Plant-Parasitic Nematodes – Biosecurity and Management in Northern Australia

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1. Introduction

1.1 What are nematodes

- Nematodes are tiny, worm-like animals that live in soil and water.
- Most are harmless or beneficial, helping to break down organic matter.
- Plant-parasitic nematodes (PPNs) feed on plant roots, reducing water and nutrient uptake. Damage often looks like nutrient or water stress, but unlike those problems, plants won't recover after fertilising or watering.
- Most are too small to see without a microscope but can cause major yield losses.

1.2 Why biosecurity matters

- Biosecurity is about preventing pathogens and pests from entering and spreading.
- PPNs can easily spread through soil on shoes, machinery, or tools, as well as via water flow and planting material.
- Once PPNs infest a paddock, they are usually only manageable, not eradicable. Prevention is the best defence.

1.3 Why nematodes matter to agriculture in Northern Australia

- PPNs can weaken plants, cause stunting, yellowing, tuber defects and poor root systems.
- Yield losses vary by crop and nematode type; small losses (<10%) are often uneconomic, but susceptible crops or outbreaks can exceed 20%.
- Crops at risk include broadacre crops (cotton, wheat, mungbeans, etc.), fruit crops (melons, bananas, pineapple, etc.), and vegetables (sweet potato, capsicum, tomato, cucumber, etc.).
- Tropical conditions allow nematodes to multiply quickly. If unmanaged, outbreaks can spread between farms.

2. Plant-Parasitic Nematodes in Northern Australia

Plant-parasitic nematodes (PPNs) feed on plant roots in different ways, depending on the species and crop. Some feed only on outer root tissue, while others penetrate deeper or completely enter the root. PPNs use a specialised needle-like structure (stylet) to feed. Some induce the plant to form enlarged or nutrient-rich cells that support nematode growth, while others directly damage root tissue.

These feeding activities reduce plant vigour and yield, leading to stunted growth, poor root systems, reduced yield, or, in severe cases, unmarketable produce or crop failure. Understanding how nematodes interact with roots helps growers recognise symptoms and select effective management strategies.

This section highlights the main PPNs affecting crops in Northern Australia, their biology, symptoms, and practical management options.

2.1 Sedentary endoparasite

Sedentary endoparasitic nematodes enter plant roots and stay fixed in one place, developing swollen females embedded inside the root tissue. They cause distinctive root damage and reduce crop growth.

2.1.1 Root-knot Nematodes (*Meloidogyne* spp.)

Common Name

Root-knot nematodes

Scientific Name

Meloidogyne spp.

Figure 1. Root-knot nematode juvenile (collected by Yujuan Jady Li)

Figure 2. Aboveground symptoms of root-knot nematode damage on pawpaw (collected by Yujuan Jady Li)

Figure 3. Zucchini root galls caused by root-knot nematodes (collected by Yujuan Jady Li)

Host Range

- Over 5,000 plant species, including melons, tomatoes, capsicum, cucumber, sweetpotato, eggplant, ornamental and pasture plants.

Symptoms

- **Roots:** Galled and stunted.

- **Aboveground:** Stunted growth, wilting, uneven crop performance, especially under heat or drought stress.

Life Cycle

- 4-6 weeks at 24-28°C; faster in tropical conditions
- A single female lays up to 1,000 eggs.

Reported Species in Northern Australia

- *M. arenaria, M. enterolobii*. *M. incognita*, *M. javanica*, *M. thamesi*

Potential Threat Species (Not Detected in Australia)

- *M graminicola* – can infect rice, cereals (wheat, sorghum, soybean), vegetables (potato, tomato, onion), and grasses; reported in Indonesia, Thailand, Bangladesh, India, Laos, and Brazil.

Why They Matter

- Major plant-parasitic nematodes in Northern Australia and worldwide.
- Can reduce yields by more than half and cost billions globally.
- Thrive in light soils and warm climates, multiplying year-round in northern regions.
- *M. enterolobii* can bypass resistance genes in many crops.

Management Options

Cultural Practices

- Use resistant or tolerant crop varieties where available.
- Rotate crops with non-host.
- Avoid moving soil, plants, or equipment from infested areas.
- Monitor crops regularly for root damage or poor growth.
- Manage weeds and cover crops that can host nematodes.

Biological Approaches

- Maintain healthy soils with compost, organic matter, and good soil structure.
- Avoid practices that harm beneficial soil organisms, such as excessive tillage or unnecessary chemicals.
- Commercial biological products can be used; check efficacy and follow local advice.

Chemical Control

- Use nematicides only when necessary.
- Confirm registered crops and safe via APVMA website (apvma.gov.au) or local agronomists.

Further Information

Hay F, Stirling GR (2014). Management of root-knot nematode in vegetable crops. Horticulture Innovation Australia.

MeloRisk Australasia: Reducing the risk of exotic root-knot nematodes in Australasia. Queensland Department of Agriculture and Fisheries / ACIAR, 2024. Available at: https://www.aciar.gov.au/projects/search/melorisk-australasia

2.1.2 Cyst nematodes (*Globodera* spp. & *Heterodera* spp.)

Common Name

Cyst nematodes

Scientific Name

Globodera spp. & *Heterodera* spp.

Host Range

- Potato, sugarcane, cereals (wheat, barley, oat, triticale), legumes (including clovers), beets, brassicas and others.

