Cooperative Extension Service
C/T/A/H/R
College of Tropical Agriculture & Human Resources
University of Hawaii at Manoa

Plant Disease
Dec. 1998
PD-15

Plant-parasitic Nematodes and Their Management

Nematodes are roundworms, and those that attack plants are microscopic. The damage they cause to plants is often subtle and is easily confused with nutrient problems. Although hundreds of different kinds of nematodes may infect plants, less than a dozen are economically serious root-feeding pathogens in Hawaii, and only one genus here causes significant damage by feeding on foliage. If the numbers of harmful nematodes are large, plant growth is adversely affected.

The primary groups of nematodes that cause problems in Hawaii are the root-knot, cyst, burrowing, lesion, foliar, and reniform nematodes. Others, such as the spiral, pin, and lance nematodes, may occur in abundance but usually do not cause sufficient damage to warrant concern. All of these nematodes, whether root-feeders or foliage-feeders, have a spear-like mouthpart that punctures plant cells so that the nematode can feed on the cell contents. Feeding by some nematodes causes abnormal plant growth, and consequently the plants can be stunted, discolored, or both.

The environmental conditions of Hawaii are ideal for maximizing nematode damage. Nematodes thrive at the temperatures under which most crops and landscape plants are grown in Hawaii, especially where frequent rainfall or irrigation keeps the soil moist.

Control of nematodes can be optimized by basing management decisions on the relationship between nematode biology and plant response. Lacking a well informed management plan, arbitrary selection of control practices can be costly and ineffective.

Relationship between nematode biology and control

Management of nematodes must focus on reducing nematode numbers to levels below the damage threshold.

In annual crops, the higher the nematode population numbers at the time of planting, the lower the yield. In perennial crops, the relationship between plant growth and nematode populations is more complex. The initial numbers of nematodes are still important because they determine the early growth potential of the plant. However, even if numbers are low at planting, nematode populations will eventually increase and ultimately damage perennial plants. Thus, not only must the initial populations at the time of planting be low, but also the populations must be kept at a low level if the plant or crop is to remain vigorous.

Management of nematodes in the tropical and subtropical environments of Hawaii is a challenge. There are a few control measures that are effective, and these must be used under conditions in which they will work. For effective management of nematodes, the critical steps are

(1) accurate diagnosis, and

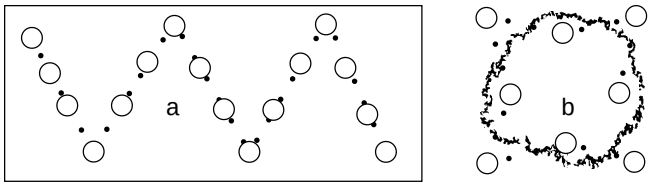
(2) proper selection of the most effective control method.

The importance of accurate assay

Accurate nematode diagnosis through a soil and/or root assay is the key to developing a successful management program. Proper sampling is necessary to obtain a reliable and accurate estimate of the nematode population. Sampling before planting ("preplant" sampling) is one relatively reliable procedure for predicting the potential of nematode damage. For diagnostic purposes, samples from a crop field or a group of plants can be collected any time after the plants have been growing actively for at least 2–3 weeks. Reliability of sampling is increased by sampling again. For preplant sampling, the repeat sampling can be done immediately. During the cropping period, the second sampling should be done a few weeks after the first.

Collecting samples for nematode assay

The proper sampling method is based on the nematode and its location in the soil profile, which depends on the crop. With turf, for example, the nematodes occur primarily in the top 4 inches (10 cm) of soil, whereas with coffee and pineapple, the highest numbers of nematodes



Collect soil samples in a systematic, zig-zag pattern in fields (a) or around individual trees (b).

occur from 8 to 20 inches (20–50 cm) deep in the soil.

Both large fields and small plantings such as home gardens should be sampled in a systematic, zigzag pattern. This sampling should consist of at least 15–20 cores or shovelfuls of soil composited into one sample per garden or 2–3-acre (¾–1¼-hectare) section of a field. Research has shown that sampling in a pattern that systematically attempts to represent the entire area being sampled will produce a more accurate estimation of the actual numbers of nematodes than sampling at random.

