Nematodes in nurseries

Microscopic worms with major consequences

Introduction

Nematodes are a diverse group of microscopic, non-segmented round worms that are tapered at each end. There are over one million species and they have been estimated to account for 80% of all individual animals in the world. About half of all nematode species are parasites of marine animals (e.g. sperm whales), 25% are free-living non-parasitic soil inhabiting nematodes, 15% are animal and human parasites (e.g. heart worm in dogs) and 10% are plant parasites.

Fig. 1. Root knot nematode on parsley.

Plant-parasitic nematodes

In nurseries, following best practice programs, nematode problems are rare. However, field grown nursery stock can be seriously affected. It only takes a small amount of contaminated soil or one infected plant introduced into a nursery to cause a serious problem.

Plant-parasitic nematodes are usually 0.5 to 1.0 mm long. They can affect a wide range of nursery plants (ornamental plants, fruit/nut trees, and vegetable seedlings). Some invade and feed on roots affecting all root functions including water and nutrient uptake. Others attack the above ground parts of plants affecting leaves and flower buds. Plant-parasitic nematodes are grouped according to their feeding behaviour. Ectoparasites exist in the soil and feed from the exterior of the root. They infect by penetrating the wall of root tips using a modified mouthpart that has a hollow stylet. These stylets pierce cell walls to suck out cell contents. Endoparasites enter the root or shoot tissues and feed within the plant. Endoparasities complete their life cycle within the roots. Some species are sedentary (establishing specific feeding sites where they remain until they die), whereas others are migratory (feeding while moving through the plant tissue).

The most important nematodes in nurseries are root-knot (*Meloidogyne* spp.), root lesion (*Pratylenchus* spp.) and foliar nematodes (*Aphelenchoides* spp.). Spiral (*Helicotylenchus* spp.), burrowing (*Radopholus* spp.) and stem and bulb (*Ditylenchus* spp.) nematodes are generally of minor importance (See Table 1).

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Spread

Nematodes are readily spread with infested soil on contaminated nursery equipment, hands, shoes and clothing. In addition, the movement of nematode infested plants or plant parts will spread the parasites. They are dispersed passively in water (rivers, flood water, irrigation water). Water is also important for their active migration in soil and on leaves. Foliar nematodes are spread in the nursery by water splash.

Symptoms

Root nematodes cause galling, root lesions, necrosis, excessive root branching and stunting. Symptoms on above ground parts of the plant include a loss of vigour, leaf yellowing, wilting and fewer and smaller leaves. These symptoms are usually not diagnostic as these symptoms are present in most plants with a functionally deprived root system resulting from root infecting fungi, physical or environmental disorders or micronutrient deficiencies. Bulb and stem nematodes produce stem swellings and shortened internodes. Bud and leaf nematodes produce necrotic, angular shaped leaf spots defined by the major veins. They also distort and kill buds.

Generic Life Cycle

Typically there are six stages within a nematode life cycle: an egg, four juvenile stages and an adult stage. Each juvenile stage and the adult are separated by a moulting phase. The egg is the first stage for all nematodes and, for most plant-parasitic nematodes, the first juvenile stage occurs inside the egg. Therefore, it is the second-stage juvenile that hatches.

Root-knot

Root-knot nematodes (*Meloidogyne* spp.) form conspicuous galls that can stop root development. This restricted root development results in the stunting of plants and yellowing of leaves. Juvenile root-knot nematodes invade roots near the tips. As individuals establish feeding sites and mature into females, they enlarge and develop into galls. Each mature female can lay about 2000 eggs in a small gelatinous mass on the root surface. Juveniles hatch from eggs and invade root tissue about 25-35 days after being laid. Root-knot nematodes produce many generations per year and soil populations can increase rapidly under optimal growing conditions.