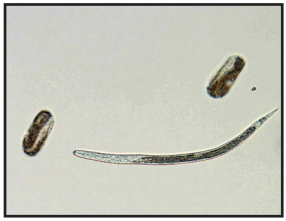

Figure 4. Potato cyst nematode eggs & juvenile (collected by Wayne O'Neill)

Symptoms

- Roots: Stunted, cysts (lemon-shaped) present.
- Aboveground: Patchy growth, yellowing, stunting.

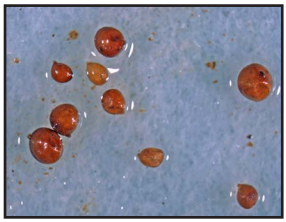

Figure 5. Potato cyst nematode cysts (collected by Wayne O'Neill)

Life Cycle

5-8 weeks; cysts can protect eggs for years.

Reported Species in Northern Australia

- *Globodera* spp. & *Heterodera* spp. (no species formally identified)

Other Key Species in Australia

- *G. rostochiensis* (Golden potato cyst nematode) only in Victoria where it is under quarantine control.
- *H. australis* (cereal cyst nematode) – found in South Australia and Victoria, mainly affecting wheat and barley.

Potential Threat Species (Not Detected in Australia)

- *G. pallida* (white potato cyst nematode) – infects potato, tomato, and some weeds; reported in >50 countries, including Indonesia, China, and Japan.
- *H. glycines* (soybean cyst nematode) – hosts include soybean, dry bean, lupine, sweet clover, and chickweed; reported in Japan, China, Korea, Indonesia, South America, former Soviet Union, and Canada.
- *H. zeae* (corn cyst nematode) – hosts include corn, barley, teosinte, millet, oat, rice, sorghum, sugarcane, wheat, and several weeds; reported in Indonesia, India, Pakistan, Egypt, and the United States.

Why They Matter

- Cause significant yield losses up to 70%.
- Long-lasting cysts make control difficult.

Management Options

Management follows the same general principles as for root-knot nematodes (Section 2.1.1). Key additional points are:

- Rotate with non-host crops; longer rotations are often needed as cysts can survive in soil for many years.

- Soil testing before planting is important to detect infestations early.
- Resistant varieties are available for some crops (e.g. potato, cereals).

Further Information

Blacket MJ, Agarwal A, Wainer J, Triska MD, Renton M, Edwards J (2019) Molecular assessment of the introduction and spread of potato cyst nematode, *Globodera rostochiensis*, in Victoria. Phytopathology 109, 659-669.

Vanstone VA, Hollaway GJ, Stirling GR (2008) Managing nematode pests in the southern and western regions of the Australian cereal industry: continuing progress in a challenging environment. Australasian Plant Pathology 37, 220-234.

Singh SK (2013) Prioritisation of pest species for biosecurity risk assessments: using plant-parasitic nematodes and Australia as examples. PhD Thesis, Charles Sturt University.

2.1.3 Achlysiella nematodes

Common Name

Achlysiella nematodes

Scientific Name

Achlysiella spp.

Host Range

- Sugarcane

Symptoms

- Often hard to spot and may look like nutrient or water stress.

Life Cycle

- Adult females swollen, sausage-shaped; full life cycle not well understood.

Why They Matter

- Rare and not known to cause significant problems in local crops.
- Awareness and monitoring can help detect any unusual occurrences early.

Management Options

- Keep an eye on sugarcane health in Nth QLD.
- Send suspicious samples for identification.
- Follow biosecurity advice to prevent spread.

Further Information

Nobbs JM (2003) Preparation of a CD-ROM library of plant parasitic nematodes: Plant parasitic nematodes recorded from sugarcane in Australia. South Australian Research and Development Institute (SARDI), Adelaide, Australia.

Siddiqi MR (2006) Tylenchida: parasites of plants and insects, 2nd ed. Commonwealth Agricultural Bureau, Slough.

2.2 Sedentary semi-endoparasite

These nematodes feed with the front part of their body inside the root, while the rear part remains outside.

2.2.1 Reniform Nematodes (*Rotylenchulus* spp.)

Common Name

Reniform nematodes

Scientific Name

Rotylenchulus spp.

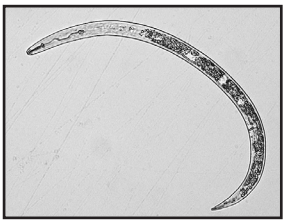

Figure 6. *Rotylenchulus reniformis* female (collected by Wayne O'Neill)

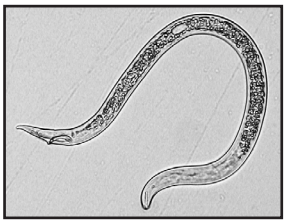

Figure 7. *Rotylenchulus reniformis* male (collected by Wayne O'Neill)

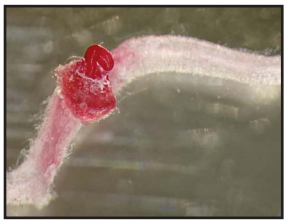

Figure 8. *Reniform* stained female with egg mass (collected by Wayne O'Neill)

Host Range

- Over 300 plant species including cotton, cowpea, soybean, tobacco, pineapple, papaya, banana, sweetpotato, okra, tomato, beans, and various weeds.