Single plants (such as a tree) should be sampled beneath the leaf drip line. The number of cores or shovelfuls of soil taken around a tree will depend on the size of the tree canopy. For a small tree (<10 ft [3 m] diameter canopy), collect 6–8 cores of soil and composite them into one sample. For larger trees, sample 10–12 locations and composite them.

Handling the nematode sample

The composited soil should be gently mixed before withdrawing a subsample of about 1 pint (½ liter). Place the subsample into a plastic bag and seal it to prevent moisture loss. Label the sample with your name, address, name of plant (including variety), and date. This sample must be handled gently and kept out of the sun, preferably in an insulated cooler or an area that is about 70°F (21°C). Send the sample to a processing laboratory such as the CTAHR Agricultural Diagnostic Service Center in a cardboard box or styrofoam container.

Control of nematodes

Nematode management should be multifaceted. Since eliminating nematodes is not possible, the goal is to manage their population, reducing their numbers below damaging levels. Common management methods used include planting resistant crop varieties, rotating crops, incorporating soil amendments, and applying pesticides. In some cases, soil solarization also may be practical.

Control methods not involving pesticides

Use of resistant plant cultivars is limited because there are only a few and their nematode resistance is very specific. Because resistance is specific, accurate identification of the nematode species and race is necessary before the proper cultivar can be selected. Crop resistance is ideally combined with a long-term crop rotation schedule and the best management practices available to favor vigorous and healthy plant growth.

Crop rotation involves growing a crop that is not a host for the nematode present before growing a crop that is susceptible. The nonhost or immune crop will cause nematode numbers in the soil to decline, giving the subsequent host crop a chance to establish a good root system. The success of this method depends on growing the nonhost crop long enough to reduce the nematode numbers. The rotation crop must be selected carefully because some nematodes (such as root-knot, reniform, and burrowing nematodes) have very wide host ranges. Also, crop rotation is difficult to use with most perennial crops. Variations on the crop rotation concept include fallowing, intercropping, and green manuring.

Keeping the soil free of plants (fallow) deprives plant-parasitic nematodes of a host, which, over time, reduces their populations. (Related to this concept is practicing good weed control, particularly when the weeds are hosts for the nematode.)

Intercropping with plants that either are not good nematode hosts or are antagonistic to the nematodes also reduces nematode numbers.

Green manuring, tilling under a crop that grows rapidly and produces a large quantity of biomass, adds organic matter and, depending on the green manure crop used, may add substances that repel or kill nematodes.

Another nonchemical approach to controlling nematodes is biological control—using other organisms against the pest organism. A high level of natural biological control is ordinarily present in the soil. This natural control probably keeps the nematode populations at 10–20 percent of what they would be in its absence. Nevertheless, the level of natural control is seldom adequate to prevent plant damage from nematodes.

The strategy of inoculating soils with biological control organisms to increase or supplement the control organisms naturally present has proven to be unrealistic and is not recommended until more predictable inoculants are developed.

Nematodes that commonly cause significant damage to plants in Hawaii

Root-knot nematode
Root-knot nematodes belong to the genus *Meloidogyne*. The two most common species in Hawaii are *M. incognita* (southern root-knot) and *M. javanica* (Javanese root-knot); other species are present but occur less frequently. The root-knot nematodes feed and mature inside the roots of plants. Their feeding induces abnormal enlargements of the root called galls. The root-knot nematode does not survive very long without a host plant, except in very low numbers and probably in the egg stage.
Diagnosis: Root galls are the primary symptom of root-knot nematodes. Species identification requires laboratory assay.

Reniform nematode
The reniform nematode, *Rotylenchulus reniformis*, is widespread throughout Hawaii and feeds on many cultivated and noncultivated plants. The juvenile stages and males live in the soil and do not feed. The adult female is swollen and is the only parasitic stage of this nematode's life cycle. The female inserts her head and neck into the root, leaving her body outside of the root. The reniform nematode survives in the soil as eggs and coiled juveniles. This nematode causes root rotting and reduced uptake of water and soil nutrients. The symptoms are general lack of vigor and discoloration of foliage, and (or) stunted plants.
Diagnosis: The reniform nematode can be accurately diagnosed only through laboratory assay of a soil sample.

