |
| Pratylenchus brachyurus            |                            |
| Pratylenchus coffeae               |                            |
| Pratylenchus crenatus              |                            |
| Pratylenchus delattrei             |                            |

Nematode threats in the NAQS region © CSIRO
Appendix B—List of all host plants considered
Table 13. List of all host plants considered in this review.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name(s)</th>
<th>Scientific name</th>
<th>Common name(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelmoschus spp.</td>
<td>aibika, okra</td>
<td>Morus spp.</td>
<td>mulberry</td>
</tr>
<tr>
<td>Allium cepa</td>
<td>onion</td>
<td>Musa spp.</td>
<td>banana &amp; plantain</td>
</tr>
<tr>
<td>Ananas comosus</td>
<td>pineapple</td>
<td>Nephelium lappaceum</td>
<td>rambutan</td>
</tr>
<tr>
<td>Annona muricata</td>
<td>soursop</td>
<td>Oryza spp.</td>
<td>rice</td>
</tr>
<tr>
<td>Annona reticulata</td>
<td>custard apple</td>
<td>Passiflora spp.</td>
<td>passion fruit</td>
</tr>
<tr>
<td>Annona squamosa</td>
<td>sugar apple</td>
<td>Persea americana</td>
<td>avocado</td>
</tr>
<tr>
<td>Arachis hypogaea</td>
<td>peanut</td>
<td>Petroselinum crispum</td>
<td>parsley</td>
</tr>
<tr>
<td>Bambusa spp.</td>
<td>bamboo</td>
<td>Phaseolus vulgaris</td>
<td>haricot bean</td>
</tr>
<tr>
<td>Beta vulgaris</td>
<td>beetroot</td>
<td>Pinus spp.</td>
<td>pine</td>
</tr>
<tr>
<td>Bougainvillea spp.</td>
<td>bougainvillea</td>
<td>Piper spp.</td>
<td>pepper</td>
</tr>
<tr>
<td>Brassica spp.</td>
<td>cabbage, broccoli</td>
<td>Psidium guajava</td>
<td>guava</td>
</tr>
<tr>
<td>Calopogonium mucunoides</td>
<td>wild ground nut</td>
<td>Psophocarpus tetragonolobus</td>
<td>winged bean</td>
</tr>
<tr>
<td>Camellia sinensis</td>
<td>tea</td>
<td>Rosa spp.</td>
<td>rose</td>
</tr>
<tr>
<td>Capsicum spp.</td>
<td>chilli, capsicum</td>
<td>Saccharum officinarum</td>
<td>sugarcane</td>
</tr>
<tr>
<td>Carica papaya</td>
<td>pawpaw</td>
<td>Solanum spp.</td>
<td>potato, aubergine, tomato</td>
</tr>
<tr>
<td>Citrullus lanatus</td>
<td>watermelon</td>
<td>Sorghum spp.</td>
<td>sorghum</td>
</tr>
<tr>
<td>Citrus spp.</td>
<td>citrus</td>
<td>Theobroma cacao</td>
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<tr>
<td>Cocos nucifera</td>
<td>coconut</td>
<td>Vigna spp.</td>
<td>bean</td>
</tr>
<tr>
<td>Coffea spp.</td>
<td>coffee</td>
<td>Vitis spp.</td>
<td>grape</td>
</tr>
<tr>
<td>Colocasia esculenta</td>
<td>taro</td>
<td>Xanthosoma spp.</td>
<td>new cocoyam</td>
</tr>
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<td>Coriandrum sativum</td>
<td>coriander</td>
<td>Zea mays</td>
<td>maize</td>
</tr>
<tr>
<td>Cucurbitaceae spp.</td>
<td>cucumber, pumpkin, squash</td>
<td>Zingiber officinale</td>
<td>ginger</td>
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<td>Dimocarpus longan</td>
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<td>yam</td>
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<td>Dracaena spp.</td>
<td>dragon tree</td>
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<td>lobster-claws, wild plantains</td>
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<td>lychee</td>
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<td>cassava</td>
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Appendix C—Detailed nematode profiles
**Ditylenchus angustus**

**Threat: Greatest**

**Taxonomy**

*Name: Ditylenchus angustus* (Butler, 1913) Filipjev 1936

*Synonyms: Tylenchus angustus* Butler, 1913
   Anguillulina angusta (Butler) Goodey, 1932

*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Anguiniidae

*Common Name:* Rice stem nematode

**Biological characteristics**

The nematode causes ufra disease, a high impact disease of deepwater and lowland rice. Plants parasitized by this nematode become more susceptible to other plant pathogens, such as *Pyricularia oryzae* (Bridge et al., 2005).

A migratory ectoparasite living on the outer surface of plants and feeding on plant shoot tissue. The lifecycle of the nematode is short, 10-20 days and it completes several generations on one plant. Post-harvest, it survives in a dessicated state in crop residues (Bridge & Starr, 2007; Whitehead, 1998).

The nematode is widespread in countries in Asia and Africa but is restricted to areas of high humidity (≥75%).

**Filter 1:** Recorded in ASEAN or NAQS countries

*ASEAN region:* Myanmar, Thailand, Vietnam, Malaysia, Philippines, Indonesia

Also Egypt, Sudan, Madagascar, India, Pakistan, Bangladesh

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Oryza* spp. (rice)

**Filter 3:** Pathway present

*Proven:* Plants or plant parts; seedlings and nursery stock; seeds; soil

*Probable:* Corms, rhizomes and tubers; flower and ornamental plants; bulbs.

**Criterion 1:** Recorded in NAQS countries

Yes; Indonesia.

**Criterion 2:** Absent from Australia

Not recorded from Australia.

**Criterion 3:** Pathogenicity to crops proven

Yield losses range from 4-100% (Bridge et al. 2005, Whitehead 1998).
**Ditylenchus destructor**

**Threat:** Probable

**Taxonomy**
Name: *Ditylenchus destructor* Thorne 1945

*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Anguinidae

*Common Name:* Potato Tuber Nematode, Potato Rot Nematode

**Biological characteristics**
On potato, plants are weakened and usually die when tubers are heavily infested. Such tubers have sunken areas with cracked, wrinkled and partly detached skin, with dry and mealy flesh, greyish to dark brown or black in colour. The discoloration may be due to secondary invasion of fungi, bacteria and other nematodes. Iris have grey to black lesions, often black roots and poorly-developed leaves with yellow tips. Groundnuts have black discoloration appearing first along longitudinal veins, shrunken kernels, brown to black testae and brown embryo (Jones & De Waele 1988).

A migratory endoparasite living in the soil, tubers and bulbs. The lifecycle of the nematode is short: 10 days at 28°C (De Waele *et al.*, 1990).

Seems unable to withstand excessive desiccation, so usually restricted to moist soils. Before *D. destructor* was described, it was regarded for a long time as a strain or race of *D. dipsaci* and recorded as such. The nematodes attacking ground nut may be a separate race (Jones & De Waele 1988).

**Filter 1:** Recorded in ASEAN or NAQS countries

*ASEAN region:* Malaysia

Also found in isolated places and countries in Africa, Europe, East and North Asia and The Americas

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Solanum* spp. (potato, aubergine, tomato etc.), *Ipomoea* spp., *Iris* spp.

**Filter 3:** Pathway present

*Proven:* Soil; Plants or Plant Parts; Corms, Rhizomes & Tubers; Bulbs; Seeds

**Criterion 1:** Recorded in NAQS countries

*No*

**Criterion 2:** Absent from Australia

Recorded from some time ago, but records doubtful and no recent findings, so now regarded as absent (Hodda 2009a, b, Thistlethwayte 2009, 2010).

**Criterion 3:** Pathogenicity to crops proven

Yield losses in ground nut (Jones & De Waele 1988) and potato (Winslow 1978).
**Globodera pallida**

**Threat: Greatest**

**Taxonomy**

*Name*: Globodera pallida (Stone, 1973) Behrens, 1975

*Synonyms*: Heterodera pallida Stone, 1973  
Globodera pallida (Stone) Mulvey & Stone, 1976


*Common Name*: Potato Cyst Nematode, Pale Nematode

**Biological characteristics**

The cause of severe losses through stunting and plant death in potato. Entry wounds provide a point of entry for pathogens such as *Pseudomonas solanacearum* (Jatala et al., 1976) and *Verticillium dahliae* (Harrison, 1971; Franco & Bendezu, 1985).

A sedentary endoparasite which feeds on plant roots. Juvenile nematodes hatch from eggs in the soil and enter the roots where they establish a permanent feeding site. Once mature, males leave the roots to mate with females which remain within the root with their posterior ends protruding outside. Fertilized females become enlarged and rounded, eventually dying but retaining up to 500 eggs within the tanned body (Scurrah et al. 2005). Without hosts, cysts may remain viable in soil for up to 30 years (Turner, 1996).

Occurs in many countries, but in highly restricted areas. Similar climatic preferences to its host the potato. Races are recognised (Kort et al., 1977).

**Filter 1: Present in ASEAN-NAQS region**

- ASEAN region: Malaysia, Indonesia
- Australo-Pacific: New Zealand
- Also found in isolated places and countries in Africa, Europe, East and North Asia and The Americas

**Filter 2: Common crop hosts present in ASEAN-NAQS region as well as in Australia**

*Solanum* spp. (potato, aubergine, tomato etc.)

**Filter 3: Pathway present**

- Proven: Soil; corms, rhizomes and tubers
- Probable: Plants and plant parts

**Criterion 1**: Recorded in NAQS countries

Yes; Indonesia.

**Criterion 2**: Absent from Australia

Not recorded from Australia.

**Criterion 3**: Pathogenicity to crops proven

Yield losses of up to 100% (Brodie & Mai 1989).
**Globodera rostochiensis**

**Threat: Probable**

**Taxonomy**

*Name:* *Globodera rostochiensis* (Wollenweber 1923) Behrens 1975

*Synonyms:* *Heterodera rostochiensis* Wollenweber 1923

*Common names:* Potato Cyst Nematode, Golden Nematode

*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Heteroderidae

**Biological characteristics**

The cause of severe losses through wilting, stunting and plant death in potato. Entry wounds provide a point of entry for pathogens such as *Pseudomonas solanacearum* (Jatala *et al.*, 1976) and *Verticillium dahliae* (Harrison, 1971; Franco & Bendezú, 1985).

