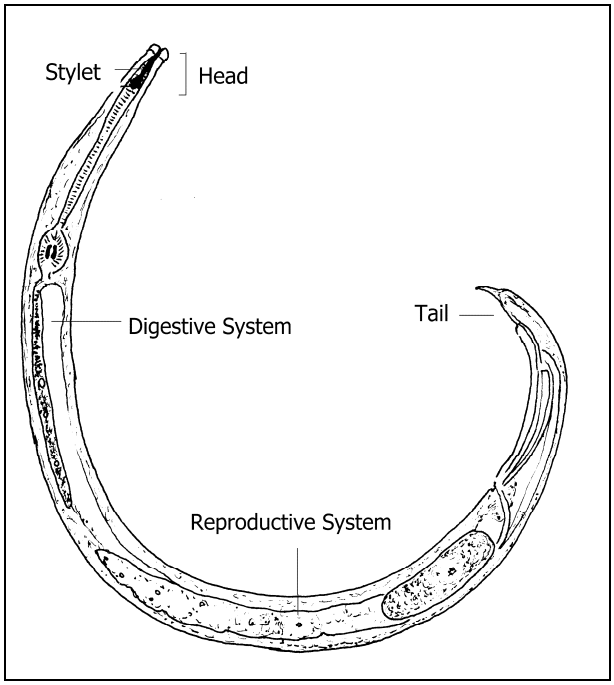
Nematodes 6

(updated November 2008)

Nematodes are microscopic worms that inhabit soil and water. Free-living species feed on bacteria, fungi and other nematodes while others parasitize insects, plants and animals. This chapter will focus on nematodes that parasitize plants. Plant parasitic nematodes are a diverse group of organisms with species that can be found in foliage, stems, roots and in the soil with most species feeding on the roots. They range in size from about 0.3-5.0 mm in length. Most feed by inserting a syringe-like mouthpart into plant tissue, which wounds the cells and creates entry sites for other disease causing organisms. Generally, nematodes do not kill the plant but produce vague symptoms such as yellowing, stunting, and general poor growth. They are often part of a complex of problems that result in plant decline. Some nematodes are capable of vectoring viruses. In the field, nematodes can spread through movement of infested soil and symptoms are often exhibited as patchy areas that expand every year. Nematodes that live in the roots and stems can spread by moving infested plants to new areas.

Nematodes commonly found on ornamental crops are meadow or root lesion nematodes (*Pratylenchus* spp.), root knot nematodes (*Meloidogyne* spp.), foliar nematodes (*Aphelenchoides* spp.), and stem and bulb nematodes (*Ditylenchus* spp.). Root lesion and root knot nematodes are found in the soil and the roots, while foliar and stem and bulb nematodes can be found in the soil, roots, stem and foliage. The populations increase with temperature and low initial populations in spring can reach damaging levels by autumn. Damage level is dependent on factors such as susceptibility of the host, soil type, temperature, type and number of nematodes present, plus stress factors affecting the crop such as drought and low fertility. Generally, damage is more severe in sandy soils. Crops in organic soils can tolerate higher numbers of nematodes. Weeds are an important host that help to maintain populations over the winter. Most damage occurs in the first year of planting. It is important that plants establish a healthy root system, especially perennials, since this enables them to tolerate some nematode feeding. Proper soil pasteurization as well as clean storage of the potting soil is essential to prevent damage caused by nematodes.

Figure 6.1: Microscopic View of a Nematode (lateral section)



Most nematode species have similar life cycles. After mating, the female lays eggs in the same area where she is feeding. The larvae go through four moults, completing their life cycle within 3 to 4 weeks. Some types or species of nematodes may go into a dormant stage if conditions are unfavourable, remaining in the soil or plant debris for many years. Movement is through soil and plant roots, as well as through films of water on leaves.

Root Lesion Nematode

Meadow or root lesion nematodes, *Pratylenchus* spp., can be found in the soil and inside the roots of many ornamental plants including bulbs. High populations in the soil and roots result in poor growth, often causing patches of dying plants in the field.

Root Knot Nematode

Root knot nematodes (*Meloidogyne* spp.) cause stunting, lack of plant vigour, and the leaves may be discoloured. When the roots of infested plants are examined they usually exhibit knots or galls. The

damaged root systems may cause plants to wilt under the slightest water stress. Damaged host plants are more susceptible to secondary disease pathogens like *Pythium, Rhizoctonia,* and *Phytophthora*. They are primarily a problem of long term greenhouse crops such as roses and carnations grown in soil beds. Transmission occurs via soil-contaminated machinery, hands, feet, and irrigation water.