Symptoms

- **Roots:** Destruction of feeder roots, reduced root volume
- **Aboveground:** Stunted growth, yellowing, wilting, delayed flowering, fewer and smaller fruits, and overall yield decline.

Life Cycle

- < 3 weeks
- A female lays 40-100 eggs.

Reported Species in Northern Australia

- *R. reniformis*

Why They Matter

- Can cut cotton yields by 10-25% (over 50% in bad seasons).
- Forms disease complexes that intensify root diseases and often go unnoticed due to symptom confusion.

Management Options

- Rotate with non-host crops and manage weeds.
- Use resistant or tolerant varieties where available.
- Optimise soil health and drainage to discourage build-up.
- Control weeds and volunteer plants that can host nematodes.

- Avoid spreading infested soil on equipment, tools, or footwear.
- Test soil before planting to detect infestations early.
- Seek local advice for safe and effective chemical or biological products.

Further Information

Lawrence KS (2022) Reniform nematode (*Rotylenchulus reniformis*) and its interactions with cotton (*Gossypium hirsutum*). In Integrated Nematode Management: State-of-the-art and visions for the future (Eds. RA Sikora et al.) CAB International, Wallingford, Chapter 14, 94-99.

Smith LJ, Scheikowski L, Kafle D (2024) The distribution of reniform nematode (*Rotylenchulus reniformis*) in cotton fields in central QLD and population dynamics in response to cropping regime. Pathogens 13, 888.

Stirling GR (2023) Reniform nematode (*Rotylenchulus reniformis*), a damaging pest of many crops in tropical and subtropical regions of Australia. In: Stirling GR (ed) Plant and soil nematodes: friend and foe. APPsNet. https://www.appsnet.org/nematodes

2.2.2 Citrus Nematode (*Tylenchulus semipenetrans*)

Figure 9. *Tylenchulus semipenetrans* juvenile (collected by Wayne O'Neill)

Common Name

Citrus nematode

Scientific Name

Tylenchulus semipenetrans

Host Range

- Primarily citrus, including orange, grapevines, persimmon, lilac, and olive.

Symptoms

- **Roots:** Stunting and general deterioration of roots.
- **Aboveground:** Poor growth and delayed production, known as the citrus replant problem.

Life Cycle

- 6-8 weeks at 24-26°C
- A female lays several hundred eggs.

Why They Matter

- Causes crop losses ranging from 10 to 50%.
- Serious economic impact due to reduced tree growth and delayed production, especially in replant situations.

Management Options

- Test soil and roots before planting or if trees show poor growth.
- Use nematode-free planting material.
- Avoid replanting citrus in heavily infested soils; apply preplant fumigation or other soil treatments if necessary.

- Use nematode-resistant or tolerant rootstocks.
- Maintain healthy soil with good drainage and organic matter.
- Prevent movement of infested soil through equipment, tools, or water runoff.
- Regularly monitor nematode populations; apply postplant nematicides only when soil tests indicate medium to high populations.

Further Information

Duncan LW (2005) Nematode parasites of citrus. In: Luc M, Sikora RA, Bridge J (eds) Plant parasitic nematodes in subtropical and tropical agriculture, 2nd ed. CAB International, Wallingford, UK, pp. 437-466.

Stirling GR (2023) Citrus nematode (*Tylenchulus semipenetrans*), the cause of slow decline of citrus. In: Stirling GR (ed) Plant and soil nematodes: friend and foe. APPsNet. https://www.appsnet.org/nematodes

2.3 Migratory endoparasite

Migratory endoparasitic nematodes stay worm-shaped and move through roots, feeding on cells and killing them before moving to new roots.

2.3.1 Root-lesion nematodes (*Pratylenchus* spp.)

Common Name

Root-lesion nematodes

Scientific Name

Pratylenchus spp.

Host Range

- Wide range of crops including cereals, tomatoes, carrots, potatoes, sugarcane, turf, grape, stone fruit, pome fruit, pineapple.

Life Cycle

6-8 weeks.

Symptoms

- **Roots:** Lesions, poor root growth and destruction of feeder roots.
- **Aboveground:** Stunted plants with yellowing leaves and fewer tillers, often seen in patches across the paddock.

Figure 10. Root-lesion nematode female (collected by Yujuan Jady Li)

Figure 12. Stained root-lesion nematodes in chickpea root (collected by Rebecca Zwart)

Figure 11. Aboveground symptoms of wheat caused by root-lesion nematodes (collected by Sarah Collins)

Figure 13. Chickpea roots damaged by root-lesion nematodes (collected by Rebecca Zwart)"

Reported Species in Northern Australia

- *P. brachyurus, P. coffeae, P. jordanensis, P. zeae*

Why They Matter

- Major pests worldwide, often underestimated because root symptoms are subtle.
- Can reduce yields by 5-15%, depending on crop type and nematode density.
- Root-lesion nematodes, especially *P. zeae*, are economically important in sugarcane-producing areas.
- Feeding damage to roots can allow other pathogens to enter, worsening overall plant health.