A sedentary endoparasite which feeds on plant roots. Juvenile nematodes hatch from eggs in the soil and enter the roots where they establish a permanent feeding site. Once mature, males leave the roots to mate with females which remain within the root with their posterior ends protruding outside. Fertilized females become enlarged and rounded, eventually dying but retaining up to 500 eggs within the tanned body (Scurrah *et al.* 2005). Without hosts, cysts may remain viable in soil for up to 30 years (Turner, 1996).

Occurs in many countries, but in highly restricted areas. Similar climatic preferences to its host the potato. Races are recognised (Kort *et al.*, 1977).

**Filter 1:** *Recorded in ASEAN or NAQS countries*

Philippines, Indonesia

Also in New Zealand, and found in isolated places and countries in Africa, Europe, East and North Asia and The Americas

**Filter 2:** *Common crop hosts present in ASEAN-NAQS region as well as in Australia*

*Solanum* spp. (potato, aubergine, tomato etc.)

**Filter 3:** *Pathway present*

Proven: Soil; corms, rhizomes and tubers

Probable: Plants and plant parts

**Criterion 1:** *Recorded in NAQS countries*

Yes; Indonesia.

**Criterion 2:** *Absent from Australia*

Presently in a defined area of Victoria only and under regulation. Recently declared eradicated from Western Australia (Collins *et al.*., 2010). Only one race found in Victoria (Quader *et al.* 2008).

**Criterion 3:** *Pathogenicity to crops proven*

Yield losses of up to 100% (Brodie & Mai 1989).
**Heterodera glycines**

**Threat: Greatest**

**Taxonomy**
Name: *Heterodera glycines* Ichinohe 1952


Common Name: Soyabean Cyst Nematode

**Biological characteristics**

A major crop pest preventing nodule formation in plants, causing “yellow dwarf” disease. Also found to interact with *Fusarium solani* in “sudden death” syndrome of soybean.

A sedentary endoparasite living inside roots. Juveniles hatch from eggs in soil, enter roots and migrate to vascular tissue, then become sedentary and establish a feeding site. Adult males leave the roots to fertilize adult females protruding from the root surface. Fertilised females form lemon-shaped cysts attached to the roots (Oyekanmi & Fawole, 2010). *H. glycines* can undergo 3-4 generations per growing season in cool areas and 6-7 generations in hotter regions (Noel, 1985).

Preferred temperature is 23-28°C: above 34°C development stops (Schmitt & Riggs, 1991; Burrows & Stone, 1985). Without hosts, cysts may remain viable in soil for 6-8 years (Slack et al., 1972). Races are recognised (Riggs & Schmidt 1988, Niblack et al., 2002).

**Filter 1:** Recorded in ASEAN or NAQS countries

ASEAN region: Indonesia

Also in isolated places and countries in Africa, Europe, East and North Asia and The Americas

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Beta vulgaris* (beetroot), Cucurbitaceae spp. (cucumber, pumpkin, squash etc.), *Glycine max* (soybean), *Phaseolus vulgaris* (haricot bean), *Solanum* spp. (potato, aubergine, tomato etc.), *Vigna* spp. (bean), *Zea mays* (maize)

**Filter 3:** Pathway present

Proven: Soil

Probable: Roots and Rootstock; Seedlings & Nursery Stock; Plants or Plant Parts

**Criterion 1:** Present in NAQS region of interest

Yes; Indonesia.

**Criterion 2:** Absent from Australia

Not recorded from Australia.

**Criterion 3:** Pathogenicity to crops proven

Recorded yield losses range from 10-80% (Jacobsen et al., 1983).
**Heterodera zeae**

**Threat: Greatest**

**Taxonomy**
*Name:* Heterodera zeae Koshy, Swarup & Sethi, 1971  
*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Heteroderidae

**Biological characteristics**
An important crop pest causing general disease symptoms. Disease symptoms increase in the presence of *Cephalosporium maydis* in the field/laboratory testing, indicating that the nematode may increase the plant’s susceptibility to other plant pathogens.

A sedentary endoparasite living inside roots. Juveniles hatch from eggs in soil, enter roots and migrate to vascular tissue, then become sedentary and establish a feeding site. Adult males leave the roots to fertilize adult females protruding from the root surface. Fertilised females form lemon-shaped cysts attached to the roots. The lifecycle is short at 15-18 days, with 6-7 generations in 1 crop season (McDonald & Nicol, 2005). Cysts remain viable for a long time.

Environmental preferences poorly known.

**Filter 1:** Recorded in ASEAN or NAQS countries

- **ASEAN region:** Thailand, Indonesia  
- Also in New Zealand, and found in isolated places and countries in Africa, Europe, East and North Asia and The Americas

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

- *Bambusa* spp. (bamboo), *Capsicum* spp. (chilli, capsicum etc.), *Citrus* spp., *Oryza* spp. (rice), *Saccharum officinarum* (sugarcane), *Solanum* spp. (potato, aubergine, tomato etc.), *Sorghum* spp. (sorghum), *Triticum* spp. (wheat), *Zea mays* (maize)

**Filter 3:** Pathway present

- **Proven:** Soil  
- **Probable:** Roots and Rootstock; Seedlings & Nursery Stock; Plants or Plant Parts

**Criterion 1:** Recorded in NAQS countries

- Yes; Indonesia.

**Criterion 2:** Absent from Australia

- Not recorded from Australia.

**Criterion 3:** Pathogenicity to crops proven

- One of the most economically important nematodes attacking cereals with reported yield losses of 13-73% (Krusberg *et al.*, 1997).
**Hirschmanniella miticausa**

**Threat: Greatest**

**Taxonomy**
*Name*: *Hirschmanniella miticausa* Bridge, Mortimer & Jackson 1983

*Synonyms*: None

*Taxonomic Position*: Nematoda: *Chromadorea*; Panagrolaimida: Tylenchina: Pratylenchidae

*Common Name*: None

**Biological characteristics**
The nematode causes ‘miti miti’ disease or corm rot of taro (*Calocasia esculentum*). The above ground symptoms include chlorotic leaves and heavy infestation by this nematode causes plant death due to corm damage (Bridge et al., 1983). Infested corms, when cut exhibit red streaks radiating from the base of the corm.

A migratory endoparasite living on the outer surface of plants and feeding on corm and root tissue. The lifecycle of the nematode has not been studied and little is known about its true host range.

The nematode has been reported from Solomon Islands and PNG, from taro grown in dryland soils, rainfed mountain slopes and in flooded swamp pits.

**Filter 1**: Recorded in ASEAN or NAQS countries

*NAQS region*: PNG, Solomon Islands

**Filter 2**: Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Calocasia esculentum* (taro)

**Filter 3**: Pathway present

*Proven*: Soil; Corms, Rhizomes and Tubers; Plants or Plant Parts; Seedlings and Nursery Stock

*Probable*: Flower and Ornamental Plants; Bulbs; Sea Swept Plant Debris

**Criterion 1**: Recorded in NAQS countries

Yes; PNG, Solomon Islands

**Criterion 2**: Absent from Australia

Not recorded from Australia.

**Criterion 3**: Pathogenicity to crops proven

The corms of *C. esculenta* infested by this nematode are inedible. In the Solomon Islands, the impacts on production are so severe that cultivation of taro is abandoned in fields with high populations of this nematode.
**Hirschmanniella oryzae**

**Threat: Greatest**

**Taxonomy**
Name: *Hirschmanniella oryzae* (van Breda de Hann, 1902) Luc & Goodey 1964

**Synonyms:**
- *Tylenchus oryzae* van Breda de Haan 1902
- *Anguillulina oryzae* (van Breda de Haan) Goodey 1932
- *Hirschmannia oryzae* (van Breda de Haan) Luc & Goodey 1962
- *Radopholus oryzae* (van Breda de Haan) Thorne 1949
- *Rotylenchus oryzae* (van Breda de Haan) Filipjev & Schuurmans Stekhoven 1941
- *Tylenchus apapillatus* Imamura 1931
- *Anguillulina apapillata* (Imamura) Goodey 1932
- *Rotylenchus apapillatus* (Imamura) Filipjev 1936
- *Hirschmanniella apapillata* (Imamura) Siddiqi 1986
- *Hirschmanniella nana* Siddiqi 1966
- *Hirschmanniella exigua* Khan 1972

**Taxonomic Position:** Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Pratylenchidae

**Common Name:** Rice Root Nematode

**Biological characteristics**
This nematode thrives in rice fields and is able to withstand flooded conditions. The above-ground symptoms of damage by this nematode are not easily identifiable. The symptoms include slow growth and reduced tillering, which can be confused with symptoms of nutrient deficiency.

*Hirschmanniella oryzae* is a migratory endoparasite and feeds on the root tissue of rice plants. The lifecycle of this nematode under ideal conditions can be completed in 30 days but the number of generations is variable with 1-2 generations per year (Kuwahara & Kisabu, 1970).

The nematode is widespread in rice growing regions in Asia and has restricted distributions in parts of Africa, Central America and Caribbean, Europe, North America and South America.