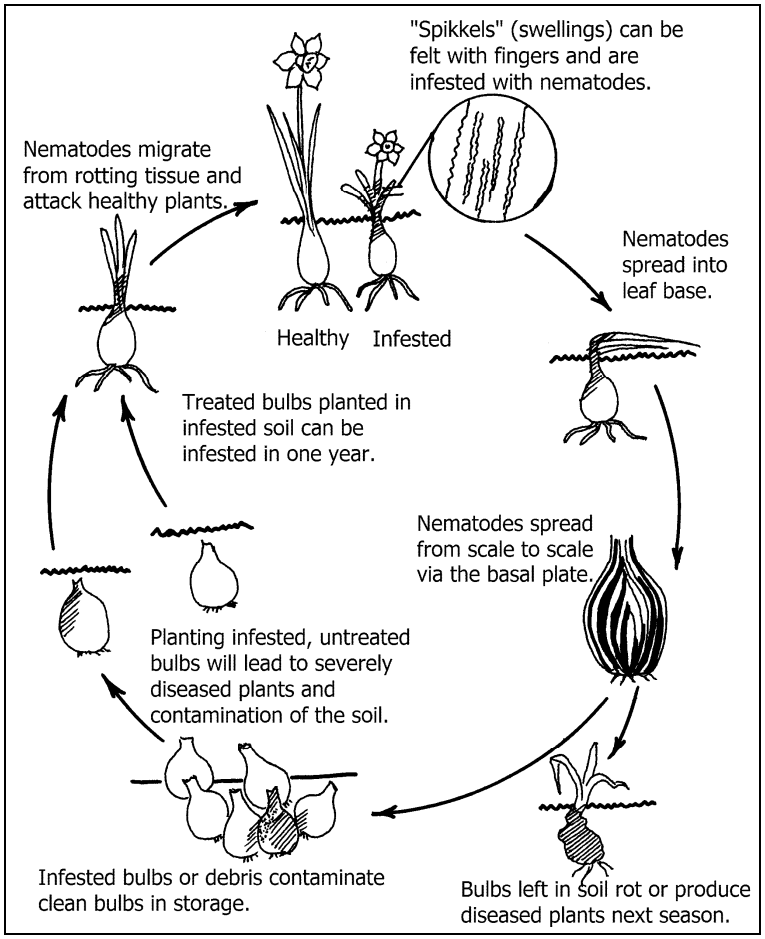
Foliar Nematode

Foliar nematodes (A*phelenchoides* spp.) can attack a wide range of plants including anemones, begonias, chrysanthemums, crocus, iris, narcissus, strawberry, and tulips. They feed on the outside of young foliage, stems, and buds, causing curling, twisting, and stunting damage to new growth. They can also crawl into the leaf through wounds or via the stomata, resulting in water soaked or yellow areas that eventually turn brown. Affected areas tend to be limited by veins. Leaves later dry up and turn brown. Foliar nematode symptoms may be similar to sunburn, high temperature, or pesticide damage, which makes accurate visual diagnosis difficult. If allowed to build up they can cause serious losses in crops such as Easter lilies and begonias. Infested plants exhibit stunted, blotched, and curled leaves that fade from green to yellow, and finally to brown. If plants are growing close together so that the leaves are touching, the nematodes can move from one leaf to another during wet weather. They survive from year to year in bulbs, leaf tissue, and in the soil.

Stem & Bulb Nematodes

The most important nematode pest of bulbs is the narcissus stem and bulb nematode (*Ditylenchus dipsaci*). As many as 400 different species of plants including all of the bulb crops, strawberries, onions, alfalfa, cereals, perennial flowers including phlox, and numerous weeds may be attacked by one or more races of this nematode. Some populations can attack a wide range of hosts while others are restricted to only a few. A related species, *Ditylenchus destructor* is a pest of dahlias and potatoes, however this nematode has not been found in BC.

Figure 7.2: Life Cycle of Bulb Nematodes



In the field, infested narcissus plants tend to start growth early but the leaves are shorter and often wider than normal. Some of the leaves are bent or otherwise deformed and exhibit pale areas with elongated swellings known as ‘spikkles’. These swellings contain nematodes that become dormant when the leaves dry up and then fall to the soil where they can be reactivated when conditions are favourable.

Infected bulbs are softer than normal and may exhibit a dark neck rot. When suspect bulbs are cut in cross section, concentric rings of dark infested scales are seen alternating with white uninfested scales.

