ENY-039

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Nematode Management for Nursery Crops (Ornamentals and Planting Stock of Fruits and Nuts) [1]

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Foliage ornamentals, floral crops, landscape ornamentals, and fruit and nut trees are all produced in Florida nurseries; most may be produced in containers, in ground beds or fields, or by some combination of both growing sites. Most principles of nematode management for nursery crops apply equally to all ornamentals. Pesticide labels often group herbaceous (foliage and floral crops) ornamentals, woody ornamentals, and non-bearing fruit/nut trees together for pesticide registration restrictions. Therefore, these groups of plants are not treated separately here. However, it is the **grower's responsibility** to determine from the label that his crop, method, and application site are legal for the pesticide he intends to use.

Important nematodes of nurseries include root-knot (*Meloidogyne* spp.), lesion (*Pratylenchus* spp.), foliar (*Aphelenchoides* spp.), and stunt (*Tylenchorynchus* spp.) nematodes. Burrowing (*Radopholus* spp.) and reniform (*Rotylenchulus* spp.) nematodes can injure nursery crops and are subject to quarantine. Citrus nematode (*Tylenchulus semipenetrans*) disqualifies a site for use as a citrus nursery.

Nematodes are spread easily in any manner by which infested soil or plant material are moved within growing areas. Equipment, water, hands, shoes, clothing, transplants and seeds can help spread them (Even wind-borne dust sometimes carries nematodes).

Nematodes often may be avoided by careful cultural practices and strict sanitation procedures. However, nematicides are often needed to control established infestations.

Diagnosis

Symptoms of Nematode Injury

Typical Root Symptoms of nematode attack are: root knots or root galls (Figures 1, 2), root lesions (Figure 3), excessive root branching, injured root tips, stunted or abbreviated root systems (Figure 4), and rotting of roots (Figure 5), bulbs (Figure 6), and rhizomes.

Above-Ground , affected plants often exhibit slow decline (Figure 7) and foliar yellowing (chlorosis) (Figure 8); where foliar nematodes are

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Figure 1. Roots with galls caused by root-knot nematodes (left) and healthy roots (right).

Figure 2. Root-knot nematode galls on a potted plant.

Figure 3. Lesions on amaryllis roots caused by lesion nematode.

Figure 4. Some nematodes cause an abbreviated or "stubby" root system.

Figure 5. Rotting of palm roots caused by burrowing nematode.

Figure 6. Rotting of Easter lily bulb caused by lesion nematode.

involved, leaves may be stunted and have dark spots of collapsed or dead issues (Figure 9). Loss of foliage may eventually result from either foliar nematode damage to leaves or root damage by other nematodes. Infested areas in ground beds, raised beds, or a field may appear as gradually widening

patches which expand as the infestation spreads. Diagnosing a problem should not be based on above-ground symptoms alone; similar symptoms and symptom patterns may be caused by soil-borne fungal pathogens, nematode-pathogen complexes, insects or mites, and nutrient or cultural problems.

Figure 7. Above-ground symptoms of nematode damage may resemble symptoms of any other plant stress, including discoloration and dropping of leaves.

Figure 8. Nematode damage to roots can cause symptoms of nutrient deficiency. The gardenia on the left is being affected by root-knot nematodes.

Nematode Detection

Nematodes are microscopic worms (Figure 10) which require specialized laboratory procedures to separate them from soil or plant samples and to identify them. Growers who suspect that they have nematode infestations or wish to monitor their soils, soil mixes, or plants for nematodes can use the Florida Nematode Assay Laboratory, Building 78 Mowry Rd., University of Florida, Gainesville, FL 32611, phone (352) 392-1994, email: nemalab@ifas.ufl.edu. This is not the same

Figure 9. Symptoms of foliar nematode damage are often angular shaped leaf spots.

laboratory or agency which must inspect and certify plant material to be free of nematodes before shipping out of state, and cannot be substituted for it. For out-of-state certification, contact the local Agricultural Products Specialist of the State Department of Agriculture and Consumer Services. They must also be involved in selection and establishment of all citrus nursery sites. Several private diagnostic laboratories also offer nematode sample analysis: contact them for information about their services and charges.

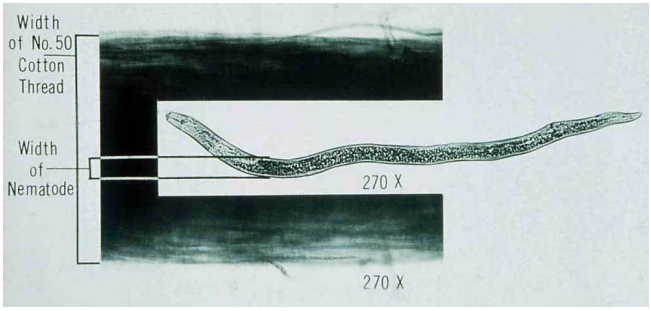

Figure 10. Size comparison of a typical plant-parasitic nematode to a cotton thread.