**Filter 1:** Recorded in ASEAN or NAQS countries
- **ASEAN region:** Malaysia, Myanmar, Philippines, Thailand, Vietnam
- **NAQS region:** Indonesia

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia
- *Abelmoschus* spp. (aibika, okra etc.), *Oryzae* spp. (rice), *Saccharum officinarum* (sugarcane), *Solanum* spp. (potato, aubergine, tomato etc.), *Sorghum* spp. (sorghum), *Triticum* spp. (wheat), *Zea mays* (maize)

**Filter 3:** Pathway present
- **Proven:** Soil, Plants or plant parts; seedlings and nursery stock
- **Probable:** Corms, rhizomes and tubers; flower and ornamental plants; bulbs; sea swept plant debris

**Criterion 1:** Recorded in NAQS countries
- Yes; Indonesia

**Criterion 2:** Absent from Australia
- Not recorded from Australia.

**Criterion 3:** Pathogenicity to crops proven
- Important pest of rice, yield reduced by 25-39% (Babatola & Bridge 1980; Cho *et al.* 1994)
Longidorus elongatus

**Threat:** Probable

**Taxonomy**

*Name:* Longidorus elongatus (De Man 1876) Micoletzky 1922

**Synonyms:**
- Dorylaimus elongatus De Man 1876
- Trichodorus elongatus (De Man 1876) Filipjev 1921
- Dorylaimus (Longidorus) elongatus De Man 1876 (Micoletzky 1922)
- Dorylaimus tenuis Linstow 1879
- Longidorus monohystera Altherr 1953
- Longidorus menthasolanus Konicek & Jensen 1961

**Taxonomic Position:** Nematoda: Dorylaimida: Dorylaimina: Longidoridae

**Common Name:** No common name

**Biological characteristics**

Direct feeding causes severe stunting and galling of root systems in many crops, and is associated with Docking Disorder of sugarbeet (Whitehead & Hooper 1970). Transmits plant viruses including Raspberry Ringspot Virus and Tomato Black Ring Virus.

A migratory ectoparasite living on the outer surface of plants and feeding on plant roots. The lifecycle of the nematode is 9 weeks at 30°C (Wyss 1970) but probably only one generation per year occurs in the field (Thomas 1969).

The nematode is widespread in temperate regions, with more limited occurrence in the tropics.

**Filter 1:** Recorded in ASEAN-NAQS region

*ASEAN region:* Myanmar, Thailand, Vietnam, Malaysia, Philippines, Indonesia

Also New Zealand, and found in isolated places and countries in Europe, East and North Asia and The Americas.

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

- Allium cepa (onion), Arachis hypogaea (peanut), Beta vulgaris (beetroot), Brassica spp. (cabbage, broccoli etc.), Cucurbitaceae (cucumber, pumpkin, squash etc.), Ficus spp. (figs), Lactuca spp., Phaseolus vulgaris (haricot bean), Rosa spp., Solanum spp., Vitis spp., Zea mays.

**Filter 3:** Pathway present

- **Proven:** Soil; Seedlings & Nursery Stock
- **Probable:** Plants or Plant Parts; Corms, Rhizomes & Tubers; Bulbs; Flower & Ornamental Plants

**Criterion 1:**

Yes; Indonesia.

**Criterion 2:** Absent from Australia

One record from Lolium sp. in South Australia.

**Criterion 3:** Pathogenicity to crops proven

Yes (Hunt 1993).
**Meloidogyne enterolobii**

**Threat: Probable**

**Taxonomy**

*Name*: *Meloidogyne enterolobii* Yang & Eisenback, 1983

*Synonyms*: *Meloidogyne mayaguensis* Rammah & Hirschmann, 1988


*Common Name*: Pacara Earpod Tree Root-Knot Nematode

**Biological characteristics**

An emerging threat to vegetable production recently included on the quarantine list for EPPO. It causes serious root galling and plant decline via a combination of a high reproduction rate, large galls and a very wide host range. It is virulent against several sources of resistance to other *Meloidogyne* species and can overcome the important *Mi-1* resistance gene (Castagnone-Sereno 2012).

A sedentary endoparasite feeding on underground plant tissues, especially roots. After hatching, juveniles locate and enter roots, then establish a permanent feeding site. A gall is induced around this feeding site as the juveniles become sedentary and mature into females. The females remain in the gall for the rest of their lifecycle and lay eggs in a gelationous matrix outside the root. This species can complete its lifecycle in 24 days (Westerich et al., 2011).

Seems to prefer mild conditions under which many vegetables grow. It is also a particular pest in enclosed production systems (greenhouses).

**Filter 1**: Present in ASEAN-NAQS region

*ASEAN region*: Vietnam

Mainly found in Central America, it is also found in isolated places and countries in Africa, Europe, East and North Asia

**Filter 2**: Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Capsicum* spp. (chilli, capsicum etc.), *Coffeea* sp. (coffee), *Cucurbitaceae* spp. (cucumber, pumpkin, squash etc.), *Psidium guajava* (guava), *Solanum* spp. (potato, aubergine, tomato etc.), *Nicotiana tabacum* (tobacco)

**Filter 3**: Pathway present

*Proven*: Soil; Plants or Plant Parts; Roots and Rootstock; Flower & Ornamental Plants

**Criterion 1**: Recorded in NAQS countries

No.

**Criterion 2**: Absent from Australia

Not recorded from Australia.

**Criterion 3**: Pathogenicity to crops proven

Causes losses of up to 65% in some crops (Cetintas et al. 2007).
**Meloidogyne exigua**

**Threat: Probable**

**Taxonomy**

Name: *Meloidogyne exigua* Goeldi, 1892  
Synonyms: *Heterodera exigua* (Goeldi) Marcinowski, 1909  
Taxonomic Position: Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Meloidogynidae  
Common Name: Coffee Root-Knot Nematode

**Biological characteristics**

Coffee is the main host, however it can parasitise a wide range of other plants as well. Above-ground symptoms on coffee include yellowing of leaves, leaf fall and tree death in case of heavy infestation.  
Adult females are sedentary endoparasites, residing and feeding in specialised cells which form characteristic galls on the roots. The lifecycle of this nematode can be completed in 15-30 days (Lima & Ferraz 1985).  

The nematode is widespread in coffee growing regions in Central and South America. Incidental reports from China, Greece, India and Thailand (Srinivasan & D'Souza 1965; Zhang & Xu 1994; Karssen & Van Hoenselaar 1998).

**Filter 1:** *Recorded in ASEAN or NAQS countries*  
ASEAN region: Thailand

**Filter 2:** *Common crop hosts present in ASEAN-NAQS region as well as in Australia*  
*Allium cepa* (onion), *Capsicum* spp. (chilli, capsicum etc.), *Citrullus lanatus* (watermelon), *Citrus* spp., *Coffea* sp. (coffee), *Cucurbitaceae* spp. (cucumber, pumpkin, squash etc.), *Ipomoea* spp., *Musa* spp. (banana & plantain), *Oryza* spp. (rice), *Saccharum officinarum* (sugarcane)

**Filter 3:** *Pathway present*  
Proven: Plants or plant parts; seedlings and nursery stock; seeds; soil  
Probable: Corms, rhizomes and tubers; flower and ornamental plants; bulbs.

**Criterion 1:** *Recorded in NAQS countries*  
No

**Criterion 2:** *Absent from Australia*  
No, but only recorded from New South Wales.

**Criterion 3:** *Pathogenicity to crops proven*  
Pathogenic to coffee; caused yield loss of 45% (Barbosa et al., 2004; Barbosa et al., 2010)
**Meloidogyne graminicola**

**Threat: Greatest**

**Taxonomy**

*Name*: Meloidogyne graminicola Golden & Birchfield, 1965  
*Common Name*: Rice Root-Knot Nematode

**Biological characteristics**

Causes serious disease of rice often involving swollen and hooked root tips. Symptoms in dry or shallow water rice include stunting, reduced tillering, wilting, unfilled spikelets, and chlorosis. In deepwater rice, plants do not emerge above water (Bridge & Page 1982).

A sedentary endoparasite feeding on underground plant tissues, especially roots. After hatching, juveniles locate and enter roots, establish a permanent feeding site. A gall is induced around this feeding site as the juveniles become sedentary and mature into females. The females remain in the gall for the rest of their lifecycle and lay eggs in a gelationous matrix outside the root.

This species prefers wet conditions but survives in dry conditions as well. *M. graminicola* can survive in soil flooded to a depth of 1 m for at least 5 months (Bridge and Page, 1982) and egg masses can remain viable for at least 14 months in waterlogged soil (Roy, 1982).

**Filter 1**: Present in ASEAN-NAQS region  
ASEAN region: Thailand, Myanmar, Lao PDR, Vietnam, Malaysia, Singapore, Philippines, Indonesia  
Very isolated occurrences outside SE Asia: Europe, East and North Asia and The Americas

**Filter 2**: Common crop hosts present in ASEAN-NAQS region as well as in Australia  
*Allium cepa* (onion), *Brassica* spp. (cabbage, broccoli etc.), *Glycine max* (soybean), *Oryza* spp. (rice), *Solanum* spp. (potato, aubergine, tomato etc.), *Sorghum* spp. (sorghum), *Triticum* spp. (wheat), *Zea mays* (maize)

**Filter 3**: Pathway present  
Proven: Soil; Plants or Plant Parts; Roots and Rootstock; Flower & Ornamental Plants

**Criterion 1**: Recorded in NAQS countries  
Yes; Indonesia.

**Criterion 2**: Absent from Australia  
Not recorded from Australia.

**Criterion 3**: Pathogenicity to crops proven  
A major rice pest with recorded yield losses of up to 80% (De Waele & Elsen, 2007).
**Meloidogyne naasi**

**Threat: Probable**

**Taxonomy**

*Name:* *Meloidogyne naasi* Franklin, 1965

*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Meloidogynidae

*Common Name:* Barley Root-Knot Nematode

**Biological characteristics**

A serious pest of grasses and other plants, inducing stunting and severe root galling with sometimes more than 100 nematodes per gall. Galls are curved, horseshoe or spiral shaped (Kort, 1972). May interact with *Fusarium* spp. to cause corchosis (a disease) in plants (Manzanilla-López & Starr, 2009).

A sedentary endoparasite feeding on underground plant tissues, especially roots. After hatching, juveniles locate and enter roots, establish a permanent feeding site. A gall is induced around this feeding site as the juveniles become sedentary and mature into females. The females remain in the gall for the rest of their lifecycle and lay eggs in a gelatinous matrix outside the root. There is usually only 1 generation per growing season (Rivoal and Cook, 1993).

Prefers temperate climates.