Management Options

- Test soil and roots regularly to detect infestations early, as aboveground symptoms can resemble nutrient or water stress.
- Rotate with non-host or poor-host crops to reduce nematode populations.
- Use resistant or tolerant crops or rootstocks where available.
- Maintain soil health with good nutrition, organic amendments, and adequate moisture.
- Manage weeds that may host nematodes.
- Seek local advice before using chemical or biological control products.

Further Information

Thompson JP, Owen KJ, Stirling GR, Bell MJ (2008) Root lesion nematodes (*Pratylenchus thornei* and *P. neglectus*): a review of recent progress in managing a significant pest of grain crops in northern Australia. Australasian Plant Pathology 37, 235-242.

Vanstone VA, Hollaway GJ, Stirling GR (2008) Managing nematode pests in the southern and western regions of the Australian cereal industry: continuing progress in a challenging environment. Australasian Plant Pathology 37, 220-234.

2.3.2 Burrowing Nematodes (*Radopholus* spp.)

Common Name

Burrowing nematodes

Scientific Name

Radopholus spp.

Figure 14. *Radopholus similis* female (collected by Wayne O'Neill)

Host Range

- Wide range of crops including bananas, sugarcane, ginger, turmeric, cardamom, peppers, soybeans, sorghum, maize, eggplant, coffee, tomatoes, and potatoes.
- Some weed species such as annual ryegrass and wild radish can host these nematodes.

Figure 15. Poor growth of banana plants caused by burrowing nematodes (collected by NAQS)

Figure 16. Banana fallout caused by nematodes
(collected by Tony Pattison)

Figure 17. Banana roots damaged by burrowing nematodes
(collected by Wayne O'Neill)

Symptoms

- **Roots:** Dark red to black spots that join together.
- **Aboveground:** Weak, yellow, stunted, and produce smaller bunches. In wet, windy weather, weakened roots may cause plants to fall over.

Life Cycle

- 20-25 days at 24-32 °C.

Reported Species in Northern Australia

- *R. capitatus, R. nativus, R. nigeriensis, R. rectus, R. similis*

Potential Threat Species/Strains (Not Detected in Australia)

- *R. citri,* - infect citrus; reported in Indonesia.
- *R. similis* - exotic strains, such as those in Fiji, cause severe damage to ginger.

Why They Matter

- *R. similis* is the most damaging species to bananas, causing severe yield losses of up to 95% over 10 years.
- Other *Radopholus* species affect citrus, with reported losses of 40–70% in oranges and 50–80% in grapefruits.

Management Options

- Use clean, nematode-free planting material and enforce quarantine measures.
- Monitor susceptible crops regularly to detect damage early.
- Rotate crops with non-host or poor-host species to reduce populations.
- Maintain strict field sanitation and avoid moving infested soil.
- Retain crop residues and apply organic amendments to improve soil health.
- Seek local advice before using chemical or biological control products.

Further Information

Cobon JA, Pattison AB, Penrose LDJ, Chandra KA, O'Neill WT, Smith MK (2019) Comparison of the reproduction and pathogenicity of isolates of *Radopholus similis* (burrowing nematode) from Australia and Fiji on ginger (*Zingiber officinale*) and banana (*Musa* spp.). Australasian Plant Pathology 48, 529-539.

Pattison AB, Cobon JA, Araya-Vargas M, Chabrier C (2024) Towards sustainable management of nematodes in banana. In Drenth A, Kema G (eds.) Achieving sustainable cultivation of bananas Volume 3: Diseases and pests. Burleigh Dodds Science Publishing, pp. 419-450.

Plant Health Australia Ltd (2025) Biosecurity Plan for the Australian Citrus Industry (Version 4.1). Plant Health Australia, Canberra, ACT.

2.3.3 Stem and Bulb Nematodes (*Ditylenchus* spp.)

Common Name

Stem and bulb nematodes

Scientific Name

Ditylenchus spp.

Host Range

- Rice, oat, faba bean, field pea, lentil, canola, onion, garlic, tomato and others.

Symptoms

- Stunted growth, swollen stem bases, yellow or brown streaks on leaves.

Life Cycle

- 10-20 days; survives in a dry state within crop residues.

Reported Species in Northern Australia

- *D. anchilospomosus*

Other Key Species in Australia

- *D. dipsaci* infects many crops including cereals, legumes, bulbs (onion, garlic), potato, carrot, pea, and strawberry.
- *D. destructor* infects iris, tulip, and other ornamental bulbs, as well as sweetpotato, sugar beet, carrot, potato, and peanut.

Potential Threat Species (Not Detected in Australia)

- *D. angustus* (rice stem nematode) reported in Indonesia, India, Egypt, Madagascar.

Why They Matter

- Can reduce crop establishment and yield through damage to stems and bulbs.
- Potential to spread via infected seed, bulbs, or contaminated soil.
- Limited knowledge on distribution, host range, and economic impact in Northern Australia highlights the need for monitoring and further research.

Management Options

- Use certified nematode-free seed and planting material
- Avoid movement of infected soil or plant material
- Remove and destroy infected crop residues
- Monitor susceptible crops, especially in newly detected regions

Further Information

Bridge J, Starr JL (2007) Plant Nematodes of Agricultural Importance. Manson Publishing Ltd., London.

Singh SK (2013) Prioritisation of pest species for biosecurity risk assessments: using plant-parasitic nematodes and Australia as examples. PhD Thesis, Charles Sturt University.

