

## Plant Parasitic Nematodes in Ontario

There are many beneficial nematodes in agricultural soil, however some nematodes are plant parasitic. When plant parasitic nematodes are present in high numbers in soil, they can cause significant yield losses to horticultural crops. The extent of loss depends on the crop, nematode species and soil populations.

The most destructive and common plant parasitic nematodes in Ontario fruit crops are root-lesion (*Pratylenchus penetrans*) and northern root-knot (*Meloidogyne hapla*). The northern root-knot nematode is becoming more prevalent. The pin (*Paratylenchus sp.*) and dagger (*Xiphinema sp.*) nematodes occasionally cause yield losses to some fruit crops in isolated fields. The dagger nematode is mainly a virus vector on grape, raspberry and apple.

Generally, symptoms of nematode injury include:

- uneven plant growth
- poor plant establishment
- plants weakening over time
- poor root growth
- knots or galls on roots
- excessive branching of roots, hairy root symptoms

On strawberries:

- Root-lesion nematodes cause discolouration of the fine feeder roots and tiny brown scratch-like lesions on the young white roots. These lesions merge to form large brown areas. Root-lesion nematodes are involved in the black root rot complex and aggravate verticillium wilt of strawberries and other host plants. Severely infected plants appear stunted and unthrifty.
- Root-knot nematode feeding stimulates root cells to enlarge. Groups of enlarged cells look like small galls or beads (1 mm). As more and more nematodes establish feeding sites in the same region of the root, the groups of enlarged cells become one larger root-knot.

On raspberries:

- Root-lesion nematode feeding causes scratch-like lesions on roots, similar to the symptoms on strawberry roots. Severely infested plants have thinner and fewer canes per crown. Up to 25% of first-year canes may be killed by severe infestations of these nematodes.
- Dagger nematodes spread tomato ringspot virus, which causes crumbly berries, mottled leaves and cane dieback.

On tree fruits:

- Root-lesion nematodes can be a major cause of orchard replant failures, and are a significant factor in Apple Replant Disorder (ARD). They can also cause a decline in vigour of existing peach and cherry orchards. These nematodes cause small brown lesions on the white lateral roots and kill the fine feeder roots. When lesions merge, the entire root system appears discoloured. Root lesions are frequently invaded by other pathogens which can cause root rot. Severely affected trees may lose all feeder roots. Young replant trees may die. Existing trees lack uniformity.

## Thresholds

Nematode populations above economic thresholds can significantly reduce yields. The economic threshold for nematode populations refers to the population at planting. Planting a susceptible crop in soils with a population of nematodes near or above the economic threshold will result in crop losses over time. For economic thresholds, see Table 7–1. *Nematode Thresholds for Fruit Crops*, on this page.

**Table 7–1.** Nematode Thresholds for Fruit Crops

Type of Nematode	Economic Threshold (nematodes/kg soil)
Root-lesion	1,000 (exception: 500 on strawberries)
Root-knot	1,000
Pin	5,000
Dagger	100
Bulb and stem	100

- Nematode problems are most often found in sandy-loam and sandy soils. Always sample these soils for nematode populations before planting fruit crops.
- Root-lesion and root-knot nematode problems are not usually found in clay or clay-loam soils. Sample these soils for nematodes before planting in replant sites or where susceptible crops have been recently grown.
- Sample clay or clay-loam soils for dagger nematode before planting on virus-susceptible grape, raspberry or tree fruit.

For more information, see OMAFRA Factsheet, *Sampling Soil and Roots for Plant Parasitic Nematodes*. Information on how to sample soil for nematodes and where to send the samples can be found in Appendix F: *Diagnostic Services*, page 436.

## Nematode Management

Nematode management starts a year before planting a susceptible crop like fruit trees. Try to reduce nematode populations so that clean stock can establish well before the nematodes rebound to damaging levels. Young plants tolerate much less nematode feeding than established plants. Use a combination of the following methods to manage nematodes:

- Start new fields with transplants free from nematodes, and grown by an accredited plant propagator.
- Rotate susceptible crops with non-host crops for several years.
- Grow nematode-suppressing cover crops in the years prior to establishing fruit crops.
- Destroy residual crop roots.
- Plant resistant fruit cultivars where available.
- Control weeds, as they are good hosts of nematodes.
- Use soil fumigation before planting when nematode populations in soil reach or exceed thresholds (see Table 7–1. *Nematode Thresholds for Fruit Crops*, page 387).