**Filter 1: Present in ASEAN-NAQS region**

ASEAN region: Thailand

Also in New Zealand, and found in Europe as well as isolated places and countries in North Asia and The Americas

**Filter 2: Common crop hosts present in ASEAN-NAQS region as well as in Australia**

*Allium cepa* (onion), *Beta vulgaris* (beetroot), *Oryza* spp. (rice), *Solanum* spp. (potato, aubergine, tomato etc.), *Sorghum* spp. (sorghum), *Triticum* spp. (wheat)

**Filter 3: Pathway present**

Proven: Soil; Plants or Plant Parts; Roots and Rootstock; Flower & Ornamental Plants

**Criterion 1: Recorded in NAQS countries**

No.

**Criterion 2: Absent from Australia**

Not recorded from Australia.

**Criterion 3: Pathogenicity to crops proven**

Reported to cause significant damage with up to 75% yield loss in some crops and 100% losses under some conditions (Allen *et al.*, 1970; Schneider, 1967).
**Meloidogyne thailandica**

**Threat: Probable**

**Taxonomy**
Name: *Meloidogyne thailandica* Handoo, Skantar, Carta & Erbe, 2005

Taxonomic Position: Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Meloidogynidae

**Biological characteristics**
Unknown. This species has not been studied in its native locality (Thailand). Species was described based on specimens obtained from intercepted infected ginger sent to the USA from Thailand (Handoo *et al.*, 2005). Species within this genus are sedentary endoparasites which enter plant tissues as juveniles and establish a permanent feeding site inducing gall formation.

**Filter 1:** **Present in ASEAN-NAQS region**
Asia: Thailand

**Filter 2:** **Common crop hosts present in ASEAN-NAQS region as well as in Australia**
*Zingiber officinale* (ginger)

**Filter 3:** **Pathway present**
Proven: Soil; Plants or Plant Parts; Roots and Rootstock; Flower & Ornamental Plants

**Criterion 1:** **Recorded in NAQS countries**
No.

**Criterion 2:** **Absent from Australia**
Not recorded from Australia.

**Criterion 3:** **Pathogenicity to crops proven**
This species has not been proven to damage crops, but very little is known about it and there have been no tests. All species in the genus cause some degree of damage and at least 10 cause proven major economic losses, so it is probable that the species is pathogenic under at least some conditions.
**Radopholus arabocoffeae**

**Threat: Probable**

**Taxonomy**

*Name:* Radopholus arabocoffeae Trinh, Nguyen, Waeyenberge, Subbotin, Karssen & Moens, 2004

*Taxonomic Position:* Nematoda: Chromadorea: Panagrolaimida: Tylenchina: Pratylenchidae

**Biological characteristics**

In controlled laboratory tests, this species caused major damage, but symptoms and effect under field conditions are untested as yet.

A migratory endoparasite which lives within the host plant, moving through and feeding on internal tissues. The rest of its life history is unknown.

Appears to be restricted to warm humid conditions.

**Filter 1:** Present in ASEAN-NAQS region

ASEAN region: Vietnam

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia

*Coffea* spp. (coffee)

**Filter 3:** Pathway present

Proven: Plants or plant parts; seedlings and nursery stock; soil

**Criterion 1:** Recorded in NAQS countries

No.

**Criterion 2:** Absent from Australia

Not recorded from Australia.

**Criterion 3:** Pathogenicity to crops proven

Caused the highest level of damage in laboratory testing compared with *Pratylenchus coffeae* and *Radopholus duriophilus*, two other plant-parasitic nematodes of coffee (Trinh *et al.*, 2004). There is very little information on the impact of this pest in the field.
**Radopholus bridgei**

**Threat: Probable**

**Taxonomy**

*Name:* Radopholus bridgei Siddiqi & Hahn, 1995

*Taxonomic Position:* Nematoda: Chromadorea; Panagrolaimida; Tylenchoidea; Pratylenchidae

*Common Name:* None

**Biological characteristics**

Limited information is available on host range and symptoms of this species. Other species of the genus to cause necrosis on roots and allow ingress of other root pathogens, particularly fungi. Tumeric is the type host but the species has also been intercepted on aquarium plants (*Anubias* sp., *Echinodores* sp., *Ophiopogon* sp.) imported into Poland from Southeast Asia (Ryss and Karnkowski 2010).

All species from the genus are migratory endoparasites. Information on the lifecycle of this nematode is not available.

Environmental preferences of this species are poorly known. Thus far it has been reported from Indonesia only.

**Filter 1:** *Recorded in ASEAN or NAQS countries*

NAQS region: Indonesia

**Filter 2:** *Common crop hosts present in ASEAN-NAQS region as well as in Australia*

*Cucuma zedoaria* (Tumeric)

**Filter 3:** *Pathway present*

*Proven:* Soil, Plants or Plant Parts (including aquatic plants); Corms, Rhizomes and Tubers; Roots and Root Stock;

*Probable:* Flower and Ornamental Plants; Sea Swept Plant Debris

**Criterion 1:** *Recorded in NAQS countries*

Yes, Indonesia

**Criterion 2:** *Absent from Australia*

Not recorded from Australia.

**Criterion 3:** *Pathogenicity to crops proven*

Not known
Radopholus citri

Threat: Greatest

Taxonomy
Name: Radopholus citri Machon & Bridge, 1996
Common Name: None

Biological characteristics
Causes severely reduced growth in Citrus spp., accompanied by necrosis and root damage. There is limited information on host range: reported from the field on citrus only, however can be cultured on excised maize roots and carrots (Machon and Bridge, 1996).

A migratory endoparasite feeding on the roots of Citrus spp. There is limited information available on the life cycle of this species.

There is limited information on the environmental preferences of this species, other than its distribution seems limited.

Filter 1: Recorded in ASEAN or NAQS countries
ASEAN: Indonesia (Type locality is East Java)

Filter 2: Common crop hosts present in ASEAN-NAQS region as well as in Australia
Citrus spp.

Filter 3: Pathway present
Proven: Soil; Plants or Plant Parts; Roots and Rootstock

Criterion 1: Recorded in NAQS countries
Yes; Indonesia.

Criterion 2: Absent from Australia
Not recorded from Australia.

Criterion 3: Pathogenicity to crops proven
Pathogenicity demonstrated to Citrus spp. in pot trials at 1000 nematodes per plant (Machon and Bridge, 1996).
Radopholus similis

Threat: Probable

Taxonomy
Name: Radopholus similis (Cobb, 1893), Thorne 1949

Synonyms: Tylenchus similis Cobb, 1893
             Anguillulina similis (Cobb) Goodey, 1932
             Rotylenchus similis (Cobb) Filipjev, 1936
             Tylenchus granulosus Cobb, 1893 (= senior synonym)
             Anguillulina granulosa (Cobb) Goodey, 1932;
             Tetylenchus granulosus (Cobb) Filipjev 1936;
             Radopholus granulosus (Cobb) Siddiqi, 1986
             Tetylenchus acutocaudatus Zimmermann, 1898
             Anguillulina acutocaudata (Zimmermann) Goodey, 1932
             Tylenchorhynchus acutocaudatus (Zimmermann) Filipjev, 1934
             Radopholus acutocaudatus (Zimmermann) Siddiqi, 1986
             Tylenchus biformis Cobb, 1909
             Anguillulina biformis (Cobb) Goodey, 1932
             Radopholus biformis (Cobb) Siddiqi, 1986
             Radopholus similis similis Cobb, 1893 (Siddiqi, 1986)
             Radopholus similis citrophilus Huettel, Dickson & Kaplan, 1984
             Radopholus similis citrophilus Huettel, Dickson & Kaplan, 1984 (Siddiqi, 1986)

Subspecies: Radopholus similis similis (Cobb, 1893) Thorne, 1949 (Siddiqi, 1986)
            Radopholus similis citrophilus Huettel, Dickson & Kaplan, 1984 (Siddiqi, 1986) (= citrus race of
            R. similis)


Common Name: Burrowing nematode

Biological characteristics
The type subspecies is a destructive pathogen of banana and a wide range of other crop and ornamental plants, but not Citrus spp.. Subspecies citrophilus—also known as the Citrus race—parasitises Citrus spp., as well as many other plants but not banana. On banana, heavy infestation of the roots causes root-rot, weakening of the root system and toppling of the plant, a typical symptom of this nematode. On citrus, the species causes spreading decline, a slow loss of general health. On pepper, it causes the yellows disease. Damage to many other crops has been recorded.

A migratory endoparasite residing and feeding in root cortex, corms and tubers. It can complete its lifecycle in 20-25 days under ideal conditions (Gowen et al., 2005).

The burrowing nematode parasitizing banana and other crops is widespread in most tropical and subtropical areas of the world. The subspecies attacking Citrus spp. is known from Florida, USA, and possibly a few other locations in Central and South America. There is considerable variability within the species which is still to be understood (Moens & Perry 2009) and there may be other races or subspecies (Gafur unpublished).

Filter 1: Recorded in ASEAN or NAQS countries
ASEAN region: Brunei Darussalam, Malaysia, Thailand
NAQS region: Indonesia, PNG, Solomon Islands

Filter 2: Common crop hosts present in ASEAN-NAQS region as well as in Australia
Abelmoschus spp. (okra, abika etc.), Ananas comosus (pineapple), Arachis hypogaea (peanut), Bambusa spp. (bamboo), Beta vulgaris (beetroot), Brassica spp. (cabbage, broccoli etc.), Camellia sinensis (tea), Capsicum spp. (chilli, capsicum etc.), Citrullus lanatus (watermelon), Cocos nucifera (coconut), Coffea sp. (coffee), Cucurbitaceae spp. (cucumber, pumpkin, squash etc.), Dioscorea spp., Ficus spp. (figs), Gardenia sp., Glycine max (soybean), Heliconia spp., Hibiscus spp., Ipomoea spp., Lactuca spp., Litchi chinensis (lychee), Mangifera spp. (mango), Momordica

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charantia (bitter melon), Musa spp. (banana & plantain), Persea americana (avocado), Petroselinum crispum (parsley), Phaseolus vulgaris (haricot bean), Pinus spp. (pine), Piper spp. (pepper), Psidium guajava (guava), Saccharum officinarum (sugarcane), Solanum spp. (potato, aubergine, tomato etc.), Sorghum spp. (sorghum), Theobroma cacao (cacao), Triticum spp. (wheat), Vigna spp. (bean), Zea mays (maize), Zingiber officinale (ginger)

Filter 3: Pathway present

Proven: Soil; Plants or Plant Parts (including aquarium plants); Corms, Rhizomes and Tubers; Roots and Root Stock; Seedlings & Nursery Stock; Flower and Ornamental Plants
Probable: Sea Swept Plant Debris

Criterion 1: Recorded in NAQS countries

Yes, Indonesia, PNG, Solomon Islands

Criterion 2: Absent from Australia

Present in Australia. There is evidence that a very restricted part of the known worldwide variation within this species is present (Cobon & Pattison 2003, Kaplan et al. 2000, Stirling & Pattison 2008, Tan et al. 2010).