2.4 Ectoparasite

Ectoparasitic nematodes stay in the soil and feed from outside the roots, damaging root tips and slowing root growth. Their impact is less studied than nematodes that live inside roots.

2.4.1 Dagger Nematodes (*Xiphinema* spp.)

Common Name

Dagger nematodes

Scientific Name

Xiphinema spp.

Host Range

- Perennial horticultural crops (fruit trees, grapevines, strawberries, figs, tomatoes), rice, sugarcane, peanuts, soybeans.

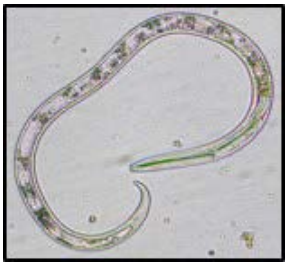

Figure 18. Dagger nematode juvenile
(collected by Yujuan Jady Li)

Symptoms

- **Roots:** Stunted, tips damaged.
- **Aboveground:** Poor vigour and yield.

Life Cycle

- ~1 year; prefers mild soils (~20°C) with moderate moisture (25-80%).

Reported Species in Northern Australia

- *X. americanum, X. elongatum, X. insigne, X. monohysterum, X. radicicola, X. setariae, X. truncatum, X. vulgare*

Other Key Species in Australia

- *X. index,* vector of Grapevine Fanleaf Virus (GFLV); reported in the Rutherglen district, north-eastern Victoria.

Why They Matter

- Damage to root tips limits water and nutrient uptake, lowering yields.
- Some species transmit plant viruses, increasing biosecurity risks.

Management Options

- Use clean planting material and avoid moving infested soil.
- Rotate crops and use resistant rootstocks when available.
- Keep crops healthy with good nutrition, moisture, and drainage.

Further Information

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

2.4.2 Needle Nematodes (*Paralongidorus* spp.)

Figure 19. Needle nematode (collected by Yujuan Jady Li)

Common Name

Needle nematodes

Scientific Name

Paralongidorus spp.

Host Range

- Mainly perennial crops; *P.* australis notably impacts rice in Nth QLD.

Symptoms

- **Root:** Stunted with dead tips.
- **Aboveground:** Poor vigour and reduced growth.

Life Cycle

- Several weeks.

Why They Matter

- Cause serious disease in rice and potentially other perennial crops
- Serve as vectors for certain plant viruses, increasing biosecurity risks
- Probably more widespread than reported due to limited surveys in the north.

Management Options

- Monitor susceptible crops, especially rice.
- Use clean planting material and avoid moving infested soil.
- Rotation or fallow may help in annual crops, but options are limited in perennials.
- Maintain crop health (adequate nutrition, moisture, and good drainage) to reduce impact.

Further Information

Stirling GR, Vawdrey LL (1985) Distribution of a needle nematode, *Paralongidorus australis*, in rice fields and areas of natural vegetation in North Queensland. Australasian Plant Pathology 14, 71-72.

Stirling GR (2023) Ectoparasitic plant-parasitic nematodes known to cause crop damage in Australia. In: Stirling GR (ed) Plant and soil nematodes: friend and foe. APPsNet. https://www.appsnet.org/nematodes

2.4.3 Southern Sting Nematode (*Ibipora lolii*)

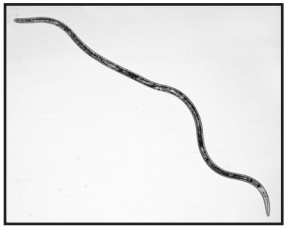

Figure 20. Sting nematode female (collected by Wayne O'Neill)

Common Name

Southern sting nematode

Scientific Name

Ibipora lolii

Host Range

- Turfgrasses (bowling greens, golf tees, putting greens); potential risk to cereals, sugarcane and maize.

Symptoms

- **Root:** Severely reduced.
- **Aboveground:** Turf decline, often mistaken for other stresses.

Life Cycle

- ~ 21 days.

Why They Matter

- Most destructive nematode pest of turfgrass in Australia.
- Spreads easily in sandy soils.
- Impacts sports fields and recreational areas.

Management Options

- Monitor turfgrass in high-risk areas.
- Use clean planting material and treat soil where needed.

Further Information

Siviour TR, McLeod RW (1979) Redescription of *Ibipora lolii* (Siviour 1978) comb. n. (Nematoda: Belonolaimidae) with observations on its host range and pathogenicity. Nematologica 25, 487-493.

2.4.4 Stubby Nematodes (*Paratrichodorus* spp.)

Figure 21. Stubby nematode (collected by Yujuan Jady Li)

Common Name

Stubby nematodes

Scientific Name

Paratrichodorus spp.

Host Range

- Tomatoes, corn, onions, sugarcane, grapefruit, and others.

Symptoms

- **Root:** Shortened and thickened; reduced fine feeder rootlets.
- **Aboveground:** Poor growth.

Life Cycle

- 16-22 days at 22-30°C; grow best in sandy loam soils.

Why They Matter

- Can transmit plant viruses.
- Damage roots and reduce nutrient/water uptake.

Management Options

- Monitor susceptible crops, especially in high-risk areas.
- Manage soil health and structure to limit nematode population build-up.
- Use clean planting material and avoid moving infested soil.

