ALABAMA COOPERATIVE Extension SYSTEM

ANR-30

ALABAMA A&M AND AUBURN UNIVERSITIES

Nematode Control in the Home Vegetable Garden

Most gardeners are familiar with problems caused by diseases and insects because such problems are easily recognized. Few gardeners, however, are aware of the damage nematodes can cause.

Nematodes are microscopic (less than 1 mm long), wormlike animals too small to be seen with the unaided eye (Figure 1). The majority of plant parasitic nematodes live in the soil and damage plants by feeding in large numbers on the roots, impairing the plant's ability to take up water and nutrients. Severe root damage (Figure 2) caused by nematodes typically results in aboveground symptoms that may include stunting (Figure 3), yellowing of leaves (Figure 4), loss of plant vigor and/or an overall general decline in plant performance (Figure 5). Damage is often more pronounced when plants are under other stresses such as lack of water or nutrients or when damaged by other diseases or insects. Although nematodes rarely kill plants, they can drastically reduce plant growth and yields. Nematodes are usually confined to localized areas in the garden spreading very slowly under their own power; however, nematodes may be dispersed more rapidly by movement of infested soil through cultivation, on soil clinging to garden tools and tillers, in water, or on roots of transplants.

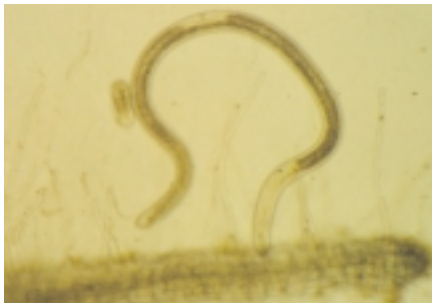

Figure 1. Most plant-parasitic nematodes are microscopic, wormlike animals that live in the soil and damage plants by feeding on their roots.

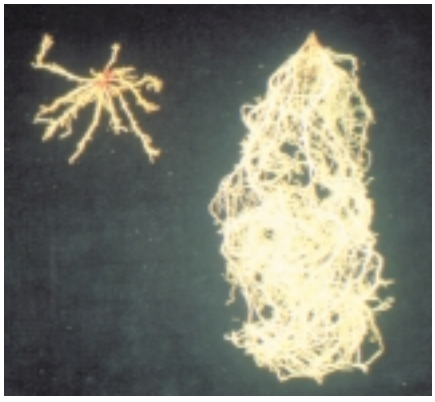

Figure 2. *Left,* severe root damage from needle nematodes to a corn plant's root system (*right,* healthy root system) can impair the plant's ability to take up water and nutrients.

Figure 3. *Left,* stunting of strawberry plant (*right,* healthy plant) resulting from severe root damage caused by dagger nematodes.

Figure 4. Watermelon plants in a root-knot nematode-infested field displaying yellowed foliage, a common aboveground symptom of nematode damage.

Figure 5. Tomato plants infected with root-knot nematodes often exhibit yellowed foliage and a loss of plant vigor.

Though there are at least 10 different genera of plant parasitic nematodes found in Alabama, the most important is the root-knot nematode. Root-knot nematodes have a wide host range, but the most serious problems occur on broadleaf crops. Root-knot nematodes attack the roots of plants causing distinct knots, swellings, or galls to form on the infected roots (Figures 6 and 7). Galls may grow as large as one inch in diameter where they merge, but usually they are not much larger than a pea. There are several different species of root-knot nematodes in Alabama and several species may be present in any one location depend-

Figure 6. Distinct knots, swellings, or galls visible on the root system of a tomato plant infected with root-knot nematodes.

Figure 7. Root-knot nematode galls on tubers of Irish potatoes.

ing on which crops were grown previously (different species have different host ranges), sources of contamination, and geographical region in the state. Nematode species other than root-knot nematodes can cause damage to vegetables. These species include dagger, reniform, ring, stubby root, stunt, sting, root lesion, and cyst nematodes. With the exception of the cyst nematode, which produces distinctive egg-containing cysts on roots (Figures 8 and 9), identification of these other nematode species requires laboratory analysis.

Nematode management requires long-term planning. No current control practice will permanently eradicate nematodes from the garden. Nematodes can be effectively managed in the home garden by the use of one or more of the following practices.