Burrowing and lesion nematodes
Adult burrowing nematodes (*Radopholus similis*) and lesion nematodes (*Pratylenchus* spp.) cause root rot. These worm-shaped nematodes are migratory, living most of their life, including the hatching and feeding stages, inside the roots and sometimes the lower stem of their host plants. They can move through the soil from one root to another during their life cycle.
Diagnosis: The root rot caused by this nematode is not characteristic for diagnosis. It is necessary to have the soil and roots assayed to determine the numbers and kinds of species present; root assays are the most reliable.

Sugar-beet cyst nematode
Sugar-beet cyst nematode (*Heterodera schachtii*), is primarily a problem on cabbage, broccoli, and cauliflower in Hawaii in the Kula, Maui, area. This nematode penetrates the root, and the female enlarges as it matures to become a white, lemon-shaped structure that breaks through the root surface at maturity. When the female dies, her body turns brown. Eggs survive inside the dead female body (called a cyst) for many years.
Diagnosis: Direct observation of the organism with a magnifying glass is helpful, because the white cysts are about the size of the period at the end of this sentence. Root aphids are also white, so some experience may be needed to differentiate between these two white structures clinging to the roots. Confirmation by a diagnostic laboratory is recommended.

Foliar nematode
Aphelenchoides besseyi, *A. ritzema-bosi*, and *A. fragariae* feed inside foliage. The entire nematode life cycle is completed in the leaves. Plants can be stunted with deformed, discolored, or dying leaf tissue; "dieback" can also occur.
Diagnosis: Accurate identification requires laboratory assay of leaf-tissue samples.

A more realistic strategy for biological control of nematodes is to incorporate soil amendments such as manures (particularly chicken manure) and compost. Such additions of organic matter contribute to biological activity in the soil and enhance the natural activity of organisms antagonistic to nematodes.

Solarization, the heating of soil by using clear plastic tarps to increase and trap the sun's heat, can be an effective means of controlling nematodes in the soil. The soil needs to be moist, well tilled, and heated to at least 140°F (60°C) for several days, preferably several weeks. This method can be practical for home gardens, but it

should be done during the hot months of mid-summer.

Similarly, other heat and steam-based pasteurization methods can be used to prepare potting soil. Healthy plants grown in nematode-free media have a better chance to survive after being transplanted to the soil.

Pesticides (nematicides)

Nematicides are sometimes used in agriculture, but few of them are available in Hawaii. Most nematicides are highly toxic synthetic pesticides commercially available only to commercial growers. These products can be used only on particular crops, and they usually must be purchased and applied by a licensed pesticide applicator.

Two types of nematicides are fumigants and nonfumigants. Fumigant nematicides are usually more effective, but nonfumigant nematicides can also be used effectively. Fumigant nematicides such as metam sodium and 1,3-dichloropropene are applied before planting. Some nonfumigant nematicides such as Nemacur®, Mocap®, or Vydate® are moderately effective and can be used both pre- and post-planting.

Some "natural" products claiming to provide control of nematodes have been developed from biological sources. The apparent recovery of plants resulting from using these products can sometimes be due to growth enhancement by plant nutrients contained in the formulations.

As with all pesticides, nematicide use is subject to state and federal regulations. The pesticide label must specifically allow its use in the crop or situation, and label directions must be followed.

Donald P. Schmitt and Brent S. Sipes
Department of Plant Pathology

Suggestions for managing nematodes in the home garden

- Susceptible plants can be grown in containers with a nematode-free soil or growth media; keep the containers off the ground.
- Sow seedlings for transplanting in clean media in containers kept off the ground.
- Check the roots of container-grown nursery stock for nematode galls before transplanting them.
- Add large amounts of organic matter to the soil.
- Keep weeds controlled at all times.
- As soon as plants are not needed, pull them up or till them in to stop their roots from hosting nematodes.
- Infected plant roots systems should be destroyed and not composted.
- Rotate susceptible plants with resistant or immune plants.

Important points about nematodes

- Nematodes are microscopic and transparent.
- Symptoms of nematode infection are often indistinct and usually mimic nutrient deficiency.
- Soil assays for the presence of nematodes are necessary for accurate diagnosis.
- Management strategies usually must be directed at the particular nematode species present.

A note to commercial growers

For assistance with diagnosis of crop problems that may be due to nematodes, contact your local office of the Cooperative Extension Service. Soil assay for nematodes and identification of the nematode species is necessary to develop a management plan. Nematode assay is available from commercial laboratories, or from CTAHR's Agricultural Diagnostic Service Center via your local CES office.