Criterion 3: Pathogenicity to crops proven

Damages banana and a wide range of other crops such as ginger (Gowen, Queneherve & Fogain 2005): yields reduced by 40-70% (oranges), 50-80% (grapefruits) and 95% after 10 years (Esser et al. 1988). Damage to turmeric, cardamoms, ginger and peppers has been reported in various field locations, along with severe damage in inoculation trials on soyabean, sorghum, maize and sugarcane, and moderate damage to roots of aubergines, coffee, tomatoes and potatoes.
**Xiphinema americanum s.l.**

**Threat: Probable**

**Taxonomy**

*Name:* Xiphinema americanum Cobb 1913 sensu lato

*Synonyms:* Tylencholaimus americanus (Cobb 1913) Micoletzky 1922

*Taxonomic Position:* Nematoda: Dorylaimae: Dorylaimida: Xiphinematidae

*Common Name:* American Dagger Nematode

**Biological characteristics**

Direct feeding causes damage to roots in many crops (McElroy, 1992). Transmits plant viruses including tomato ringspot nepovirus (TomRSV), tobacco ringspot nepovirus (TRSV), cherry rasp leaf nepovirus (CRLV) and peach rosette mosaic nepovirus (PRLV).

A migratory ectoparasite living on the outer surface of plants and feeding on plant roots. The lifecycle of the nematode 1 year (Hunt 1993).

The nematode is widespread, preferring drier sandy soils and moderate temperatures (20-24ºC) but also occurs in heavy soils and higher or lower temperatures.

**Filter 1:** Recorded in ASEAN or NAQS countries

ASEAN region: Philippines, Thailand

Also New Zealand, and found in Europe, East and North Asia and The Americas.

**Filter 2:** Common crop hosts present in ASEAN-NAQS region as well as in Australia


**Filter 3:** Pathway present

**Proven:** Soil

**Probable:** Plants or Plant Parts; Corms, Rhizomes & Tubers; Bulbs; Flower & Ornamental Plants

**Criterion 1:** Recorded in NAQS countries

No.

**Criterion 2:** Absent from Australia

Widespread in Australia, but a limited number of species within the complex are known (Sturhan et al., 1997).

**Criterion 3:** Pathogenicity to crops proven

Yes (Lamberti and Ciancio, 1994).

**Notes**

*Xiphinema americanum* sensu lato is a species complex of about 40 species. *Xiphinema americanum* sensu stricto is a valid species, but the complex is still to be resolved taxonomically. Differences between species are very small and intraspecific variability remains unresolved (Hunt 1993, Lamberti and Ciancio, 1994). Hence
reports may refer to any of the species in the complex, and the complex is dealt with as a whole for quarantine purposes (eg Lamberti and Ciancio, 1994).
Appendix D—Nematodes recorded on host crops considered

The following lists include all nematode species that have been found on each host, not just those recorded in the NAQS countries, ASEAN countries or Australia.

**Bold underlined**—greatest nematode threats

**Bold**—probable nematode threats.
Abelmoschus spp. (aibika, okra etc.)
Belonolaimus longicaudatus
Helicotylenchus dihystera
Helicotylenchus multicinctus
Hirschmanniella imamurai
Hirschmanniella oryzae
Hoplolaimus indicus
Meloidogyne arenaria
Meloidogyne incognita
Meloidogyne javanica
Paratrichodorus minor
Paratrichodorus porosus
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus thornei
Pratylenchus zeae
Rotylenchulus reniformis
Scutellonema clathricaudatum
Scutellonema sp.
Ananas comosus (pineapple)
Helicotylenchus dihystera
Hemicriconemoides mangiferae
Heterodera schachtii
Hoplolaimus pararobustus
Hoplolaimus seinhorsti
Hoplolaimus sp.
Longidorus sp.
Macroposthonia onoensis
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus brachyurus
Pratylenchus sp.
Radopholus similis
Radopholus sp.
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema sp.
Annona reticulata (custard apple)
Hoplolaimus pararobustus
Pratylenchus brachyurus
Bambusa spp. (bamboo)
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Hemicriconemoides mangiferae
Hemicriconemoides strictathecatus
Heterodera zeae
Macroposthonia xenoplax
Merlinius brevidens
Paratrichodorus porosus
Paratylenchus hamatus
Pratylenchus brachyurus
Pratylenchus neglectus
Pratylenchus penetrans
Radopholus similis
Scutellonema brachyurum
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchulus semipenetrans
Xiphinema americanum
Bougainvillea spp.
Helicotylenchus dihystera
Meloidogyne incognita
Meloidogyne javanica
Xiphinema americanum
Xiphinema index
Xiphinema pachtaicum
Zygotylenchus sp.

Nematode threats in the NAQS region

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Brassica spp. (cabbage, broccoli etc.)
- Aphelenchoides fragariae
- Belonolaimus longicaudatus
- Ditylenchus dipsaci
- Helicotylenchus dihystera
- Helicotylenchus multicinctus
- Helicotylenchus pseudorobustus
- Heterodera cruciferae
- Heterodera schachtii
- Heterodera trifolii
- Hoplolaimus galeatus
- Hoplolaimus indicus
- Hoplolaimus seinhorsti
- Longidorus elongatus
- Longidorus sp.
- Meloidogyne arenaria
- Meloidogyne graminicola
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Merlinius brevidens
- Paratrichodorus minor
- Paratrichodorus porosus
- Pratylenchus hamatus
- Pratylenchus coffeae
- Pratylenchus hexincisus
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus pratensis
- Pratylenchus scribneri
- Pratylenchus thornei
- Pratylenchus vulnus
- Radopholus similis
- Rotylenchulus reniformis
- Scutellonema clathricaudatum
- Scutellonema sp.
- Tylenchorhynchus clarus
- Tylenchorhynchus claytoni
- Xiphinema americanum
- Xiphinema index
- Xiphinema italica
- Xiphinema pachtaicum
- Xiphinema sp.

Calopogonium caeruleum
(Not common in study area, see p14)
- Helicotylenchus dihystera

Calopogonium mucunoides
- Helicotylenchus dihystera
- Helicotylenchus arenaria
- Meloidogyne arenaria
- Meloidogyne incognita
- Pratylenchus brachyurus
- Pratylenchus coffeae

Camellia sinensis (tea)
- Ditylenchus destructor
- Helicotylenchus dihystera
- Hoplolaimus pararobustus
- Meloidogyne arenaria
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Meloidogyne sp.
- Meloidogyne thamesi
- Paratrichodorus minor
- Pratylenchus brachyurus
- Pratylenchus loosi
- Pratylenchus penetrans
- Pratylenchus pratensis
- Pratylenchus pseudopratensis
- Pratylenchus sp.

Radopholus similis
- Radopholus sp.

Capsicum spp. (chilli, capsicum etc.)
- Belonolaimus longicaudatus
- Ditylenchus destructor
- Helicotylenchus dihystera
- Hemicyclophora arenaria
- Hoplolaimus galeatus
- Hoplolaimus indicus
- Hoplolaimus seinhorsti
- Longidorus sp.
- Meloidogyne arenaria
- Meloidogyne enterolobii
- Meloidogyne exigua
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Merlinius brevidens
- Paratrichodorus minor
- Pratylenchus brachyurus
- Pratylenchus coffeae
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus scribneri
- Pratylenchus thornei
- Pratylenchus zeae

Radopholus similis
- Rotylenchulus reniformis
- Scutellonema brachyurum
- Xiphinema americanum
- Xiphinema index
- Xiphinema sp.
- Zygotylenchus sp.
Carica papaya (pawpaw)
Helicotylenchus dihystera
Hemicriconemoides cucophila
Hemicriconemoides mangiferae
Hemicriconemoides strictathecatus
Hoplolaimus pararobustus
Meloidogyne arenaria
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus penetrans
Pratylenchus zeae
Rotylenchulus parvus
Rotylenchulus reniformis
Rotylenchulus sp.
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.

Celosia argentea (cock’s comb)
(Not common in study area, see p14)
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus penetrans
Scutellonema sp.

Citrus spp.
Belonolaimus longicaudatus
Ditylenchus destructor
Helicotylenchus dihystera
Helicotylenchus microcephalus
Helicotylenchus multicornis
Helicotylenchus pseudorobustus
Hemicriconemoides mangiferae
Hemicriconemoides sp.
Hemicriconemoides strictathecatus
Hemicycliophora arenaria
Hemicycliophora sp.
Hoplolaimus galeatus
Hoplolaimus indicus
Hoplolaimus pararobustus
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne exigua
Meloidogyne incognita
Meloidogyne javanica
Meloidogyne sp.
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Paratrichodorus sp.
Paratylenchus hamatus
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus hexincisus
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus sp.
Pratylenchus thornei
Pratylenchus vulnus

Radopholus citri
Radopholus similis
Radopholus sp.
Rotylenchulus parvus
Rotylenchulus reniformis
Rotylenchus robustus
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus sp.
Tylenchulus semipenetrans
Tylenchulus sp.