Site Selection

Consider nematodes when selecting a site for a vegetable garden. Have the soil from the proposed area tested for nematodes before planting. If possible, collect soil in the fall when nematode populations are highest. The worst time to sample is in late winter or early spring. Nematode populations are at their lowest during this period and may not be detected in the sample. Take samples with a soil probe or hand shovel in a zigzag pattern across the garden area from the top 8 to 10 inches of soil. Mix samples thoroughly and remove 1 pint of soil for laboratory analysis. Refer to Extension publication ANR-114, "Collecting Soil and Root Samples for Nematode Analysis."

Figure 8. White to yellow adult females of soybean cyst nematodes visible on the outside of a bean root.

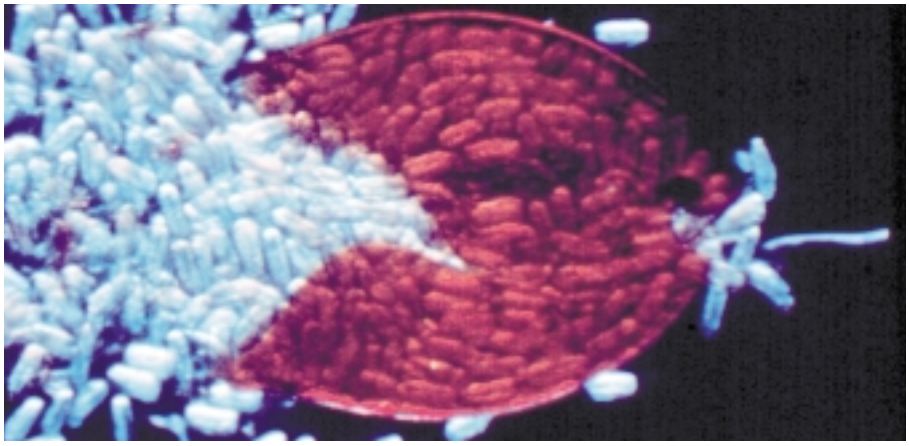

Figure 9. Distinctive egg-containing brown cyst (dead soybean cyst nematode female) may be seen on carefully removed and examined bean roots.

Sanitation

Sanitation aids in reducing plant parasitic nematode populations. Nematode infected plants (including roots) should be removed from the garden and destroyed as soon as the vegetables have been harvested. This practice can be particularly effective in small gardens. Plow the garden immediately after the final harvest to bring plant roots to the surface. Work the soil in this manner two to four times during the winter. The drying action of the wind and sun will destroy many nematodes and their eggs, thus preventing further buildup. Vegetable roots left in the soil through the winter

Figure 10. *Left,* soybean cultivars resistant to soybean cyst nematode compared to various susceptible cultivars, *center and right.*

serve as hosts on which nematodes can maintain or increase their population for the following year.

Crop Rotation

Rotating crops from year to year can be an effective means of controlling plant parasitic nematodes. Closely related crops are more likely to support the same nematodes, diseases, and other pests than unrelated plants. A particular vegetable or vegetables belonging to the same family should never be grown in the same location more than once every three years. If space is available, it is a good practice to rotate garden sites. Where garden space is limited, rotate related vegetables in one family group with vegetables in an unrelated family group. For specific family groupings, refer to Table 1. Crop rotation is not always an effective strategy for controlling root-knot nematodes because of their wide host range. However, rotating crops in combination with fallowing or soil solarization can be used to manage most nematode problems.

Table 1. Plant Families

Family Name	Members
Goosefoot	Beets, Swiss chard, spinach
Daisy	Chicory, dandelion, endive, lettuce, marigolds, sunflowers
Cabbage (crucifers)	Alyssum, Bok choy, broccoli, Brussels sprouts, cabbage, cauliflower, collards, cress, kale, many oriental greens, mustard, radishes, rutabagas, turnips
Squash (cucurbits)	Cucumbers, gourds, cantaloupes, pumpkins, squash, watermelons
Grass	Barley, corn, oats, rice, rye, wheat
Pea or bean (legumes)	Alfalfa, beans (lima, pole, snap), lupines, peanuts, English peas, southern or field peas, soybeans
Lily	Asparagus, chives, garlic, leeks, onions, shallots (green onions, bunching onions)
Buckwheat	Buckwheat, rhubarb, sorrel
Mallow	Okra, cotton
Morningglory	Sweetpotato
Rose	Brambles or caneberries, strawberries, apples, peaches
Nightshade	Eggplant, nicotiana, peppers, petunias, Irish potatoes, tomatoes
Carrot	Carrots, celery, chervil, dill, parsley, parsnips

Use of Resistant Varieties

Resistant varieties offer the easiest, least expensive, and most effective method of controlling nematodes in the home garden (Figure 10). Unfortunately, resistant vegetable varieties are only available for root-knot nematodes and only for a limited number of crops. Nematodes are unable to feed on a resistant variety, resulting in a population decline over time due to starvation (as long as weed hosts of the nematodes are also eliminated). Asparagus, onion, and strawberry are resistant to most root-knot nematode populations in Alabama. Refer to Table 2 for vegetable varieties resistant to root-knot nematodes. Also check seed catalogs each year to identify newly released vegetable varieties with resistance to nematodes.