Further Information

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

2.4.5 Ring nematodes (Family Criconematidae)

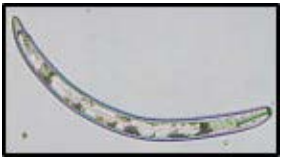

Figure 22. Ring nematode (collected by Yujuan Jady Li)

Common Name

Ring nematodes

Scientific Name

Various species in the family Criconematidae (e.g., *Caloosia, Hemicriconemoides, Macroposthonia, Morulaimus*)

Host Range

- Tropical tree fruits (e.g., mango, litchi), turfgrass, and native vegetation; specific crop impacts are not well known.

Symptoms

- **Root:** Subtle damage, may include stunting or reduced function.
- **Aboveground:** Slight decline in vigour, often not obvious.

Life Cycle

- 26-29 days under favourable conditions.

Why They Matter

- Often under-sampled due to slow movement and difficult extraction.
- True economic impact is uncertain but may affect woody plants.

Management Options

- Use improved detection methods (e.g., sugar flotation, centrifugation) to identify infestations.
- Prevent spread by careful management of soil and plant material.

Further Information

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

2.4.6 Stunt nematodes (*Tylenchorhynchus* spp.)

Common Name

Stunt nematodes or stylet nematodes

Scientific Name

Tylenchorhynchus spp.

Figure 23. Stunt nematode (collected by Yujuan Jady Li)

Host Range

- Rice, corn, wheat, sugarcane, sorghum, citrus, soybean, sweet potato, lettuce, grape, and others.

Symptoms

- **Roots:** Stunted and reduced root mass; corn roots may weigh 40-60% less when infested.
- **Aboveground:** Stunted shoots, yellowing, wilting, and defoliation.

Life Cycle

- Populations can increase from 10 to 5,000 individuals in ~8 months under favourable conditions.

Why They Matter

- Cause major root damage, reducing plant growth and yields.
- Potential to affect many crops in Northern Australia due to wide host range.

Management Options

- Monitor soil and root health regularly.
- Rotate crops and use resistant varieties where available.
- Maintain soil health and avoid practices that encourage nematode build-up.

Further Information

Handoo ZA (2000) A key and diagnostic compendium to the species of the genus *Tylenchorhynchus* Cobb, 1913 (Nematoda: Belonolaimidae). Journal of Nematology 32(1), 20-34.

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

2.4.7 Spiral nematodes (*Helicotylenchus* spp., *Rotylenchus* spp. & *Scutellonema* spp.)

Common Name

Spiral nematodes

Scientific Name

Helicotylenchus spp., *Rotylenchus* spp. & *Scutellonema* spp.

Figure 24. *Helicotylenchus* sp. (collected by Yujuan Jady Li)

Host Range

- Banana, horticultural crops, root/tuber crops such as yam.

Symptoms

- **Roots:** Stunted, necrotic, dry rot in yam tubers.
- **Aboveground:** Reduced growth and yield.

Life Cycle

- 30-35 days at 24-32°C for some *Helicotylenchus* species.

Why They Matter

- *H. multicinctus* is a major pest in banana, causing significant economic losses.
- *Scutellonema* spp. cause dry rot in yam tubers, reducing quality and storage life.
- Wide host range and prevalence increase potential crop damage.

Management Options

- Use resistant or tolerant crop varieties where available.
- Rotate with non-host crops to reduce populations.
- Maintain good soil health and drainage.
- Avoid moving infested soil or plants.
- Monitor susceptible crops regularly for early detection.

Further Information

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

Bridge J, Coyne D, Kwoseh CK (2005) Nematode parasites of tropical root and tuber crops. In: Luc M, Sikora R, Bridge J (eds) Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 2nd edn. CAB International, Wallingford, UK, pp 221-258.

2.4.8 Lance nematodes (*Hoplolaimus* spp.)

Common Name

Lance nematodes

Scientific Name

Hoplolaimus spp.

Host Range

- Cotton, rice, citrus, sugarcane, mango, tamarind, cowpea, baobab tree, banana, corn, soybean and others.

Symptoms

- **Roots:** Stunted, fewer tillers.
- **Aboveground:** Reduced plant vigour and yield.

Life Cycle

- Thrives in sandy soils; reproduction under suitable conditions. Detailed information is limited.

Reported Species in Northern Australia

- *H. seinhorsti*

Other Key Species in Australia

- *H. pararobustus* only reported in QLD so far.

Why They Matter

- Reduce rice yields by up to 18% in upland systems.
- Pot trials: 100-10,000 nematodes per plant reduced tillers by 22-36% and grain yield by 11-18%.
- Can cause significant damage to banana crops.
- Less common than other nematodes but potentially important in sandy coastal soils.

Management Options

- Monitor sandy soils, especially in coastal cropping regions.
- Rotate with non-host crops or use resistant varieties where available.
- Maintain soil health and avoid moving infested soil or plants.

Further Information

Ramana KV, Prasad JS, Seshagiri Rao Y (1978) Influence of atmospheric conditions and soil temperature on the prevalence of the lance nematode (*Hoplolaimus indicus* Sher, 1963) in rice fields. Proceedings of the Indian Academy of Sciences, Section B 87, 39-43.

Overstreet C, McGawley EC, Khalilian A, Kirkpatrick TL, Monfort WS, Henderson W, Mueller JD (2014) Site-specific nematode management - development and success in cotton production in the United States. Journal of Nematology 46, 309-320.