Xiphinema americanum
Xiphinema basiri
Xiphinema brasiliense
Xiphinema brevicollum
Xiphinema index
Xiphinema insigne
Xiphinema italicum
Xiphinema pachtaicum
Xiphinema sp.
Nematode threats in the NAQS region

Cocos nucifera (coconut)
Helicotylenchus dihystera
Hemicriconemoides cocophilus
Hemicriconemoides mangiferae
Hemicriconemoides strictathecatus
Meloidogyne incognita
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus zeae
Radopholus similis
Radopholus sp.
Rotylenchulus reniformis
Scutellonema sp.
Tylenchorhynchus sp.
Xiphinema americanum
Xiphinema basiri
Xiphinema insigne
Xiphinema sp.
Coffee sp. (coffee)
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Hoplolaimus pararobustus
Hoplolaimus sp.
Longidorus sp.
Meloidogyne arenaria
Meloidogyne exigua
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Meloidogyne sp.
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus loosi
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus sp.
Pratylenchus vulnus
Quinisulcius capitatux
Radopholus arabocoffeae
Radopholus durioiophilus
Radopholus similis
Radopholus sp.
Rotylenchulus reniformis
Tylenchorhynchus sp.
Xiphinema americanum
Xiphinema italicae
Xiphinema sp.
Colocasia esculenta (taro)
Aphelenchoides besseyi
Helicotylenchus dihystera
Hirschmanniella mitchica
Hirschmanniella sp.
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus coffeae
Pratylenchus penetrans
Quinisulcius acatus
Rotylenchulus reniformis
Coriandrum sativum (coriander)
Meloidogyne arenaria
Meloidogyne incognita
Meloidogyne javanica
Cucurbitaceae spp. (cucumber, pumpkin, squash etc.)
Belonolaimus longicaudatus
Ditylenchus destructor
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus multicipunctatus
Helicotylenchus pseudorobustus
Hemicycliphora arenaria
Heterodera glycines
Heterodera trifolii
Hoplolaimus indicus
Hoplolaimus seinothorsti
Longidorus elongatus
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne arenaria
Meloidogyne enterolobii
Meloidogyne exigua
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Paratylenchus hamatus
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus crenatus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus vulnus
Radopholus similis
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Tylenchorhynchus clarus
Xiphinema americanum
Xiphinema pachtaicum
Xiphinema rivesi
Zygotylenchus sp.
Dimocarpus longan (longan)
- Hemicriconemoides mangiferae

Dioscorea spp.
- Aphelenchoides besseyi
- Helicotylenchus dihystera
- Hoplolaimus pararobustus
- Longidorus sp.
- Meloidogyne arenaria
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Paratrichodorus minor
- Paratrichodorus porosus
- Pratylenchus brachyurus
- Pratylenchus coffeeae
- Pratylenchus loosi
- Pratylenchus penetrans
- Pratylenchus pratensis
- Radopholus similis
- Rotylenchus reniformis
- Scutellonema clathricaudatum
- Scutellonema sp.

Dracaena spp.
- Helicotylenchus dihystera
- Meloidogyne incognita
- Meloidogyne javanica
- Pratylenchus coffeeae
- Pratylenchus penetrans
- Pratylenchus vulnus
- Rotylenchus reniformis
- Scutellonema brachyurum

Durio spp. (durian)
- Radopholus duriophilus
- Radopholus sp.

Elettaria cardamomum (cardamom)
- Meloidogyne incognita
- Meloidogyne javanica
- Pratylenchus coffeeae
- Rotylenchus reniformis

Ficus spp. (figs)
- Aphelenchoides fragariae
- Helicotylenchus dihystera
- Heterodera fici
- Heterodera sp.
- Longidorus elongatus
- Longidorus sp.
- Macroposthonia onoensis
- Macroposthonia sp.
- Meloidogyne arenaria
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Merlinius brevidens
- Paratrichodorus minor
- Paratrichodorus porosus
- Paratylenchus hamatus
- Pratylenchus brachyurus
- Pratylenchus coffeeae
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus pratensis
- Pratylenchus thornei
- Pratylenchus vulnus
- Radopholus similis
- Rotylenchus reniformis
- Rotylenchus sp.
- Scutellonema brachyurum
- Scutellonema sp.
- Tylenchorhynchus annulatus
- Tylenchorhynchus clarus
- Xiphinema americanum
- Xiphinema index
- Xiphinema pachtaicum
- Xiphinema sp.

Gardenia sp.
- Helicotylenchus dihystera
- Meloidogyne arenaria
- Meloidogyne incognita
- Merlinius brevidens
- Paratrichodorus porosus
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus vulnus
- Radopholus similis
- Scutellonema brachyurum
- Xiphinema americanum
Glycine max (soybean)
(Not common in study area, see p14)
Aphelenchoides besseyi
Belonolaimus longicaudatus
Belonolaimus sp.
Ditylenchus destructor
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Helicotylenchus sp.
Heterodera glycines
Hoplolaimus galeatus
Hoplolaimus seinhorsti
Hoplolaimus sp.
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne arenaria
Meloidogyne graminicola
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Meloidogyne sp.
Meloidogyne trifoliophila
Paratrichodorus minor
Paratrichodorus porosus
Pratylenchus alleni
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus hexincisus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pseudopratensis
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus teres
Pratylenchus thornei
Pratylenchus vulnus
Pratylenchus zeae
Quininsulcius acutus
Radopholus similis
Rotylenchulus parvus
Rotylenchulus reniformis
Rotylenchulus sp.
Scutellonema brachyurum
Scutellonema sp.
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus sp.
Xiphinema americanum
Xiphinema sp.
Heliconia spp.
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus coffeae
Pratylenchus goodeyi
Radopholus similis

Hibiscus spp.
Aphelenchoides besseyi
Aphelenchoides fragariae
Aphelenchoides ritzemabosi
Helicotylenchus dihystera
Helicotylenchus multicinctus
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Paratrichodorus minor
Pratylenchus brachyurus
Pratylenchus loosi
Pratylenchus penetrans
Pratylenchus vulnus
Radopholus similis
Rotylenchulus reniformis
Scutellonema sp.
Xiphinema americanum
Ipomoea spp.
Aphelenchoides besseyi
Aphelenchoides fragariae
Belonolaimus longicaudatus
Ditylenchus destructor
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus microcephalus
Helicotylenchus multicinctus
Hoplolaimus indicus
Longidorus sp.
Macroposthonia onoensis
Meloidogyne arenaria
Meloidogyne exigua
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Pratylenchus brachyurus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Radopholus similis
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema sp.
Tylenchorhynchus annulatus
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus sp.
Lactuca spp.
Aphelechoides ritzemabosi
Belonolaimus longicaudatus
Helicotylenchus dihystera
Helicotylenchus multicinctus
Helicotylenchus pseudorobustus
Heteroder a crassiferae
Longidor us elongatus
Longidor us sp.
Meloidogyne arenaria
Meloidogyne fallax
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Pratylench us coffeae
Pratylench us crenatus
Pratylench us neglectus
Pratylench us penetrans
Pratylench us pratensis
Pratylench us thornei
Pratylench us zeae
Radophol us similis
Rotylench us parvus
Rotylench us reniformis
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Trichodora cylindricus
Tylenchorhynch us clarus
Tylenchorhynch us claytoni
Xiphinema americanum
Litchi chinensis (lychee)
Hemicriconemoides mangiferae
Hemicriconemoides sp.
Hemicriconemoides strictathecatus
Paratrichodorus mirzai
Paratrichodorus sp.
Radophol us similis
Rotylench us reniformis
Tylenchorhynch us claytoni
Tylenchorhynch us sp.
Xiphinema americanum
Mangifera spp. (mango)
Helicotylench us dihystera
Hemicriconemoides cocophilus
Hemicriconemoides mangiferae
Hemicriconemoides sp.
Hemicriconemoides strictathecatus
Hoplolaimus indicus
Hoplolaimus pararobustus
Hoplolaimus seinhorstii
Hoplolaimus sp.
Meloidogyne incognita
Pratylench us brachyurus
Pratylench us loosi
Pratylench us penetrans
Pratylench us sp.
Pratylench us teres
Quininsulcius acutus
Radophol us similis
Rotylench us reniformis
Tylenchorhynch us annulatus
Xiphinema americanum
Xiphinema basiri
Xiphinema brasiilense
Xiphinema rivesi
Xiphinema sp.
Manihot esculenta (cassava)
Helicotylench us dihystera
Hemicriconemoides mangiferae
Meloidogyne incognita
Meloidogyne javanica
Pratylench us brachyurus
Pratylench us coffeae
Rotylench us reniformis
Scutellonema clathricaudatum
Scutellonema sp.
Tylenchorhynch us mashhooodi
Tylenchorhynch us sp.
Manilkara zapota (sapodilla)
Hemicriconemoides mangiferae
Hemicriconemoides strictathecatus
Xiphinema americanum
Momordica charantia (bitter melon)
Helicotylench us dihystera
Meloidogyne incognita
Pratylench us coffeae
Radophol us similis
Rotylench us reniformis
**Morus spp. (mulberry)**
- Helicotylenchus pseudorobustus
- Hoplolaimus seinhorsti
- Hoplolaimus sp.
- Longidorus sp.
- Macroposthonia xenoplax
- Meloidogyne arenaria
- Meloidogyne incognita
- Meloidogyne javanica
- Meloidogyne sp.
- Paratrichodorus porosus
- Pratylenchus coffeae
- Pratylenchus penetrans
- Pratylenchus vulnus
- Scutellonema brachyurum

**Xiphinema americanum**
- Xiphinema index
- Xiphinema pachtaicum
- Xiphinema sp.

**Musa spp. (banana & plantain)**
- Helicotylenchus dihystera
- Helicotylenchus microcephalus
- Helicotylenchus multicinctus
- Helicotylenchus pseudorobustus
- Helicotylenchus sp.
- Helicotylenchus varicaudatus
- Hemicriconemoides cocophilus
- Hemicriconemoides mangiferae
- Hemicriconemoides strictathecatus
- Heterodera oryzae
- Hoplolaimus indicus
- Hoplolaimus pararobustus
- Hoplolaimus seinhorsti
- Hoplolaimus sp.
- Longidorus sp.
- Macroposthonia xenoplax
- Meloidogyne arenaria
- Meloidogyne exigua
- Meloidogyne hapla
- Meloidogyne incognita
- Meloidogyne javanica
- Meloidogyne sp.
- Merlinius brevidens
- Paratrichodorus minor
- Paratrichodorus porosus
- Paratylenchus hamatus
- Pratylenchus coffeae
- Pratylenchus goodeyi
- Pratylenchus loosi
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus sp.
- Pratylenchus thornei
- Pratylenchus vulnus
- Pratylenchus zeae