Integrated Nematode Management

Plant injury and losses to nematodes are most effectively reduced by an integrated program of preventive measures, sanitation, and chemical nematicides. For greatest energy and financial efficiency, consider all practical management techniques to select the combination that best fits each growing situation. Sanitation and prevention of stock plant infestation are the best defenses against nematodes in nursery crops. Knowledge of visual symptoms and nematode testing services offer the

means to monitor these situations during the life of a crop. If a nematode infestation develops despite preventive measures, appropriate nematicides often may be applied with a good prospect of success if the infestation is detected early.

Sanitation and Preventive Maintenance

1. Plant only in pest- and pathogen-free soils or planting mixtures; heat-treat or fumigate if necessary to assure that planting mix is clean (Table 1 and Table 2).
2. Disinfest all plant containers, bins, benches and other equipment. A surface disinfestant such as sodium hypochlorite can be used for this purpose (Table 3).
3. Keep plant containers, flats, and planting soil clean (Table 3). Store clean containers, sand, peat, and other potting medium components or completed media on concrete slabs, in concrete bins, or other surfaces or containers that prevent contamination by run-off water, casual soil contact, etc.
4. Do not move soil, plant material, pots, flats or any other materials from areas known to be infested to uninfested areas. A color code can be used as an aid to restrict movement.
5. Wash hands and disinfect tools frequently when working in planting stock. Do this especially when moving from one area to another. Clean heavy machinery before it is used to move clean medium or medium components.
6. Use nematode-free propagating stock; this may often be obtained from unrooted cuttings that have never been in contact with soil or other source of infestation. Source plants of some species which have been infested may be treated with hot water (Table 4), thus enabling production of more propagating material above ground, but nematode eradication is never assured.
7. Use raised benches if possible; do not allow hose nozzles or tools to touch the ground. Quarantine regulations of some markets, such as California, may specify the height of raised benches.
8. Where maximum greenhouse sanitation is desired, reduce the level of wind-blown soil that enters the structure, especially in windy weather, by maintaining continuous vegetative cover such as mowed turf around them. Paved roadways running near the structures also help. The value of some crops, particularly plugs from tissue culture, may merit such precautions.

Biological Control

Although biological control of some pests, particularly insects and mites, is being advocated commercially for a few specific situations, practical biological control of plant parasitic nematodes has not yet been achieved. Extensive research on nematode biological control agents is under way in UF laboratories and many other places in the world.

Chemicals

Chlorfenapyr is the active ingredient in Pylon® (Olympic Horticultural Products), a miticide/nematicide labeled for use on greenhouse ornamentals. Chlorfenapyr is a foliar treatment that can be used to manage foliar (*Aphelenchoides* spp.) nematodes. This product is not for use on root-feeding nematodes.

Pre-Plant Fumigation

Soil Fumigation

There are several broad-spectrum soil fumigants that may be used to disinfest potting media and/or soil in field nurseries before planting. Of these methyl bromide is most effective. There are several broad-spectrum soil fumigants that may be used to disinfest potting media and/or soil in field nurseries before planting. Of these methyl bromide is most effective. Existing supplies of methyl bromide may still be used by nurseries in Florida if it can be obtained.

Metam sodium (Vapam®, Busan®, Nemasol®, and several other tradenames) is injected into soil as a liquid and turn into a gas following application. it is fairly effective against weeds and moderately effective against fungi and nematodes. Different

formulations are labeled for use on both potting media (Table 1) and field soil.

Dazonet (Basamid®) is incorporated with soil as a granular material, but releases gases as it breaks down in soil. It is fairly effective against weeds and moderately effective against fungi and nematodes. Basamid is labeled for use on both potting media (Table 1) and field soil.

1,3-Dichloropropene is mixed with chloropicrin in Telone® C-17 to get a broad-spectrum of activity. 1,3-Dichloropropene is fairly effective against nematodes and chloropicrin is fairly effective against fungi. Neither chemical has much activity against weeds. Telone® C-17 is labeled only for use on field soil.

Phytotoxicity

It is strongly recommended that the potential phytotoxic (plant injury) effects of the nematicides be evaluated by the grower on a few plants under his conditions before treating large areas. Phytotoxic effects will be noticeable within one week to one month. Some plants or varieties may show temporary growth retardation after treatment.

The instructions for use on the labels of agricultural chemicals must be followed very closely. Damage to plants is likely to occur if the recommended application rates and frequencies are exceeded.