2.4.9 Pin nematodes (*Paratylenchus* spp. & *Gracilacus* spp.)

Common Name

Pin nematodes

Scientific Name

Paratylenchus spp. & *Gracilacus* spp.

Host Range

- Mint, tall fescue, celery, carnations, figs, and others.

Figure 25. Pin nematode (collected by Yujuan Jady Li)

Symptoms

- **Roots:** Usually only affected at high population densities, causing stunted growth.
- **Aboveground:** Subtle decline in vigour, often overlooked.

Life Cycle

- *Paratylenchus projectus*: 36-38 days at 20-28°C.

Why They Matter

- Populations can rise rapidly (>500 per 100 cm^3 soil).
- Rapid population growth potential makes monitoring and management important.

Management Options

- Monitor populations regularly, especially in susceptible crops.
- Rotate crops and maintain healthy soils to reduce risk.
- Avoid moving infested soil or plants.

Further Information

Claerbout J, Vandevelde I, Venneman S, Kigozi A, de Sutter N, Neukermans J, Bleyaert P, Bert W, Höfte M, Viaene N (2020) A thorough study of a *Paratylenchus* sp. in glasshouse-grown lettuce: Characterisation, population dynamics, host plants, and damage threshold as keys to its integrated management. Annals of Applied Biology. 178(1), 62–79.

Wood FH (1973) Biology and host range of *Paratylenchus projectus* Jenkins, 1956 (Nematoda: Criconematidae) from a subalpine tussock grassland. New Zealand Journal of Agricultural Research 16, 381-384.

2.4.10 Sheath nematodes (*Hemicycliophora* spp.)

Figure 26. Sheath nematode (collected by Yujuan Jady Li)

Common Name

Sheath nematodes

Scientific Name

Hemicycliophora spp.

Host Range

- Globally: wide range of crops, fruit/nut trees, and ornamentals (e.g., black pepper, banana, cucurbits, citrus, rice, tobacco, yardlong bean, bamboo, cardamom).
- Australia: no crop damage reported.

Symptoms

- No observable plant symptoms in Australia.

Life Cycle

- Varies by species; survives in moist soils.

Why They Matter

- Several species cause significant crop damage internationally (*H. arenaria, H. conida, H. parvana, H. poranga, H. similis, H. typica*).
- Broad host range and potential pathogenicity warrants monitoring.

Management Options

- Monitor high-risk areas and susceptible crops.
- Maintain soil health and avoid waterlogging.

Further Information

Nguyen HT, Trinh QP, Couvreur M, Nguyen TD, Bert W (2021) Description of *Hemicycliophora cardamomi* sp. n. (Nematoda: Hemicycliophoridae) associated with *Amomum longiligulare* T.L. Wu and a web-based key for the identification of *Hemicycliophora* spp. Journal of Helminthology 95, e2.

Van Gundy SD, Rackham RL (1961) Studies on the biology and pathogenicity of *Hemicycliophora arenaria*. Phytopathology 51, 393-397.

2.5 Foliar, leaf or bud nematodes (*Aphelenchoides* spp.)

Common Name

Foliar nematodes

Scientific Name

Aphelenchoides spp.

Host Range

- Strawberry, ferns, lilies, chrysanthemums and other ornamentals.

Symptoms

- Necrotic leaf lesions, leaf distortion, malformed buds/growing points.

Life Cycle

- 10-14 days; survive several months in dry leaves and reproduce in water films on plant surfaces.

Why They Matter

- Damage leaves and buds, reducing plant vigour and yield.

Management Options

- Use nematode-free planting material.
- Remove and destroy infected plant debris.
- Maintain good air circulation and avoid excess moisture on foliage.

Further Information

Jenkins WR, Taylor DP (1967) Plant Nematology. Reinhold Publishing Corporation, New York, USA.

3. Preventing Nematode Spread

Preventing nematodes from entering or moving within your farm is the first line of defence. Key steps include:

3.1 Sanitize Equipment and Tools

- Remove soil and plant debris from machinery, tools, and footwear before moving between fields.
- Pay special attention to tyres, treads, blades, and boots.
- Where appropriate, use chemical sanitisers (e.g., quaternary ammonia, bleach) and follow instructions carefully.

3.2 Manage Planting Material and Soil Movement

- Use certified nematode-free seeds, seedlings, and transplants.
- Avoid moving soil, compost, mulch, or plant material from known infested areas.
- Test and treat soil if movement is unavoidable.

3.3 Quarantine New Plants

- Isolate newly sourced plants before planting.
- Monitor for early signs of nematode infection (stunting, yellowing, poor roots).
- Seek advice from local biosecurity or extension services if symptoms appear.

4. Integrated Nematode Management

Nematode control works best when multiple strategies are combined, tailored to your crops, soils, and tropical conditions.

4.1 Monitoring and Record-Keeping

- Inspect crops and soil regularly; early detection allows targeted, lower-cost control.
- Track nematode levels, crop rotations, and treatments to support management decisions.

4.2 Crop Rotation and Cultural Practices

- Rotate crops with non-host or poor-host plants to disrupt nematode life cycles.
- Use cover crops and maintain soil organic matter to support beneficial organisms.
- Adjust planting times, solarise soil, or bare fallow when practical.
- Maintain plant health through good nutrition and moisture.

