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2022–2023 Florida Citrus Production Guide: Nematodes[1]

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Integrated pest management (IPM) for nematodes requires (1) determining whether pathogenic nematodes are present within the grove; (2) determining whether population densities of some nematodes are high enough to cause economic loss; and (3) selecting a profitable management option. Attempting to manage nematodes may be unprofitable unless the above procedures are carefully followed. Similarly, some management methods pose risks to people and the environment, and therefore it is important to know that their use is justified by the actual conditions in a grove.

Nematode Pests

Although many different species of nematode have been found in association with citrus roots, relatively few have been documented to be economically important. The nematode species of major economic importance in Florida include the citrus nematode (*Tylenchulus semipenetrans*), causal agent of "slow decline" of citrus; the burrowing nematode (*Radopholus similis*), causal agent of "spreading decline" of citrus; the coffee lesion nematode (*Pratylenchus coffeae*); the sting nematode (*Belonolaimus longicaudatus*); and the dagger nematode (*Xiphinema vulgare*). The first three species listed are endoparasites, which parasitize feeder roots either by establishing a feeding site within the cortical root tissue, where they remain throughout their life (citrus nematode), or by continuously migrating through the feeder roots, thereby impairing root function and permitting further infection by microbial pathogens. Sting and dagger nematodes are ectoparasites that remain in the soil feeding at the tips of fibrous roots, stopping root growth, which causes stubby root symptoms that greatly reduce fibrous root mass and function. These ectoparasites are especially damaging to newly planted trees.

Typical Symptoms

Most nematode species that are known pathogens of citrus do not actually kill the tree but can significantly reduce tree vigor, growth, and grove productivity. Nematode-infested trees generally grow more slowly and may ultimately be of smaller size and quality. Aboveground symptoms that develop due to root damage include thinner canopies with less new foliar growth and twig dieback within the upper tree canopy. Symptoms of decline frequently increase with time and are more apparent during periods of environmental stress (i.e., drought or freezing temperature) or when combined with other damaging soil pests (e.g.,

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root weevils, *Phytophthora*) or other adverse soil condition (flooding, high salinity).

Monitoring Nematodes

The distribution and abundance of nematodes in soil prior to or after planting will affect the severity of the problem and define the need for nematode management. The only effective way of determining the presence or distribution of nematodes within a grove is by soil and root tissue sampling of undercanopy areas of individual trees. A representative grove sample for most nematode species consists of soil and roots (using a shovel or soil sampling tube) collected from the undercanopy areas of 20–30 trees within a 5-acre block. When sampling for burrowing nematodes, collect a large quantity of fibrous roots from the surface 0–12 inches beneath 10–12 declining trees (enough to loosely fill a 1-gallon freezer bag). Immediately after collecting the sample, thoroughly rinse soil from the roots and from inside the bag, and place the roots back in the freezer bag. Once soil and root samples have been collected, they should never be subjected to overheating, freezing, drying, or prolonged periods of exposure to direct sunlight. Samples should be submitted immediately to a commercial laboratory or to the UF/IFAS Nematode Assay Laboratory for analysis and recommendations. Damaging levels of citrus nematode have been estimated based on when samples are taken. In Florida, the citrus nematode population densities are highest during mid-late spring, just prior to the onset of the summer rainy season. Sample accuracy is highest at this time of year. Springtime numbers of 800–3600 citrus nematodes extracted from 100 grams of soil or 300–1400 females from one gram of roots are moderate levels that may respond to management, primarily at the higher ends of these ranges. Numbers of citrus nematode below these levels require no management, but annual monitoring is advisable. Numbers exceeding these ranges are likely to decrease the size and quantity of harvested fruit. Vigorous, highly productive groves are capable of supporting very high population levels of the nematode, but at the expense of carbohydrates otherwise destined for fruit. High nematode levels will also slowly impair tree health. If samples are taken at other times of year, comparable ranges are 400–2400 soil stages or 100–1100 females. Detection of any burrowing or coffee lesion nematodes indicates that serious root damage is likely occurring. No threshold ranges are available for sting or dagger nematodes because their population levels are not seasonally predictable. However, when detected in samples, damaging levels of these nematodes are evidenced by the stubby or swollen roots of declining trees.