**Radopholus similis**
- Radopholus sp.
- Rotylenchulus reniformis
- Scutellonema brachyurum
- Scutellonema clathricaudatum
- Scutellonema minutum
- Scutellonema sp.
- Tylenchorynchus clarus
- Tylenchorynchus claytoni
- Tylenchorynchus nudus
- Tylenchorynchus sp.
- Tylenchulus semipenetrans

**Xiphinema americanum**
- Xiphinema italica
- Xiphinema sp.

**Nephelium lappaceum (rambutan)**
- Meloidogyne hapla
<table>
<thead>
<tr>
<th><strong>Nicotiana tabacum (tobacco)</strong></th>
<th><strong>Oryza spp. (rice)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Not common in study area, see p14)</td>
<td></td>
</tr>
<tr>
<td>Aphelenchoides ritzemabosi</td>
<td>Aphelenchoides besseyi</td>
</tr>
<tr>
<td>Ditylenchus dipsaci</td>
<td>Ditylenchus angustus</td>
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<tr>
<td>Globodera sp.</td>
<td>Ditylenchus sp.</td>
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<tr>
<td>Helicotylenchus dihystera</td>
<td>Helicotylenchus dihystera</td>
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<td>Helicotylenchus pseudorobustus</td>
<td>Helicotylenchus multiceps</td>
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<td><strong>Hirschmanniella oryzae</strong></td>
<td>Helicotylenchus pseudorobustus</td>
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<tr>
<td>Longidorus sp.</td>
<td>Hemicriconemoides cocophilus</td>
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<tr>
<td>Meloidogyne arenaria</td>
<td>Hemicriconemoides sp.</td>
</tr>
<tr>
<td>Meloidogyne enterolobii</td>
<td>Heterodera oryzae</td>
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<tr>
<td>Meloidogyne hapla</td>
<td>Heterodera sacchari</td>
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<td>Meloidogyne incognita</td>
<td>Heterodera schachtii</td>
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<td>Meloidogyne javanica</td>
<td>Heterodera sp.</td>
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<tr>
<td>Meloidogyne sp.</td>
<td><strong>Heterodera zeae</strong></td>
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<tr>
<td>Paratrichodorus minor</td>
<td>Hirschmanniella imamuri</td>
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<tr>
<td>Paratrichodorus sp.</td>
<td><strong>Hirschmanniella oryzae</strong></td>
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<td>Pratylenchus brachyurus</td>
<td>Hirschmanniella sp.</td>
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<td>Pratylenchus neglectus</td>
<td>Hoplolaimus galeatus</td>
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<tr>
<td>Pratylenchus penetrans</td>
<td>Hoplolaimus indicus</td>
</tr>
<tr>
<td>Pratylenchus sp.</td>
<td>Hoplolaimus pararobustus</td>
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<tr>
<td>Pratylenchus teres</td>
<td>Hoplolaimus seinhorsti</td>
</tr>
<tr>
<td>Pratylenchus vulnus</td>
<td>Hoplolaimus sp.</td>
</tr>
<tr>
<td>Pratylenchus zeae</td>
<td>Macroposthonia onoensis</td>
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<tr>
<td>Quinissulcius acatus</td>
<td>Macroposthonia xenoplax</td>
</tr>
<tr>
<td>Rotylenchulus parvus</td>
<td>Meloidogyne arenaria</td>
</tr>
<tr>
<td>Rotylenchulus reniformis</td>
<td>Meloidogyne exigua</td>
</tr>
<tr>
<td>Rotylenchulus sp.</td>
<td>Meloidogyne graminicola</td>
</tr>
<tr>
<td>Scutellonema brachyurum</td>
<td>Meloidogyne incognita</td>
</tr>
<tr>
<td>Scutellonema clathricaudatum</td>
<td>Meloidogyne javanica</td>
</tr>
<tr>
<td>Scutellonema sp.</td>
<td>Meloidogyne naasi</td>
</tr>
<tr>
<td>Trichodora sp.</td>
<td>Meloidogyne sp.</td>
</tr>
<tr>
<td>Tylenchorhynchus claytoni</td>
<td>Merlinius brevidens</td>
</tr>
<tr>
<td>Tylenchorhynchus sp.</td>
<td>Paralongidorus australis</td>
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<tr>
<td><strong>Xiphinema americanum</strong></td>
<td>Paratrichodorus minor</td>
</tr>
<tr>
<td>Xiphinema rivesi</td>
<td>Paratrichodorus sp.</td>
</tr>
<tr>
<td>Xiphinema sp.</td>
<td>Paratrichodorus minor</td>
</tr>
</tbody>
</table>

**Nematode threats in the NAQS region**

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Passiflora spp. (passion fruit)
Aphelenchoides ritzemabosi
Helicotylenchus dihystera
Meloidogyne arenaria
Meloidogyne incognita
Meloidogyne javanica
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema sp.
Xiphinema americanum

Persea americana (avocado)
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Longidorus sp.
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Pratylenchus hamatus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus thornei
Pratylenchus vulnus

Radopholus similis
Radopholus sp.
Rotylenchulus reniformis
Scutellonema brachyurum
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus semipenetrans

Xiphinema americanum
Xiphinema brasiliense
Xiphinema italicum
Xiphinema sp.

Petroselinum crispum (parsley)
Ditylenchus dipsaci
Heterodera schachtii
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Paratylenchus hamatus
Pratylenchus penetrans

Radopholus similis
Tylenchorhynchus clarus
Tylenchorhynchus sp.
Zygotylenchus sp.

Phaseolus vulgaris (haricot bean)
Aphelenchoides ritzemabosi
Belonolaimus longicaudatus
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus multicinctus
Helicotylenchus pseudorobustus

Heterodera glycines
Heterodera schachtii
Heterodera trifolii
Hoplolaimus galeatus
Hoplolaimus pararobustus
Hoplolaimus seinhorsii

Longidorus elongatus
Longidorus sp.
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Pratylenchus brachyurus
Pratylenchus goodeyi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus scribneri
Pratylenchus thornei
Pratylenchus vulnus
Quininsulcius acatus

Radopholus similis
Rotylenchulus parvus
Rotylenchulus reniformis
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus sp.

Xiphinema americanum
Xiphinema index
**Pinus spp. (pine)**
- Belonolaimus longicaudatus
- Bursaphelenchus sp.
- Bursaphelenchus xylophilus
- Ditylenchus dipsaci
- Helicotylenchus dihystera
- Helicotylenchus pseudorobustus
- Hoplolaimus galeatus
- Hoplolaimus indicus
- Hoplolaimus sp.
- Longidorus sp.
- Macroposthonia xenoplax
- Meloidogyne arenaria
- Meloidogyne incognita
- Merlinius brevidens
- Paralongidorus sp.
- Paratrichodorus minor
- Paratrichodorus porosus
- Paratrichodorus renifer
- Paratrichodorus sp.
- Paratylenchus hamatus
- Pratylenchus brachyurus
- Pratylenchus crenatus
- Pratylenchus neglectus
- Pratylenchus penetrans
- Pratylenchus pratensis
- Pratylenchus sp.
- Pratylenchus teres
- Pratylenchus thornei
- Pratylenchus vulnus

**Radopholus similis**
- Radopholus sp.
- Rotylenchulus parvus
- Rotylenchus robustus
- Rotylenchus sp.
- Scutellonema brachyurum
- Scutellonema sp.
- Tylenchorhynchus clarus
- Tylenchorhynchus claytoni
- Tylenchorhynchus sp.

**Xiphinema americanum**
- Xiphinema index
- Xiphinema italica
- Xiphinema rivesi
- Xiphinema sp.

**Piper spp. (pepper)**
- Helicotylenchus dihystera
- Helicotylenchus varicaudatus
- Hemicriconemoides mangiferae
- Hoplolaimus seinhorsti
- Hoplolaimus sp.
- Macroposthonia onoensis
- Macroposthonia sp.
- Meloidogyne arenaria
- Meloidogyne incognita
- Pratylenchus coffeae

**Radopholus similis**
- Radopholus sp.
- Rotylenchulus reniformis
- Scutellonema clathricaudatum
- Scutellonema sp.
- Xiphinema sp.

**Psidium guajava (guava)**
- Helicotylenchus dihystera
- Hemicriconemoides cocophilus
- Hemicriconemoides mangiferae
- Hoplolaimus indicus
- Hoplolaimus pararobustus
- Meloidogyne arenaria
- Meloidogyne enterolobii
- Meloidogyne sp.
- Pratylenchus pratensis
- Pratylenchus zeae

**Radopholus similis**
- Tylenchorhynchus sp.

**Xiphinema americanum**
- Xiphinema italica

**Psophocarpus tetragonolobus (winged bean)**
- Meloidogyne incognita
- Rotylenchulus reniformis

**Rhododendron spp.**
- (Not common in study area, see p14)
- Aphelenchoides fragariae
- Aphelenchoides ritzemabosi
- Helicotylenchus dihystera
- Helicotylenchus multifilis
- Macroposthonia xenoplax
- Meloidogyne incognita
- Merlinius brevidens
- Paratrichodorus minor
- Paratrichodorus porosus
- Pratylenchus crenatus
- Pratylenchus penetrans
- Pratylenchus vulnus
- Rotylenchus robustus
- Scutellonema brachyurum
- Tylenchorhynchus clarus
- Tylenchorhynchus claytoni
- Tylenchorhynchus sp.
- Xiphinema americanum
**Rosa spp. (rose)**
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Hemicriconemoides mangiferae
Hemicriconemoides strictathecatus
Hoplolaimus pararobustus
Hoplolaimus seinhorsti
**Longidorus elongatus**
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Paratylenchus hamatus
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus crenatus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus thornei
Pratylenchus vulnus
Rotylenchus robustus
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
**Xiphinema americanum**
Xiphinema basiri
Xiphinema index
Xiphinema rivesi
Xiphinema sp.
Saccharum officinarum (sugarcane)
Achlysiella williamsi
Belonolaimus longicaudatus
Cactodera cacti
Helicotylenchus dihystera
Helicotylenchus microcephalus
Helicotylenchus pseudorobustus
Hemicriconemoides cocophilus
Hemicriconemoides mangiferae
Hemicriconemoides sp.
Hemicycliophora arenaria
Hemicycliophora sp.
Heterodera sacchari
Heterodera schachtii
Heterodera sp.
Hirschmanniella imamuri
Hirschmanniella oryzae
Hoplolaimus galeatus
Hoplolaimus indicus
Hoplolaimus pararobustus
Hoplolaimus seinhorsti
Hoplolaimus sp.
Longidorus sp.
Macroposthonia onoensis
Macroposthonia sp.
Meloidogyne arenaria
Meloidogyne exigua
Meloidogyne incognita
Meloidogyne javanica
Paratrichodorus minor
Paratrichodorus mirzai
Paratrichodorus porosus
Paratrichodorus sp.
Pratylenchus brachyurus
Pratylenchus delattrei
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus sudanensis
Pratylenchus thornei
Pratylenchus zeae
Quinisulcius acutus
Radopholus similis
Radopholus sp.
Rotylenchulus parvus
Rotylenchulus reniformis
Rotylenchulus sp.
Scutellonema brachyurum
Scutellonema sp.
Tylenchorhynchus annulatus
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus mashhoodi
Tylenchorhynchus nudus
Tylenchorhynchus sp.
Xiphinema americanum

Xiphinema italicae
Xiphinema sp.