## Cover Crops for Nematode Suppression

Cover crops may reduce populations of plant parasitic nematodes when properly managed in the year before planting. In Ontario, these nematode-suppressing cover crops have been successful:

- oilseed radish
- certain white and oriental mustard cultivars like White Gold, Pacific Gold, Caliente, Cutlass or Forge
- specific sorghum × sudan-grass hybrids
- African marigold cultivars like Crackerjack or Creole
- Canadian Forage Pearl Millet 101 (root lesion nematode suppression)

Not all cultivars of the above cover crops reduce nematode populations. Choose the right variety. One or more years of nematode-suppressing cover crops may be required to reduce nematodes below economic thresholds.

Cover crops suppress nematodes in different ways:

- Canadian Forage Pearl Millet 101 is a poor host and inhibits the ability of root lesion nematodes to reproduce in its root-system.
- Certain cultivars of African marigolds produce a root exudate that is toxic to nematodes in the soil.
- Nematode-suppressing cultivars of oilseed radish and certain white and oriental mustards produce glucosinolates and an enzyme in their leaves, stems and petioles. The enzyme converts the glucosinolates into isothiocyanates, which are toxic to nematodes when the cover crop is cut green and incorporated immediately into the soil.

Exclude cover crops such as clovers and buckwheat from berry and orchard rotations. These are excellent hosts for root-lesion nematodes. Wheat or barley are the best cereal crops to grow before planting.

For more information, visit [ontario.ca/crops](http://ontario.ca/crops) and search the *Soil Management, Fertilizer Use, Crop Nutrition and Cover Crops for Fruit Production* webpage.

## Other Cultural Practices to Reduce Nematodes

Nematode populations can build on many weed species. A good weed control program is essential the year before planting fruit crops. Plan an intensive weed management strategy for the cover crop where nematode-suppressing cover crops are grown.

Keep land fallow the year before planting to reduce nematode numbers. A disadvantage to fallow land is increased susceptibility to soil erosion. In orchards, choose ground covers for planting between the rows that do not support nematodes, such as annual or perennial ryegrass, or creeping red fescue.

## Soil Fumigation

Pre-plant soil fumigation is the most effective method of controlling nematode problems. Fumigants can be broadcast over the whole field or applied only in bands where crop will be planted. Tree-row application, or the treatment of a 2.0–2.5 m strip centred on the row, is more economical, but requires good planning. However, broadcast fumigation will reduce the risk of re-contamination if non-fumigated soil is mixed into the fumigated strip.

For products, rates and other information on fumigants, refer to Table 7–2. *Products for Management of Nematodes and Other Soil-borne Pests*, page 390.

### Application of fumigants before planting

Most fumigants are applied by shank injection using specialized application equipment. Some formulations of metam sodium can be applied to the soil surface and watered in. See the product label for application instructions.

- Fumigate when soil temperatures are above 4°C at 20 cm depth. Warmer temperatures (15°C and over) are preferred for more rapid fumigant dispersal in the soil. Fumigation in the early fall before planting is best for fruit crops which are planted in early spring when soils are still cool.
- Land preparation is critical for effective fumigant application. Fumigants cannot easily penetrate large clumps of soil and organic matter. Remove trash and old root systems. One week prior to fumigation, work the soil to a depth of 25–30 cm and obtain good seedbed tilth and moisture. Keep soil moist and if necessary irrigate the treated area during the week prior to fumigation.

A light cultivation immediately before fumigation may be necessary if a soil crust has developed.

- Soil moisture in the top 15–20 cm must be at the level stipulated by the fumigant label prior to and during fumigation. If soil moisture is not sufficient, it must be adjusted before product application can occur. For best results, keep the soil surface moist during application and for 24 hours after application.
- Seal the soil surface immediately after injection of the fumigant. The best method for sealing the soil is covering it with tarps, however, rolling or cultipacking immediately behind the fumigant applicator can also be used. Some fumigants have specific requirements for sealing the soil—consult product labels to determine what is legally permissible for the fumigant and type of application. Light watering after application will further prevent the escape of fumigant from the soil.
- Leave soil undisturbed for at least 1 week after injection of the fumigant. Colder soils (below 15°C) require longer periods from injection to aeration.
- Work the soil and aerate for about a week before planting. For fall planting, work the soil and aerate for 2 weeks before planting. The time interval between fumigation and planting into fumigated soil depends upon the product used, the rate and the temperature following fumigation (consult product label).
- Use high-quality planting stock, preferably grown in fumigated soil. Nursery operators can provide information on how to manage nematodes.
- Always read the product label. All fumigant labels now contain detailed Good Agricultural Practices for soil conditions, sealing, application and re-entry. These are mandatory and must be followed for all fumigant applications.