Root-lesion

Root-lesion nematodes (*Pratylenchus* spp.) invade the outer root tissues causing black areas of dead or

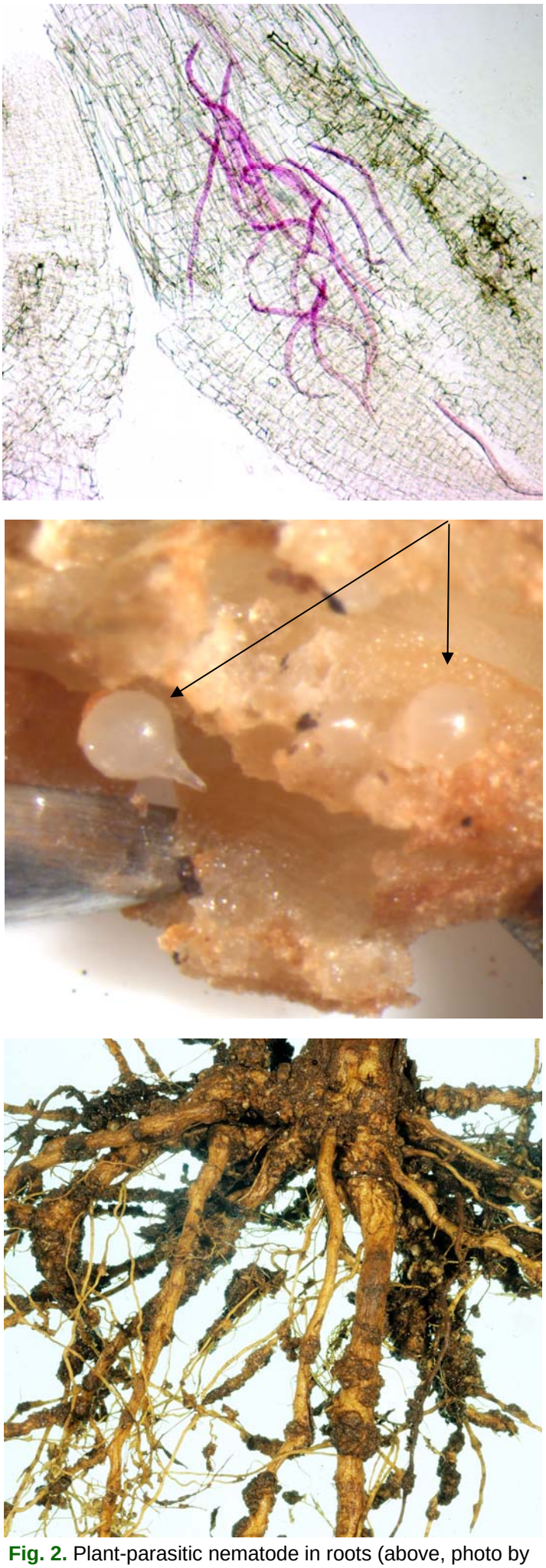

Fig. 2. Plant-parasitic nematode in roots (above, photo by J. Cobon) and root-knot nematodes dissected from a root (middle) and infecting rice flower (below).

injured cells on the root surface. This root necrosis may spread over the entire root system causing yellowing of leaves and stunting of plants.

Root-lesion nematodes are endoparasitic and primarily live in roots, moving through the outer root surface, feeding and generally disrupting the physiological processes of the roots. They only enter the soil when migrating from one root to another. Lesion nematodes first moult in the egg stage, then hatch and pass through three juvenile stages before reaching adulthood. Both juvenile and adult nematodes can penetrate roots, so infested roots can contain all development stages - eggs, juveniles and adults. Reproduction occurs quickly in summer with each generation being completed in 29-45 days.

Table 1. Plant-parasitic nematode genera that are most likely to occur in Australian nurseries. Many other species may possibly occur, particularly on native plant species.

Genera	Common name	Mode of parasitism	Symptoms
Aphelenchoides	Foliar nematode	Ectoparasites and endoparasites of leaves and buds	Leaf and bud lesions
Meloidogyne	Root-knot nematode	Sedentary endoparasites of roots	Plant stunting Plant wilting Root galls Root distortion
Pratylenchus	Root-lesion nematode	Migratory endoparsites of roots	Plant stunting Root lesions
Helicotylenchus	Spiral nematode	Migratory endoparsites of roots	Root lesions
Radopholus	Burrowing nematode	Migratory endoparasites of roots	Root necrosis Plant lodging
Ditylenchus	Stem and bulb nematode	Endoparsites of stems and bulbs	Seedling death Plant stunting Distorted growth