Nematode threats in the NAQS region © CSIRO
Solanum spp. (potato, aubergine, tomato etc.)
Aphelenchoides fragariae
Aphelenchoides ritzemabosi
Belonolaimus longicaudatus
**Ditylenchus destructor**
Ditylenchus dipsaci
**Globodera pallida**
**Globodera rostochiensis**
Globodera sp.
Helicotylenchus dihystera
Helicotylenchus multicinctus
Helicotylenchus pseudorobustus
Hemicycliophora arenaria
**Heteroderia glycines**
Heterodera oryzae
Heterodera schachtii
Heterodera trifolii
Hirschmanniella imamuri
**Hirschmanniella oryzae**
Hoplolaimus galeatus
Hoplolaimus indicus
Hoplolaimus seinhorstii
**Longidorus elongatus**
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne arenaria
**Meloidogyne enterolobii**
Meloidogyne fallax
**Meloidogyne graminicola**
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
**Meloidogyne naasi**
Meloidogyne thamesi
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus renifer
Paratylenchus hamatus
Pratylenchus allenii
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus crenatus
Pratylenchus goodeyi
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus pseudopratensis
Pratylenchus scribneri
Pratylenchus thornei
Pratylenchus vulnus
Pratylenchus zeae
**Radopholus similis**
Radopholus sp.
Rotylenchulus parvus
Rotylenchulus reniformis
Rotylenchus robustus
Scutellonema brachyurum

**Scutellonema clathricaudatum**
Scutellonema sp.
Trichodora cylindricus
Tylenchorynchus brassicae
Tylenchorynchus clarus
Tylenchorynchus claytoni
Tylenchorynchus sp.
Xiphinema americanum
Xiphinema basiri
Xiphinema index
Xiphinema pachtaicum
Xiphinema sp.
Zygotylenchus sp.
Sorghum spp. (sorghum)
Belonolaimus longicaudatus
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Heterodera avenae
Heterodera zea
Hoplolaimus indicus
Hoplolaimus pararobustus
Hoplolaimus seinhorsti
Longidorus sp.
Macroposthonia onoensis
Macroposthonia xenoplax
Meloidogyne arenaria

Meloidogyne graminicola
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica

Meloidogyne naasi
Meloidogyne sp.
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Paratrichodorus sp.
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus delattrei
Pratylenchus goodeyi
Pratylenchus hexincisus
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus scribneri
Pratylenchus sudanensis
Pratylenchus thornei
Pratylenchus zeae
Quinisulcius acutus

Radopholus similis
Rotylenchulus parvus
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Tylenchorhynchus annulatus
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus nudus
Tylenchorhynchus sp.

Xiphinema americanum
Xiphinema rivesi
Triticum spp. (wheat)
(Not common in study area, see p14)
Anguina tritici
Belonolaimus longicaudatus
Bitylenchus dubius
Ditylenchus angustus
Ditylenchus destructor
Ditylenchus dipsaci
Ditylenchus sp.
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Helicotylenchus sp.
Helicotylenchus varicaudatus
Heterodera avenae
Heterodera cruciferarum
Heterodera schachtii
Heterodera sp.

Heterodera zeae
Hirschmanniella imamuri
Hirschmanniella oryzae
Hoplolaimus indicus
Hoplolaimus pararobustus
Longidorus sp.
Meloidogyne arenaria
Meloidogyne graminicola
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Meloidogyne naasi
Meloidogyne sp.
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus sp.
Pratylenchus brachyurus
Pratylenchus delattrei
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pinguicaudatus
Pratylenchus pratensis
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus thornei
Radopholus nativus

Radopholus similis
Radopholus sp.
Rotylenchulus reniformis
Scutellonema clathricaudatum
Scutellonema sp.
Subanguina radicicola
Trichodora sp.
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus nudus
Tylenchorhynchus sp.

Xiphinema americanum
Xiphinema pachtaicum
Xiphinema sp.

Vigna spp. (bean)
Belonolaimus longicaudatus
Ditylenchus dipsaci
Helicotylenchus dihystera
Helicotylenchus multicinctus
Helicotylenchus pseudorobustus
Hemicycliophora arenaria
Heterodera glycines
Heterodera schachtii
Hoplolaimus indicus
Hoplolaimus pararobustus
Hoplolaimus seinhorstii
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus thornei
Pratylenchus vulnus
Quinisulcius acutus

Radopholus similis
Rotylenchulus parvus
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.

Xiphinema americanum
Vitis spp. (grape)
Belonolaimus longicaudatus
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Helicotylenchus sp.
Hemicriconemoides mangiferae
Hemicriconemoides sp.
Hemicriconemoides strictathecatus
Hemicycliophora arenaria
Heterodera schachtii
Hoplolaimus pararobustus
Hoplolaimus seinhorsti
Longidorus elongatus
Longidorus sp.
Macroposthonia xenoplax
Meloidogyne arenaria
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Meloidogyne sp.
Meloidogyne thamesi
Merlinius brevidens
Neodolichodorus sp.
Paratrichodorus minor
Paratrichodorus porosus
Paratrichodorus renifer
Paratrichodorus sp.
Paratylenchus hamatus
Pratylenchus brachyurus
Pratylenchus coffeeae
Pratylenchus crenatus
Pratylenchus goodeyi
Pratylenchus hexincisus
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus pratensis
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus thornei
Pratylenchus vulnus
Quinisculius acutus
Rotylenchulus reniformis
Rotylenchulus sp.
Rotylenchus robustus
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Tylenchorhynchus clarus
Tylenchorhynchus claytoni
Tylenchorhynchus mashhoodi
Tylenchulus semipenetrans
Xiphinema americanum
Xiphinema brasilienne
Xiphinema brevicollum
Xiphinema index
Xiphinema insigne
Xiphinema italae
Xiphinema pachtaicum
Xiphinema rivesi
Xiphinema sp.
Xiphinema vuittenezi
Zygotylenchus sp.
Xanthosoma spp.
Helicotylenchus dihystera
Meloidogyne incognita
Meloidogyne javanica
Pratylenchus coffeae
Rotylenchulus reniformis
Zea mays (maize)
Aphelenchoides besseyi
Belonolaimus longicaudatus
Ditylenchus destructor
Ditylenchus dipsaci
Dolichodorus sp.
Helicotylenchus dihystera
Helicotylenchus pseudorobustus
Hemicriconemoides mangiferae
Hemicycliophora sp.
Heteroder aavenae
Heterodera glycines
Heterodera oryzae
Heterodera schachtii
Heterodera sp.
Heterodera zeae
Hirschmanniella imamuri
Hirschmanniella oryzae
Hoplolaimus galeatus
Hoplolaimus indicus
Hoplolaimus seinhorsti
Hoplolaimus sp.
Longidorus elongatus
Longidorus sp.
Meloidogyne arenaria
Meloidogyne graminicola
Meloidogyne hapla
Meloidogyne incognita
Meloidogyne javanica
Merlinius brevidens
Paratrichodorus minor
Paratrichodorus porosus
Paratrichodorus sp.
Pratylenchus brachyurus
Pratylenchus coffeae
Pratylenchus crenatus
Pratylenchus delattrei
Pratylenchus goodeyi
Pratylenchus hexincisus
Pratylenchus loosi
Pratylenchus neglectus
Pratylenchus penetrans
Pratylenchus scribneri
Pratylenchus sp.
Pratylenchus thornei
Pratylenchus vulnus
Pratylenchus zeae
Quinisulcius acutus
Quinisulcius capitatus
Quinisulcius curvus
Radopholus similis
Radopholus sp.
Rotylenchulus parvus
Rotylenchulus reniformis
Scutellonema brachyurum
Scutellonema clathricaudatum
Scutellonema sp.
Trichodora sp.
Tylenchorhynchus clarus

Tylenchorhynchus claytoni
Tylenchorhynchus mashhoodi
Tylenchorhynchus sp.
Xiphinema americanum
Xiphinema pachtaicum
Xiphinema sp.
Zygotylenchus sp.
**Zingiber officinale (ginger)**
- *Helicotylenchus dihystera*
- *Meloidogyne arenaria*
- *Meloidogyne incognita*
- *Meloidogyne javanica*
- *Meloidogyne sp.*
- **Meloidogyne thailandica**
- *Pratylenchus brachyurus*
- *Pratylenchus coffeae*
- *Pratylenchus flakkensis*
- *Pratylenchus pratensis*
- *Pratylenchus zeae*
- **Radopholus similis**
- *Radopholus sp.*
- *Rotylenchulus reniformis*
- *Tylenchorhynchus mashhoodi*
- *Tylenchorhynchus sp.*
- *Xiphinema sp.*