### Fumigating single-tree sites before planting replacement trees

When trees are replanted within an existing orchard, nematodes and diseases can be controlled in the planting hole using Vapam or Busan before planting. Refer to the product label for application details, rates and safety precautions.

**Table 7–2.** Products for Management of Nematodes and Other Soil-borne Pests

**CAUTION:** These products are very toxic. Read the label and follow instructions for handling and application. Always follow manufacturer's directions carefully for dosage and methods of use. The applicator must wear suitable protective clothing, etc. These requirements vary between products and can be found on the label.

Product	Active Ingredient	Ontario Class	Pests Controlled <sup>1</sup>			Fruit Crop Registrations	Rates (shank injection or surface applied)	Rates (sprinkler application)
			Nematodes	Soil-borne Diseases	Weeds			
Busan 1020	metam sodium 33%	4	yes	yes	yes	fruit crops	375–935 L/ha (shank injection)	700–935 L/ha
Busan 1180	metam potassium 54%	3	yes	yes	yes	fruit crops	231–576 L/ha (shank injection)	431–576 L/ha
Busan 1236	metam sodium 42%	4	yes	yes	yes	fruit crops	274–683 L/ha (shank injection)	511–683 L/ha
Chloropicrin 100	chloropicrin 99%	2	yes	yes	no	strawberry, raspberry	93 L/ha <sup>2</sup> (shank injection)	do not apply with sprinklers
Enfuse M 510	metam sodium 42%	4	yes	yes	yes	fruit crops	260 L/ha (surface applied)	do not apply with sprinklers
Pic Plus	chloropicrin 85.1%	2	yes <sup>3</sup>	yes	no	strawberry, raspberry	108 L/ha <sup>4</sup> (shank injection)	do not apply with sprinklers
MustGrow	oriental mustard seed meal 100%	3	yes <sup>5</sup>	yes <sup>5</sup>	no	strawberry, raspberry tree fruit, tree nuts	1121–2240 kg/ha (surface applied)	do not apply with sprinklers
Vapam HL	metam sodium 42%	4	yes	yes	yes	fruit crops	279–696 L/ha (shank injection)	350–670 L/ha
Velum Prime	fluopyram (500 g/L)	2	yes <sup>6</sup>	yes <sup>7</sup>	no	strawberry, specialty bushberry <sup>8</sup>	do not surface apply	500 mL/ha (chemigation) <sup>9</sup>

<sup>1</sup> See label for exact registrations.

<sup>2</sup> Use 140 L/ha Chloropicrin 100 for strawberry plant production (runner production).

<sup>3</sup> Pic Plus is labelled for root-knot nematode but is not labelled for root-lesion nematode.

<sup>4</sup> Use 162 L/ha PicPlus for strawberry plant production (runner production).

<sup>5</sup> Provides suppression rather than control.

<sup>6</sup> Provides suppression of soil-dwelling, root feeding nematodes (juveniles, adults).

<sup>7</sup> Provides control of foliar disease (powdery mildew).

<sup>8</sup> Low-bush blueberry, bearberry, bilberry, cloudberry, cranberry, lingonberry, muntries, partridgeberry.

<sup>9</sup> Chemigation into the root-zone through low pressure drip, trickle, micro-sprinkler or equivalent equipment.

### ***New requirements for fumigants***

Health Canada's Pest Management Regulatory Agency (PMRA) has changed the label requirements for soil fumigant products containing chloropicrin, metam sodium and metam potassium. These requirements are intended to further limit user exposure and increase protection of workers, bystanders and the environment. The changes took effect in September 2014. Growers and applicators should ensure they have the most current version of product labels before applying any fumigant. Detailed instructions can be found on product labels, but requirements include:

- A Fumigation Management Plan (FMP) must be completed prior to the start of any fumigant application. This is an organized, written description of the steps involved to ensure a safe and effective fumigation. The specific requirements for the FMP will be listed on the product label.
- Mandatory Good Agricultural Practices are now required. This standardizes many practices already on existing labels and helps improve the safety and efficacy of soil fumigations. These practices will vary with the product and application method but will include identifying optimal weather conditions, proper soil preparation, requirements for soil moisture and temperature, methods for soil sealing and use of proper application depths.
- DO NOT apply these products when a temperature inversion is occurring or is predicted to occur within 48 hours after application is complete, as fumigant vapours may drift. For more information on how inversions affect drift of pest control products, see [www.sprayers101.com/surface-inversions/](http://www.sprayers101.com/surface-inversions/).
- DO NOT apply these products if light wind conditions (less than 3 km/h) are forecast to persist for more than 18 consecutive hours from the time the application starts until 48 hours after the application is complete. Calm conditions could indicate a temperature inversion, which could lead to spray drift. See [www.sprayers101.com](http://www.sprayers101.com) for more information on temperature inversions.
- Any person involved in the use of fumigants is considered a fumigant handler. All fumigant handlers must hold an appropriate pesticide applicator certificate or license recognized by the provincial pesticide regulatory agency where the pesticide application is to occur.
- Entry into fumigant application blocks by any person (other than fumigant handlers, emergency personnel and local, provincial or federal officials performing inspection, sampling or other official duties) is PROHIBITED during the Application Block Period.

- The Application Block Period begins at the start of application and expires at least 5 days after the application is complete. The length of the period will depend on application criteria (e.g., tarped or non-tarped, etc.). The applicator must verbally warn workers of the application.
- Fumigant application signs must be posted on all entrances to the application block. Signs must be posted prior to the start of the application (but no earlier than 24 hours prior to application) and remain posted for the duration of the Application Block Period. Signs must be removed within 3 days of the end of the Application Block Period.
- Only fumigant handlers with an appropriate pesticide applicator certificate or license recognized by the provincial regulatory agency may be in the application block from the start of the application until the Application Block Period expires, and in the buffer zone during the Buffer Zone Period.

### ***Buffer zones***

- A buffer zone must be established for all fumigant applications. A buffer zone is an area around the perimeter of the fumigated area that extends equally in all directions. The size of the buffer zone area will depend on the product and application criteria.
- Only fumigant handlers with appropriate certification may enter the buffer zone during the Buffer Zone Period, the 48-hour period following application. All non-handlers, including field workers, residents and pedestrians must be excluded from the buffer zone during the Buffer Zone Period, except for transit (e.g., vehicular or bicycle traffic).
- The size of the buffer zone will vary with application method, rate and field size. Product labels will include tables to determine the required buffer zone distance.
- Buffer zones cannot include any residential area or occupied building, outdoor residential areas (e.g., lawns, gardens, play areas) or other areas that may be occupied during the 48-hour period following application.
- An emergency preparedness plan will be required when residences or businesses are located in close proximity to the outer edge of the buffer zone.

## Nematode Suppression After Planting

### **Velum Prime**

Velum Prime is a broad-spectrum nematicide/fungicide (Fungicide Group 7) with preventative, systemic, and curative properties for the suppression of certain soil plant pathogenic nematodes and control of certain crop diseases. Velum Prime is best suited for use in a preventative treatment program. For best results, this product should be applied in the root zone through drip irrigation equipment only beginning at planting. As the roots take up the product, it suppresses root feeding nematodes and moves up into the foliar plant tissue to control certain fungal diseases such as powdery mildew.

- To limit the potential for disease resistance developing to Group 7 fungicides, do not make more than 2 sequential applications of Velum Prime or any other Group 7 product before rotating to a different fungicide group registered for the same use.
- Fungicides other than Group 7 with a different mode of action should be applied for the first foliar fungicide application.
- Do not apply more than 1 litre of Velum Prime/ha per year, regardless of formulation or method of application.
- Velum Prime can be applied up to the day of harvest.

### **Vydate**

Vydate will suppress nematodes after planting non-bearing apples and raspberries. Vydate is less effective than pre-plant soil fumigation and does not control soil-borne disease. Refer to the product label for application methods, mixing instructions, rates and precautions.

- Vydate is highly toxic to bees. Do not apply during the pink or bloom period.
- Vydate is very toxic to humans. Follow application instructions closely.

Apple-specific strategies:

- Treat young whips and non-bearing fruit trees with 1 application of Vydate as a soil drench around the base of each tree when roots are actively growing and leaf growth begins in the spring. Follow this with a foliar application of Vydate.
- An alternative method is to make 3 foliar applications on a 2–3-week schedule for a total of 3 applications.
- Do not allow spray to drift onto trees in bloom.
- Do not apply to trees under water stress or not actively growing.
- Do not re-enter treated fields for 24 hours after application.

Raspberry-specific strategies:

- Treat raspberry plants with 1 application of Vydate as a soil drench over roots in the fall before October 31. Do not apply Vydate to raspberries in the spring.
- Do not apply to raspberries more than once a year.
- Do not re-enter treated fields for 12 hours after application.