Important Notice to Growers

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) as amended provides that a pesticide must be used in accordance with label directions. However, FIFRA does allow the application of a pesticide against any target pest not specified on the label if the application is to a crop, animal, or site specified on the label and the application is made in a manner already listed on the label for other pests. The site (plant, greenhouse) must be listed, but the specific pest (nematode, insect, etc.) need not. An applicator can employ most methods of application not prohibited on the label, and the mixing of a pesticide or pesticides with a fertilizer when such mixture is not prohibited by the labeling. However, the label **must** specifically permit any application through any irrigation system (chemigation) and provide detailed guidelines for doing so. Application through an irrigation system is illegal if it is not specifically permitted and described on the product label.

The precise crop environment where certain pesticides may be used is not well defined on many pesticide labels, but products cannot be used inside enclosed growing structures unless that use site is specified on the label. Nursery plants may be grown commercially in at least three different environments -- greenhouses, shadehouses, and open fields. The picture is further complicated by seasonal modifications of many shadehouse structures. In warm weather, shadehouses are covered only with fabric materials which permit air and rain to pass through -- an environment which approximates open-field conditions with the exception of shade level. With the onset of cool weather, many shadehouses are lined with plastic film to make them more like greenhouses. The nurseryman must decide whether his shadehouse is more like open field or greenhouse conditions as he interprets a pesticide label.

Read the label carefully, for pesticide labels differ widely in plant and pest listings. Some are broad ornamental labels and others specifically list certain plants and pests for which the pesticide is labeled in such a way that application can only be made to the crops/targets listed. Many of the pesticides listed in this guide are **highly** toxic to man and animals. Handle them with care. Always read the entire label carefully and follow all precautions before using these materials. Always use gloves, boots, and other needed protective clothing when treating or working in treated areas. Do not place pesticides in contact with food or water. Store them in their original containers out of the reach of children, pets and other animals. Dispose of empty containers promptly and safely according to directions on the label. Pesticides recommended in Florida may not have the same registered uses in other states. Consult with local authorities on legality and advisability of using these recommendations outside of Florida.

Summary

The University of Florida is committed to bringing you the most current information possible. Consequently this document will be modified with each breaking development. The most current version of this document may be obtained at your county Cooperative Extension office, or found on line at the University of Florida's Electronic Document Information System (EDIS) website at http://edis.ifas.ufl.edu/.

For additional information regarding nematodes, nematode management, or help interpreting nematode assay results contact:

Dr. W. T. (Billy) Crow, Landscape Nematologist, Entomology and Nematology Dept., PO Box 110620, Gainesville, FL 32611, (352) 392-1901 ext. 138, FAX: (352) 392-0190, E-mail: wtcr@ufl.edu.

For information on submitting samples to the Florida Nematode Assay Lab or to check on the status of a sample you submitted contact:

Mr. Frank Woods, Senior Biologist, Nematode Assay Lab, PO Box 110820, Gainesville, FL 32611, (352) 392-1994, FAX: (352) 392-3438, E-mail: nemalab@ifas.ufl.edu.

Table 1. Preplant Treatment for Potting Media.

Material	Rate	Directions
Aerated steam	140 degrees F for 30 minutes	Inject steam into medium under a cover. Soil temperature at the coolest point should be maintained at 140 degrees F for 30 minutes. Excessive or low soil moisture or tightly compacted soil will reduce effectiveness.
Live steam	180 degrees F for 30 minutes	Same as for aerated steam except that soil temperature should be maintained at 180 degrees F for 30 minutes.
Chloropicrin (Chlor-O-Pic)	10 cc/cu ft	**RESTRICTED USE PESTICIDE.** Inject 6-8 inches deep into soil, in a grid pattern with injection points not more than 12 inches apart. Soil should be no more than 12 inches deep on plastic and be covered with plastic sheeting for at least 24 hours after treating.
Methyl bromide (several trade names)	1.0 lb actual/cu yd	**RESTRICTED USE PESTICIDE.** Decomposed compost, mulching materials, potting media, manure, and top soil. Place materials to be treated on a cement floor, 4-mil polyethylene or other non-soil gas-tight surface, and level to not more than 18 inches deep. Make holes on 12-inch centers in the mass with a broom handle. The material should be loose, 60 to 85 degrees F, and have sufficient moisture for good seed germination. Cover air-tight with 4-mil polyethylene and release methyl bromide at top of the pile with special applicators. Expose to fumigant 24 to 48 hr. **Aeration before planting:** 72 hr before seeding, 6 to 10 days before setting plants. If soil dries, irrigate 2 or 3 days prior to seeding or planting.
Warning: Poor growth of some ornamental crops has sometimes occurred after methyl bromide treatment of soil. Crops known to be sensitive include carnations, conifers, delphiniums, holly, multiflora rose, salvia, and snapdragons.		
Metam sodium (several trade names))	1.0 fl oz/2 cu ft	Potting soil. May be applied as a drench (1 pt metam-sodium in 5 gal water sprinkled over 100 sq ft of soil spread out in a layer 4 inches deep) or in a cement mixer or soil shredder. Pile medium on concrete slab or plastic tarp and cover with plastic tarp, or enclose in tightly sealed bin for at least 48 hr. Uncover and allow to aerate for 5 days, then mix to encourage escape of fumes. Total wait after treatment should be at least 4 weeks, agitating soil weekly to enhance aeration. Do not use until odor is gone. If in doubt of crop safety, transplant several test plants in small samples of soil and observe 24 hr for injury before planting major crop.
Dazomet (Basamid Granular)	1.0 - 1.75 oz/sq yd	**Application:** Spread moist soil 8-10 inches deep on solid surface (preferably with plastic tarp under it); spread Basamid evenly on surface, then mix thoroughly (e.g., with tiller or large-scale medium mixing equipment). Treated soil can be piled up to 1 yard high after mixing. Cover with plastic tarp. Check label for temperature-dependent waiting period (10 - 30 days) before soil is safe to use.