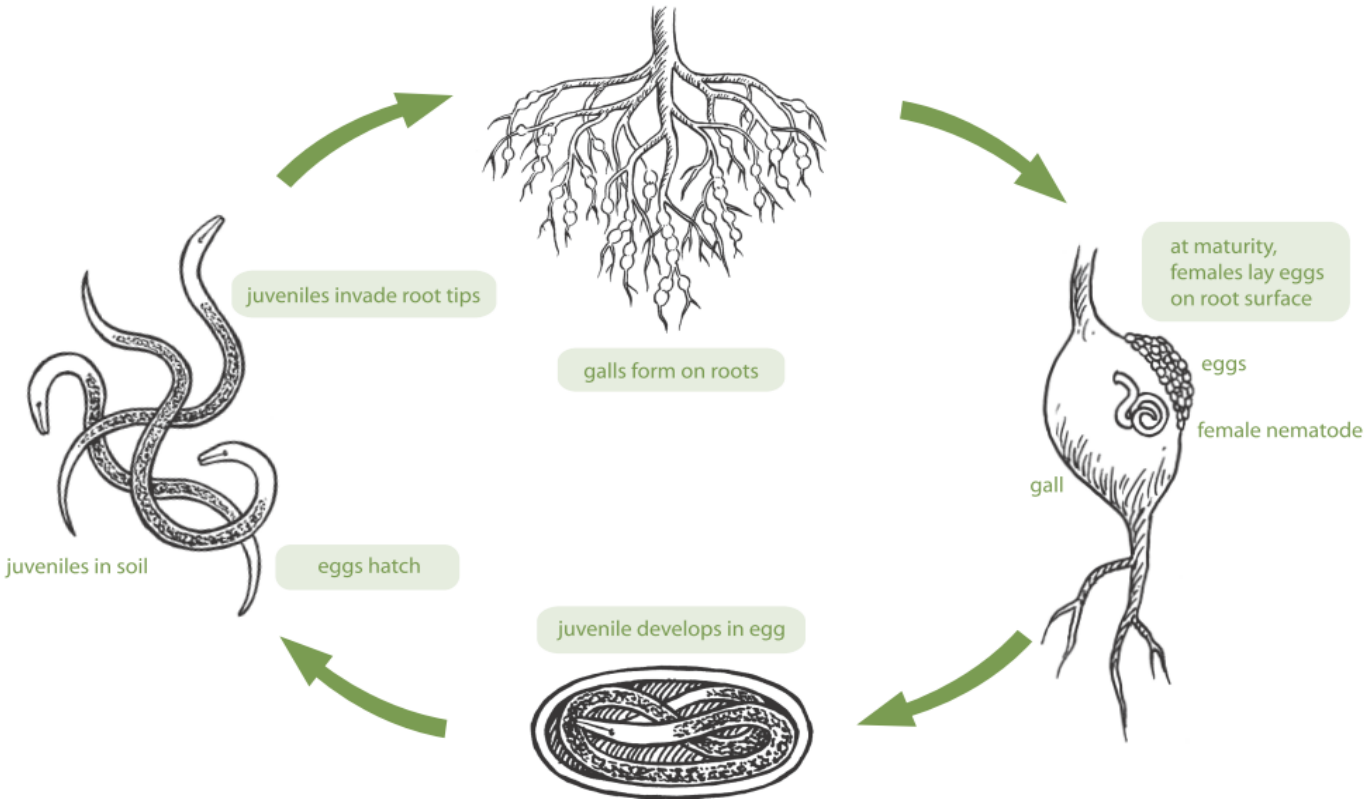

Fig. 3. The lifecycle of root knot nematode.

Leaf Nematode

Leaf nematodes (*Aphelenchoides* spp.) attack above –ground parts of plants causing leaf lesions and malformed leaves, buds and flowers. Females lay 20–30 eggs during their life span. After hatching, nematodes go through 4 larval stages before becoming adults. The entire life cycle can be completed in 2–4 weeks under favourable conditions. They survive in the soil for 3 months, or longer in plant tissue. Generations succeed one another as long as conditions are favourable. An infected leaf may contain eggs, juveniles and adults simultaneously. Of all life stages, adults are the most infective. Under cool temperature and reduced moisture these nematodes can over-winter and remain dormant until more favourable conditions return. When moisture becomes available, the nematode rehydrates and moves into a new host to begin feeding.

Control

Preventing a nematode problem is far better than trying to manage one after it has established. Avoid bringing any nematodes into the nursery. Most spread into nurseries is by movement of soil or infested plants. Risk of introducing nematodes into a nursery can be reduced by good sanitation practices. However, initial nematode infestations may go unnoticed when populations are low and plants are virtually asymptomatic. Once plant growth is seriously affected, populations are high and are unlikely to be eradicated. Growers who suspect that they have a nematode problem or wish to monitor their soils, soil mixes or plants for nematodes should contact a reputable diagnostic laboratory capable of nematode extraction and identification. Heat treatments are probably the most reliable method to disinfest nematodes from plant material. Plants should never be sold infested with plant-parasitic nematodes. The following actions can be taken to reduce the likelihood of a nematode infestation becoming established.