Management of Nematodes in Soil

Nematodes can be introduced to a field in infested soil adhering to farm equipment and in infested planting stock. To reduce the risk of introducing nematodes to a field, test the roots and associated soil of planting stock for nematodes (e.g. root lesion, stem and bulb, and root knot nematodes) prior to planting out and, clean equipment before moving between fields. It is also recommended to periodically sample field and

greenhouse soils for nematodes. If plant-feeding nematodes are detected, the following management options can be applied to reduce nematode numbers and crop damage.

- **Fumigation and Pasteurization -** For large fields, soil fumigation with Vapam (metam-sodium) is recommended to lower populations. Smaller areas may be treated with Basamid (dazomet) or steam. Efforts should be made to minimize the movement of 'dirty' soil into the field following fumigation. A waiting period of at least 4 weeks will be required post-fumigation before the field is planted.

  See the *Pasteurization and Fumigation of Soil* section in Chapter 1.

- **Keep the Field Fallow -** Populations can also be lowered by keeping the field black to starve out the nematodes, however every weed must be removed for this option to be effective and the field will be out of production for the season.

- **Soil Solarization -** Covering the soil with clear polyethylene during the heat of the summer to 'solarize' it will reduce nematode populations, however, it can be difficult to achieve the high temperature necessary for a sufficient period of time in Coastal regions and good weed control is essential. Under good conditions, populations in the top 10 cm of soil can be reduced by about 50% after 4 weeks of solarisation between early July and late August. Removing the tarp, rotovating the soil as deeply as possible, and re-applying the tarp for another two weeks should increase efficacy. Combining a soil fumigant with solarization increases the success level of reducing nematode populations.

- **Cover Crops -** The use of cover crops has many beneficial properties such as improving soil fertility, increasing water retention capacity, preventing soil erosion and competing with weeds. Increasing the organic matter in the soil by using compost, manure, or cover crops is also known to reduce crop damage from nematodes. Organic matter often has an abundance of microbial life and can include fungi and nematodes that feed on nematodes. Cover crops, such as Wheeler rye, have been shown to suppress root lesion nematodes although the mechanism of suppression is not known. Other rye cultivars are good hosts to nematodes so the cultivar choice is extremely important when choosing a cover crop to suppress nematodes.

  Some cover crops have nematicidal effects. French marigolds (*Tagetes patula*) produce phytochemicals called polythienyls that have been effective in controlling root knot and root lesion nematodes. The use of marigolds is often limited to small scale production as it is very important to keep the area free of weeds that are a good reservoir and over-wintering host for nematodes.

Table 6.1: Hot Water Treatments for Root Knot (*Meloidogyne* spp.) and Root Lesion (*Pratylenchus* spp.) Nematode Management

Crop	Nematode	Treatment
Agapanthus, Aloe, Anemone, Astilbe, Begonia tubers, *Bletilla hyacinthine* bulbs, *Cactus, Campanula, Cestrum, Cimicifuga, Cissus, Clematis, Cyclamen, Dahlia* tubers, *Dracaena, Eupatorium, Euphorbia, Gardenia, Gentiana, Gerbera, Gladiolus, Helleborus, Hibiscus, Hosta, Hoya, Iris, Jasminum,* orchid, *Ornithogalum, Paeonia, Primula, Sanseviera, Scabiosa, Sedum, Senecio, Verbena, Zantedeschia*	Root knot	Hot water at 48°C for 30 min.
Calla rhizomes	Root knot	Dip in hot water at 50°C for 30 min.
Rosa spp. except multiflora	Root knot	Dip in hot water at 51°C for 10 min.
Chrysanthemum, not including *Pyrethrum*	Root knot & Root lesion	Dip in hot water at 48°C for 25 min.
Astilbe, Clematis, Dicentra, Gardenia, Helleborus, Hibiscus, Kniphofia, Primula	Root lesion	Hot water at 48°C for 30 min.
Source: USDA-APHIS, *Schedules for Plant Pests or Pathogens (T500)*		

There are some brassica cultivars that are also effective. When the plants are incorporated into the soil, they release compounds such as isothiocyanates that are toxic to nematodes. Many other potential cover crops have been tested with promising results for specific situations. It is important to note that there is a lot of variability between cover crops and the type of nematode that they suppress.

- **Crop Rotation** – Consider rotating with a non-host crop to reduce the population of nematodes in the field.
- **Resistant Varieties** – If available, grow crop cultivars that are resistant to nematodes.
- **Soilless System** – For greenhouse crops, use a hydroponic or soilless growing system. Take steps to ensure nematodes cannot move from the soil into the containers of soilless media, i.e. do not place the soilless media in direct contact with infested soil.