Fallowing

The practice of fallowing prevents any vegetation from growing in the garden area, thus starving the nematode population. The target area must be kept completely weed free to prevent nematodes from surviving on alternate hosts. One year of fallowing will lower the nematode population to a level where an annual crop can be grown successfully. The longer an area is fallowed, the greater the decrease in the nematode population. Fallowed soil should be roto-tilled every two weeks to reduce weeds and to expose nematodes to the sun.

Plant Stress Reduction

The less stress plants are under, the better able they are to withstand nematode attack. Watering plants deeply and less frequently will encourage the development of a deep root system that will reduce stress on plants and can help minimize nematode problems. Proper man-

Table 2. Vegetable Varieties Resistant to Root-Knot Nematodes

Crop	Variety*
Sweetpotato	Cordner, Georgia Red (P), Heartogold (SPJ), Hernandez, Jasper (S), Jewel (S), Nugget, Red Jewel (J), Resisto, Southern Delite
Southernpea	California Blackeye #5 (S), Colossus 80 (SJ), Pinkeye Purple Hull, Magnolia Blackeye, Mississippi Pinkeye, Mississippi Purple (SJ), Mississippi Shipper (SJ), Mississippi Silver (S), Zipper Cream (S)
Beans (lima)	Nemagreen
Bean (snap)	Alabama No. 1 (pole)
English pea	Wando
Pimento pepper	Mississippi Nemaheart
Tomato	Beefeater VFN, Beafsteak Super VFN, Better Boy VFN, Burpee's Supersteak, Carnival, Celebrity, Early Girl, Hastings Red Chief, Jack Pot, Roma II, Lemon Boy, Monte Carlo, Patio Prize, President, Quick Pick, Red Express, Royal Flush, Small Fry, Sunripe, Sweet Chelsea (cherry), Sweet Million, Terrific VFN, Ultra Boy VFN, Viva Italia

*S = variety is resistant to the southern root-knot nematode; P = variety is resistant to peanut root-knot nematode; J = variety is resistant to the Javanese root-knot nematode.

agement of diseases and insects can also reduce stress and help reduce damage from nematodes. Nutrient deficiencies and soil compaction can inhibit root development and increase plant sensitivity to nematode damage. Nematode damage is more severe in sandy soils than in heavy soils.

Addition of Organic Soil Matter

Organic soil amendments can improve plant health and vigor, but they must be incorporated before seeding or transplanting. Amendments that improve the soil composition, moisture retention, or physical characteristics will help produce healthier plants. Compost and pine bark are two amendments that can improve soil conditions and plant health. Pine bark, which works best if fresh and ground into small pieces, has been reported to help suppress damage from root-knot nematodes. This should be done a month or more before planting.

Suppressive Crops

Nematode suppressive crops combat nematodes naturally. Several plants minimize nematode damage in vegetable crops (Table 3). These plants produce nematicidal (killing) and nemastatic (suppressive) organic compounds that are toxic to nematodes. These compounds are released from the roots of living plants or by plant's being incorporated into the soil as a green manure. Some plants may act as trap crops that prevent nematodes from maturing and reproducing once they invade the roots. Some marigolds, a few varieties of chrysanthemums, castorbeans, partridge peas, several Crotalaris spp., velvetbeans, and rapeseed are considered nematode suppressive plants. Growing a nematode suppressive crop will not eliminate nematodes from the soil; however, it may reduce nematode numbers enough to allow production of a crop in a nematode infested area. Nematode populations often rebound to pretreatment levels when a susceptible vegetable is grown following a nematode suppressive crop. Nevertheless, the use of a nematode suppressive crop has been shown to be as effective as or somewhat better than fallowing an area to reduce the nematode population. Refer to Extension publication ANR-856, "Nematode Suppressive Crops," for more information on this technique.