- Examine root health regularly. Unhealthy roots should prompt investigation as to the cause. In most cases this should involve testing through a pest and disease diagnostic service.
- Pasteurise all potting mix and use new or disinfested pots.
- Hygienically discard all plants known to be infected. Do not throw out into a rubbish heap on farm as this will increase the risk of reinfection.
- Use nematode-free propagating material. Take cuttings from uninfested plants or portions of plants well above ground level that are vigourously growing. Plants multiplied by suckers or plants with roots must be free of

Fig. 4. Foliar nematode damage on ginger (above), *Lygodium* (middle) and chrysanthemum (below).

nematodes. Multiplying plants infested with nematodes will spread nematodes and increase the magnitude of the problem.

- Do not introduce any soil, plants or pots that are from areas known to be contaminated.
- Use raised benches where possible.
- Any new plants introduced into a nursery should be kept separate from the main stock until considered to be healthy. Examine root health before inclusion in the nursery proper.
- Water splash on foliage will spread foliar nematodes. Therefore, reduce overhead irrigation and grow in protected cropping environments, if possible.

Heat treatments

Treating propagating material such as bulbs, corms, rhizomes and cuttings in hot water can eradicate nematode populations. Common usage of hot water treatments has been for stem and bulb nematode in daffodils and garlic, root-knot nematode in grape rootstocks and foliar nematode in Easter lilies. Temperature and time of treatment are critical for nematode control and needs to be carefully regulated for each crop according to the heat tolerance of the planting material. Typically, they involve treatment between 44°C and 52°C. Lower temperatures must be maintained for longer periods, e.g. 30 minutes, higher temperatures for shorter periods, e.g. 5-10 minutes. The exact temperature and time of treatment is specific to each plant species/variety and should be investigated on a case by case basis.

Biological and chemical control

In field crop situations, nematodes may be suppressed with certain biological control agents including certain fungi, bacteria and viruses as well as predatory nematodes, mites and other micro-arthropods. These organisms all have the capacity to suppress plant-parasitic nematodes. Likewise, soil conditions can also be modified to suppress plant-parasitic nematodes, e.g. increasing organic matter. However, all of these methods are extremely unlikely to eradicate plant-parasitic nematodes from nursery crops. Since the goal is to produce pest and pathogen free nursery stock, these methods are unlikely to be viable for production nurseries.

There are a number of active ingredients with nematicidal properties that may be used for at least some nursery crops as pre-plant applications, e.g. dichloropropene and chloropicrin. Nematicides may drastically reduce the number of nematodes infecting a plant for a short period of time. However, they are unlikely to eradicate plant-parasitic nematodes. As such, they are not recommended for use on nursery stock.

Fig. 5. Damage from burrowing nematode (above), pine wilt nematode symptoms (middle - photo by USDA Forest Service, Bugwood.org) and sting nematode on maize (below - photo by Dept Plant Pathology, North Carolina State University, Bugwood.org).

Biosecurity

There are many species of nematodes that are not present in Australia and would be serious pests if introduced. These include the pine wilt nematode (*Bursaphelenchus xylphilus*) and many sting nematode species (*Belonalaimus* spp.) (Fig. 5). Many other exotic species occur overseas. In addition, introduced nematodes occur in parts of Australia that should not be spread. These include sting nematodes (*Morulaimus* and *Ibipora*) in various grass species, typically turfgrass, and potato cyst nematodes (*Globodera pallida*). Refer to your state based biosecurity organisation for details on these pests.

This document was prepared by Tony Cooke and Ken Pegg (Agri-science Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY11001 Plant health biosecurity, risk management and capacity building for the nursery industry in 2015. Thanks go to Jenny Cobon, Andrew Manners and Lindy Coates for helpful comments on previous versions of this factsheet. Unless otherwise stated, photographs can be attributed to DAF (particularly Leif Forsberg).

Fig. 6. Foliar nematodes on peperomia (above), close up of root knot nematodes on parsley (middle) and stylets of plant parasitic nematodes (below). Only plant parasitic nematodes have these stylets.