Management of Nematodes in Plant Roots

Hot water treatments can be used to kill nematodes in roots before planting in clean media or soil. The success of hot water treatments is dependent on accurate time and temperature controls. Various plants have different sensitivities to the treatments. Refer to Table 6.1 for recommended treatments for specific crops.

Management of Nematodes in Foliage and Bulbs

- **Use Nematode-free Stock** – Although leaf and stem cuttings will be free of root feeding nematodes, they will not necessarily be free of foliar nematodes. Test the stock prior to use. Use only clean or hot-water-treated stock for propagation.
- **Discard Heavily Infested Bulbs.**
- **Hot Water Treatment** – Refer to Table 6.2 for recommended treatments to manage foliar and stem & bulb nematodes. Cultivars vary in tolerance to hot water treatment. Bulbs of uniform size should be treated in the same batch.

  If basal rot is present, **hot water treatment with Formalin ☠** is recommended as the hot water treatment alone can spread basal rot from infected to healthy bulbs. Cured hyacinth, iris, and narcissus bulbs should be pre-soaked in water at 24°C for 2 hours to activate the nematodes from the resting state. Treat bulbs for 4 hours in a 44°C Formalin ☠ solution (500 mL of Formalin ☠ in 100 L of water). Dry and return to cool storage.

  Read the label for detailed information.
- **Crop Rotation** – Follow a 3 to 4 year rotation between crops. During that time, weeds must be controlled and all volunteer bulbs must be removed from the field to manage stem & bulb nematodes. If it is not feasible to follow long rotations between susceptible crops, infested fields may be fumigated to reduce the nematode population.
- **Sanitation** – Rogue and destroy symptomatic plants and plants adjacent to them. Remove plant debris in greenhouses, propagation, and equipment storage areas because it can harbour these nematodes. Take care in disposing of infested material as foliar and stem & bulb nematodes can survive in plant debris for long periods of time.

  Small infestations of foliar nematodes on individual leaves can be removed and destroyed.

  Thoroughly wash all tools and equipment that come in contact with infested soil or bulbs with a solution of 1 part Formalin ☠ (formaldehyde) and 9 parts water.
- **Irrigation** – Space plants so that they do not touch one another and avoid overhead watering to prevent splashing of nematodes to new plants. Water carefully.

If you suspect nematode damage to your crop, samples can be submitted to the BC Ministry of Agriculture and Lands Plant Diagnostic Lab for analysis. Dying plants and soil should be included in the sample. Contact the Lab for information on how to take a representative sample. The Lab can be reached at 604-556-3001 or Toll-free at 1-888-221-7141.

To test soil before planting to a crop, contact you agricultural advisor. These samples should be tested in a private lab.

Table 6.2: Hot Water Treatments for Foliar (*Aphelenchoides* spp.) and Stem & Bulb (*Ditylenchus* spp.) Nematode Management		
Crop	**Nematode**	**Treatment**
Allium, Amaryllis, Bulbs (general)	Stem & bulb	Presoak bulbs in water at 24°C for 2 hours, then in hot water at 43-44°C for 4 hours.
Bletilla hyacinthina	Foliar	Hot water at 48°C for 30 min.
Hyacinthus bulbs, *Iris* bulbs and rhizomes	Stem & bulb	Presoak in water at 21-27°C for 2.5 hours, followed by hot water immersion at 43-44°C.
Narcissus bulbs	Stem & bulb	Presoak cured bulbs in water at 21-27°C for 2 hours, followed by hot water immersion at 43-44°C until all bulbs reach that temperature and hold for 4 hours.
Begonia	Foliar	Dip in hot water at 48°C for 5 min.
Astilbe, Bletilla hyacinthina, Cimicifuga, Hosta, Paeonia	Foliar	Presoak in water at 20°C for 1 hour followed by hot water soak at 43°C for 1 hour. Then dip in cold water and let dry.
Senecio	Foliar	Treat with hot water at 43°C for 1 hour.
Crocus	Foliar, Stem & bulb	Hot water at 43°C for 4 hours. Should be done immediately after digging.
Amaryllis, Gladiolus, Scilla	Stem & bulb	Hot water at 43°C for 4 hours. Should be done immediately after digging.
Muscari, Ornithogalum	Stem & bulb	Dip in hot water at 45°C for 4 hours.
Source: USDA-APHIS, *Schedules for Plant Pests or Pathogens (T500)*		