Table 2. Preplant treatments in raised benches, ground beds and propagation benches.

Soil treatment	Rate/acre	Directions
Aerated steam	140 degrees F for 30 minutes	Inject steam into soil under a cover. Measure soil temperature 6 inches below surface. Soil temperature at the coolest point should be 140 degrees F for 30 minutes. May be planted as soon as cool. Excessive or low soil moisture or tightly compacted soil will reduce effectiveness.

Table 2. Preplant treatments in raised benches, ground beds and propagation benches.

Live steam	180 degrees F for 30 minutes	Same as for aerated steam except that soil temperature should be maintained at 180 degrees F for 30 minutes.
Chloropicrin (Chlor-O-Pic)	35 gal (480 lb actual)(0.8 gal/1000 sq ft)	**RESTRICTED USE PESTICIDE. Application method:** Inject 6 to 8 inches deep with chisels or fumigun spaced 10 to 12 inches. Cover with gas-tight plastic. **Exposure period:** 24 hours. **Aeration before planting:** 14 days
(Terr-O-Gas 67)	250 lb actual(8 lb/1000 sq ft)	**RESTRICTED USE PESTICIDE. Application method:** Inject 6 to 8 inches deep with chisels spaced 10 to 12 inches apart. Cover with gas-tight plastic. **Exposure time:** 48 hours. **Aeration before planting:** 14 days.
Methyl bromide (several trade names)	872 lb actual(20 lb/1000 sq ft)	**RESTRICTED USE PESTICIDE. Application method:** Release with special applicator under plastic or inject 6 to 8 inches deep with chisels spaced 10 to 12 inches apart. Cover with gas-tight plastic.**Exposure period:** 48 hours. **Aeration before planting:** 14 days.
Metam-sodium (several trade names)	100 gal(2.3 gal/1000 sq ft)	**Application method:** Apply as a drench in water or inject through chisels 5 inches apart. Follow label instructions carefully. Treated beds should be sealed with plastic tarp for at least 48 hours after treatment and aerated with weekly cultivation for a total of at least 4 weeks after treatment. Testing with a few plants before planting the entire crop is suggested to check for complete absence of metam-sodium from treated soil.
Dazomet (Basamid Granular)	8 lb/1000 sq ft =350 lb/acre	**Application method:** Apply granules as evenly as possible, incorporate to depth desired, preferably with tiller with L-shaped tines, roll surface, then seal by either wetting soil or covering with plastic tarp. See label for rate variations, exposure times, aeration, and testing for complete escape of fumes.

Table 3. Surface Disinfestant for Containers, Bins, Benches and Equipment.

Material	Rate	Use and Directions
Sodium hypochlorite (household bleach)	1 part common bleach in 5 parts water.	**Surfaces:** - Thoroughly drench solution over the surfaces of benches, bins, and containers. Use a scrub brush to remove soil, algae and other debris before final drench in disinfestant.

Table 4. Hot water treatment of caladium tubers for nematode control.

Material	Rate	Directions
Hot Water	122 degrees F(50 degrees C)	Caladium tubers only. Soak in vat of hot water for 30 minutes and transfer to cold to avoid heat injury to tubers. Heat treatment may work well with some other plant materials, but the best combination of temperature and period of exposure will differ for each plant species and size of tissue mass to be treated.