Figure 27. Intolerant (left) vs tolerant (right) wheat to root-lesion nematodes (collected by Jason Sheedy)

Figure 28. Mulching pineapple residues to enrich soil (collected by Yujuan Jady Li)

4.3 Biological Control

- Encourage beneficial fungi, bacteria and predatory organisms that naturally suppress nematodes.
- Support these organisms with organic amendments, compost and healthy soils.
- Effectiveness varies by region and crop — combine with other strategies and monitor results.

Figure 29. Pasteuria bacteria killing root-lesion nematode in the field (collected by Yujuan Jady Li)

4.4 Chemical Control: Safe Use and Limitations

- Chemical control is sometimes necessary and nematicides come in two main types:

  (1) Fumigants (e.g., 1,3-D, metham sodium, chloropicrin) Act quickly by producing gases that diffuse through the soil. Advantages: fast, broad-spectrum control. Disadvantages: hazardous, costly, require careful soil preparation, sealing and reduce beneficial soil organisms.

  (2) Non-fumigants (e.g., fluensulphone (Nimitz®), fluopyram (Indemnify®),

fluazaindolizine (Salibro®)) are relatively safer, easier to handle, and have less impact on beneficial soil organisms. They reduce nematode reproduction and mobility but generally act more slowly.

- Use nematicides only when necessary, following label instructions and safety guidelines.
- Always combine chemical control with cultural and biological strategies for sustainable management.
- Many fumigants may be phased out in the future; integrated management programs are essential for long-term control.

Figure 30. Applying fumigants before planting (collected by Yujuan Jady Li)

Figure 31. Nematicide application in sweetpotato field (collected by Yujuan Jady Li)

Further Information

Desaeger JA, Wram C, Zasada I (2020) New reduced-risk agricultural nematicides: Rationale and review. Journal of Nematology 52, 1-16.

Norris CE, Congreves KA (2018) Alternative management practices improve soil health indices in intensive vegetable cropping systems. Frontiers in Environmental Science 8, article 50, 1-18.

Stirling GR (2023) Nematode management. In: Stirling GR (ed) Plant and soil nematodes: friend and foe. APPsNet. https://www.appsnet.org/nematodes

5. Diagnostic Services

Effective nematode management and research depend on accurate diagnosis. Correct sampling, handling and submission of soil and plant material are critical to obtain reliable results.

5.1 Where to Send Samples

- **Northern Territory (NT):**
  Department of Agriculture and Fisheries
  Plant Pathology Diagnostic Laboratory
  Combined Science Services Building, 29 Makagon Road, Berrimah NT
  Email: Plant.Pathology@nt.gov.au
  Phone: (08) 8999 2218

- **Queensland (QLD):**
  Nematology, Department of Primary Industries, Ecosciences Precinct, B3 Joe Baker Street, Dutton Park, QLD 4102
  or Grow Help
  Attn: Grow Help Australia, Department of Primary Industries, Ecosciences Precinct, B3 Joe Baker Street, Dutton Park QLD 4102
  Website: https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crops/test/grow-help-australia

- **Western Australia (WA):**
  Department of Primary Industries and Regional Development (DPIRD)
  Diagnostics and Laboratory Services (DDLS),
  3 Baron-Hay Court, South Perth WA 6151
  Email: DDLS@dpird.wa.gov.au
  Website: https://www.dpird.wa.gov.au/businesses/biosecurity/diagnostics-and-laboratory-services/

Some interstate or commercial laboratories may provide nematode testing service as well. Always confirm that the laboratory has qualified nematologists who can accurately identify nematodes and provide correct interpretation of the test results. Some laboratories may also have specific sampling requirements or submission forms — check before sending.

5.2 When to Collect Samples

- When plants show patchy stunting, yellowing, poor growth, or reduced yields.
- When roots show lesions, galls, or other abnormal symptoms.
- At the end of a crop (preferred timing for estimating nematode risk for the next crop).
- Before planting a new crop, if necessary.

5.3 How to Collect Samples

- From affected crops:
    - Dig up several plants with roots intact.
    - Collect ~500 g soil around roots and ~100 g roots.
    - Sample both poor and healthy patches for comparison.
- Before planting:
    - Preferably sample at crop removal or the end of the previous crop to assess nematode build-up.
    - If pre-plant testing is needed, take multiple cores (20-40 per field) across representative areas.
    - For low-density populations, a glasshouse bioassay with a susceptible host can help detect nematodes not recovered by soil extraction.
    - Mix gently and keep ~500 g for testing.
    - Sample different soil types or cropping histories separately.

5.4 Handling and Sending Samples

- Place soil and roots in clearly labelled plastic bags (include sample site and date).
- Keep samples cool (not in direct sun or hot environment).
- Send promptly by express courier to the diagnostic laboratory.

5.5 Information to Include with Samples

Provide background details so the laboratory can give accurate results:

- Crop/cultivar sampled and observed symptoms.
- Field history (including last two years of crops, rotations, chemical/fertilizer practices).

Further information

Stirling GR, Nicol JM, Reay F (2002) Advisory services for nematode pests. Rural Industries Research and Development Corporation (RIRDC).

6. Contributors

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