Managing Nematodes

Nematode management should be considered only after the results of soil and root sampling are available. The agency or company that processed the samples should be able to indicate whether potential nematode problems exist within a grove. In most cases, nematode management should not be considered until all other potential causes of tree decline are evaluated and corrected. For more detailed information on treatment decisions and methods of nematode management in citrus, consult the *Florida Citrus Rootstock Selection Guide* (EDIS publication SP248), *Best Management Practices for Soil-Applied Agricultural Chemicals* (chapter 6 in this guide), or local UF/IFAS Extension personnel.

Sanitation

Once established, nematodes cannot be eradicated from groves, so the best method to manage plant-parasitic nematodes in new plantings is to exclude them from a grove by using only trees from nurseries certified nematode-free by FDACS Division of Plant Industry. Use of certified trees will virtually eliminate the possibility of nematode problems in new groves planted in virgin soils or in old citrus soils never infested by nematodes, provided that care is taken to always use clean equipment in those groves. Use of certified trees also reduces damage during the early years of growth in old, previously infested groves if soil nematode populations are low. High soil nematode densities hinder the beneficial effects of the use of certified trees. Sanitation of equipment to remove soil and root debris before moving between groves is an effective means of preventing the spread of nematodes.

Cultural Practices

Proper grove management is critical to mitigate damage caused by plant-parasitic nematodes. There is no value to managing nematodes if other problems (poor soil drainage, insufficient irrigation, foot rot and fibrous root rot, root weevils, improper fertilization, poor disease control, or acid or alkaline irrigation waters) limit root function and/or reduce tree quality. In the case of burrowing nematodes, specific cultural practices (avoidance of disking, frequent irrigation, and fertigation) are critical to maintain a vigorous root system in the shallow soil horizons where the nematode is much less active.

Rootstock Resistance

Resistant rootstocks are also available to manage citrus and burrowing nematodes. Swingle citrumelo and C35 are widely planted rootstocks with resistance to citrus nematode. Neither rootstock tolerates high soil pH. In less common instances in Florida where calcareous conditions occur, Forner-Alcaide #5, a rootstock developed in Spain, is resistant to citrus nematode and tolerant of high soil pH. Milam lemon, Ridge Pineapple, and Kuharski Carrizo citrange are all resistant to burrowing nematode. The existence of races of these nematodes capable of breaking resistance compromises their value somewhat; nevertheless, large numbers of groves are currently growing well on resistant rootstocks in the presence of these nematodes. To avoid the development of resistance-breaking races, these rootstocks should only be utilized when replanting groves, not when replacing unthrifty trees in existing groves where the nematodes occur.

Chemical Control

Environmental concerns and deregistration of numerous pesticides, particularly those of older chemistry, have dramatically reduced the availability of chemical products for nematode management. In recent years, however, the discovery and commercialization of new chemical nematicides have advanced rapidly. Currently, there are no soil fumigants recommended for preplant nematode control, mainly because of a variety of labelled use restrictions, including minimum soil depths to soil layers restrictive to water movement, requirements for buffer zones, personal protective equipment, and mandatory good agricultural practices. For example, most citrus grown on deep sandy soils of the central ridge soil cannot utilize Telone II because these soils do not have a relatively shallow hard pan or soil layer restrictive to downward water movement (such as a spodic horizon) within 6 feet of the ground surface. Nevertheless, fumigation with Telone II is permitted in those areas where confining layers are present and growers are willing to comply with label requirements. Postplant nematicides can provide temporary suppression of nematodes in the shallow part of the root zone. Fluensulfone (Nimitz) and fluopyram (Velum) were registered recently for nematode management in citrus. Both compounds are highly toxic to plant-parasitic nematodes and far less toxic to humans and other animals than is the carbamate nematicide oxamyl (Vydate), which has long been used in Florida. Ongoing research is evaluating the profitability of using these products to manage nematodes on trees with severely reduced root systems due to huanglongbing.