Organic Control

Clandosan 618 produced by Igene Biotechnology in Columbia, Maryland, is an example of an organic nematicide made of chitin extracted from shellfish waste, soybean meal, and urea. The material works by increasing the soil microorganisms that feed on chitin. Chitin is one of the primary components in the body wall of nematodes. The feeding activities of the chitin-loving microorganisms have been shown to reduce the number of nematodes for two cropping sequences. Control is sporadic, however, and requires large quantities of an expensive product. Chitin products should be incorporated into the soil about two weeks before planting.

Chemical Control

There are no nematicides on the market that can be used by homeowners. Currently, licensed pesticide applicators can still use metam sodium, a preplant fumigant, on home gardens, but this chemical requires important safety precautions and may carry significant legal liabilities. Therefore, chemical control is not a viable option in home vegetable gardens.

Soil Solarization

Soil solarization is a simple, safe, and effective method of nematode control. It allows the grower to bypass lengthy crop rotations and gives the added

Table 3. Reaction of Nematode Suppressive Crops to Root-Knot Nematode Species

Suppressive Crop	Root-knot Species			
	Southern	Peanut	Northern	Javanese
French Marigold				
Tangerine	**	**	**	—
Happy Days	—	—	—	**
Lemondrop	**	—	—	—
French Dwarf Double	—	—	—	—
Chrysanthemum				
Escapade	**	—	—	—
Castor Bean				
Bronze King	**	—	—	—
Hale	—	**	—	—
Partridge Pea	—	**	—	—
Crotalaria				
Showy Crotalaria	**	**	—	**
Florida Velvetbean	**	**	—	**
Common Vetch				
Cahaba White	**	**	—	**
Vantage, Nova II	—	**	—	**
Vanguard, Warrior	—	**	—	**
Rapeseed				
Jupiter, Cascade, Elena Indore, Humus, Bridger, Dwarf Essex	**	—	—	**

** indicates a high level of suppression
— indicates no suppression or no available data

benefit of controlling other soil pests such as insects and weeds. Radiant heat from the sun is the lethal agent involved in soil solarization. A clear polyethylene mulch or tarp is used to trap solar heat in the soil (Figure 11). Over a period of several weeks to a few months, soil temperatures become high enough to kill nematodes, as well as many other soil pests and weed seed to a depth of 8 inches. None of the pests will be completely eradicated, but their numbers will be greatly reduced, allowing successful production of a crop. In sandy or sandy-loam soils, nematodes may survive at depths below the lethal temperature zone. As a result, some damage may be seen on deep-rooted crops, but those with shallow root systems should escape serious injury.

Figure 11. A clear polyethylene mulch or tarp is used to trap solar heat in the soil.

The soil to be solarized must be cultivated until it is loose and friable with no large soil clods or debris. A roto-tiller will eliminate clods or other debris creating air pockets that reduce heating of the soil or keep the tarp from fitting tightly over the soil surface. Make sure moisture levels are adequate for working the soil before laying the plastic tarp. Use a clear, UV-stabilized plastic tarp or sheeting 1 to 4 millimeters thick. The edges of the tarp must be buried to a depth of 6 inches in the soil to prevent blowing or tearing by the wind. White or black plastic usually does not transmit enough solar radiation to raise soil temperatures to lethal levels for many soil pests. Long, hot sunny days are needed to reach the soil temperatures required to kill soil pests and weed seed. The longer the soil is heated, the better and deeper the control of nematodes and other soil pests will be. In Alabama, a tarping period of 4 to 6 weeks in the summer should be sufficient to kill nematodes and soilborne plant pathogens. For effective spring or fall solarization, a 6- to 8-week period is required to ensure good pest control. Refer to Extension publication ANR-713, "Soil Solarization for the Control of Nematodes and Soilborne Diseases," for more information on this technique.

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Use pesticides **only** according to the directions on the label. Follow all directions, precautions, and restrictions that are listed. Do not use pesticides on plants that are not listed on the label.

The pesticide rates in this publication are recommended **only** if they are registered with the Environmental Protection Agency and the Alabama Department of Agriculture and Industries. If a registration is changed or cancelled, the rate listed here is no longer recommended. Before you apply any pesticide, check with your county Extension agent for the latest information.

Trade names are used **only** to give specific information. The Alabama Cooperative Extension System does not endorse or guarantee any product and does not recommend one product instead of another that might be similar.

For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

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UPS, 10M31, **Revised April 2000,** ANR-30

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