Because of Florida's uniquely porous soils, soil-applied pesticides have the potential to contaminate surface sources and groundwater. Consequently, their use should be restricted to the mid-to-late autumn and early spring, when rainfall is least in Florida. These materials should not be applied near irrigation or drinking-water wells or where the water table is close to the soil surface. Irrigation systems should always be inspected prior to pesticide application to soil to prevent overapplication of pesticide or water due to line breaks, faulty line-end pressure valves, or missing emitters. Additional considerations for the application of fumigants (where permitted) and nonfumigant nematicides to soil are outlined below.

In the case of citrus nematode, response to preplant fumigants in newly planted young trees may be particularly slow, because nematode population increase may be delayed until canopy closure of adjacent trees occurs. To protect groundwater, some preplant fumigants can only be used in areas with an underlying impermeable layer within 6 feet of the soil surface and capable of supporting seep irrigation. Tree response to postplant chemical treatment often requires a period of one to two years of repeated treatment for growth improvement and significant yield returns. Because postplant nematicides are not eradicants, repeated treatments are required to periodically suppress nematode repopulation of soil and roots. Preplant nematode management programs (sampling, selection of appropriate rootstocks, use of certified trees) are therefore important considerations for maximizing young tree growth and eventual long-term productivity, because it may not be possible to assure satisfactory tree growth with postplant chemical management programs alone. However, if nematode problems do arise on young trees, early management of the populations can have a prolonged beneficial effect on subsequent growth and productivity of the trees. Nematode control with postplant, nonfumigant nematicides occurs primarily within the zone of application and, to a much lesser degree, within and around roots outside of the zone of application due to the systemic activity of some of these pesticides. Because a large majority of fibrous roots grow within the surface 24–30 inches of soil and decrease in abundance from the tree trunk to the row middle, proper nematicide placement to maximize undercanopy coverage is of critical importance. Nematicide placement under the tree canopy can significantly improve overall nematode control by targeting applications to areas of highest fibrous root and nematode density. Treatments will be most effective if made when soil temperatures are warm enough for nematode development and uptake by the tree. Natural degradation of nematicides moving downward in soil also increases with increasing soil temperature, thereby reducing the likelihood of groundwater contamination. To confirm the value of treatment programs, it is wise to designate areas of grove that will remain untreated in order to evaluate product performance and tree growth response.

A lack or loss of nematicidal efficacy and citrus yield response can be associated with factors other than improper pesticide application rate, placement, and application timing. The repeated use of nematicides often results in diminishing activity due to accelerated microbial degradation when populations of microorganisms capable of metabolizing these products increase in response to the compound. Rotation of products is desirable, because the degradation process can be initiated after a single treatment. Postplant nematicides do not necessarily kill nematodes upon direct contact: efficacy usually requires long, continuous exposure to sublethal, yet toxic, concentrations in soil. Nematode population reduction results from a disruption of normal nematode behavior necessary to complete the life cycle. Disappearance rates of nematicides in soil (due to leaching and/or microbial degradation) are therefore critical determinants of treatment efficacy.

Pesticide leaching to depths below the primary root zone can occur as a direct result of excessive irrigation or rainfall. Given the sandy, permeable nature of citrus soils and generally low soil organic matter content, irrigation schedules based on soil moisture deficits are likely to improve nematode control and grove response to treatment by maximizing retention of toxic concentrations within the citrus tree root zone and prevent problems of environmental contamination. Undercanopy weed growth may reduce nematicide effectiveness by interception or absorption of pesticide residues targeted for citrus roots or nematodes in soil. Undercanopy weeds also interfere with microsprinkler operation and can prevent uniform coverage of chemigated nematicides.