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Plant Pathology Fact Sheet PPFS-GEN-10

Root-knot Nematode
In Commercial & Residential Crops

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Importance

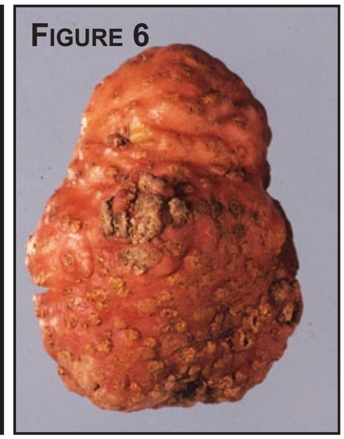
Root-knot nematode (RKN) is a soil-dwelling microscopic roundworm. This nematode is parasitic on numerous plants, including vegetables, fruits, field crops, ornamentals, and common weeds. RKN can occur in commercial and homeowner plantings. Frequently, the nematode interacts with other plant pathogens to form a disease complex in which the resulting disease is much more severe than that caused by either component alone. Root-knot nematode is particularly serious when high populations are allowed to build up due to continuous replanting of susceptible plants on the same site.

Symptoms

Aboveground symptoms

Root-knot nematodes are usually first detected in localized areas within a field (Figure 1), greenhouse, high-tunnel, nursery, or home garden. Gradually, the area of infected plants expands in size and the entire planting can eventually be affected. Aboveground symptoms usually involve stunting, chlorosis (yellowing) of lower leaves (nitrogen deficiency symptoms) (Figure 2), and yield reductions that often worsen over time. Plants may wilt during the heat of the day, especially under dry conditions or in sandier soils. Since these symptoms can also be caused by

Figure 1. Localized areas of yellowed and stunted soybeans infected with root-knot nematode.
Figure 2. Tomato plants showing yellowing and wilting symptoms typical of root-knot-nematode infection.



Root-Knot Nematode symptoms on Pumpkin (**Figure 3**), Tobacco (**Figure 4**), Tomato (**Figure 5**), and Potato (**Figure 6**).

a number of unfavorable growing conditions and other diseases, diagnosis of root-knot requires an examination of the root system or an inspection of the adjacent soil for nematodes.

Root symptoms

Carefully dig up affected plants, shake soil from the root system, and look for swollen and distorted roots. Root-knot galls may vary in size and shape (Figures 3 to 5); on heavily infected plants, galls tend to fuse together so that large areas, or the entire root, may be swollen. Lateral roots appear on root crops (e.g. carrots) resulting in a condition known as hairy root. Infected potato tubers may have small, bumpy swellings on the surface (Figure 6).

Cells where nematodes feed are stimulated to multiply and swell within a day after infection. These changes can affect the plant's ability to take up water and nutrients, resulting in stunted, wilted plants exhibiting nutrient-type deficiencies. The heavier the infection, the more severe the aboveground symptoms will be.

Cause & Disease Development

Approximately 100 species of this nematode have been identified world-wide, but the two most commonly found in Kentucky are the southern root-knot nematode (*Meloidogyne incognita*) and the northern root-knot nematode (*M. hapla*).

Female root-knot nematodes deposit eggs in a gelatinous mass at or near the root surface. A worm-shaped larva hatches and then migrates either into the soil or to a different location in the root. The larva penetrates a suitable root by repeatedly thrusting its feeding structure (stylet) into cells at the root-surface. Within a few days, the larva becomes settled with its head embedded in the developing vascular system, and it begins feeding. Enzymes secreted into cells at the feeding site cause an increase in cell size and number. As the nematode matures, the male reverts to the worm-shape (vermiform), and the female begins laying eggs. While root-knot nematodes move through soil slowly, anything that moves soil particles (equipment, shoes or boots, etc.) can carry nematodes to new locations.

The rate of population increase and length of the life cycle depend on a number of factors, including soil temperature, host susceptibility, and soil type. Warmer soil temperatures and a suitable host will encourage the nematode to complete its life cycle considerably faster. Sandy, organic muck, and peat soils are more favorable for population buildup than are the heavier clay soils generally found in Kentucky. In Kentucky, RKN typically can go through multiple generations per growing season with females producing up to 600 eggs.

Disease Management

Crop rotation
Rotating with a non-host crop will help reduce RKN population to not-damaging levels. Wheat, rye, or tall fescue (particularly KY-31 or Jesup, also called MaxQ), planted for 2 to 3 consecutive years can provide excellent control of root-knot nematode. Other non-host crops include strawberry, asparagus, marigold, and chrysanthemum. It is important to keep plantings free of weeds or volunteer plants that are susceptible to the nematode since they could serve as hosts, thus nullifying the effect of rotation. Home gardeners should try to relocate their garden and sow a non-host crop in its previous location when populations reach extremely high levels.

Resistant varieties
The use of resistant varieties is the most effective way to control RKN in the home garden. Some cultivars of snap bean, lima bean, sweetpotato, English pea, southernpea, and tomato are resistant to this disease and could be incorporated into a rotation system. Resistance in tomato only affects *M. incognita* and will have no impact in soils infested with *M. hapla*. Contact your county Extension agent for specific variety recommendations.

Sanitation
Infected transplants and potato tubers are the most common means of introducing RKN to fields and gardens. If the infested area is small with only a few plants showing symptoms, careful removal of those plants and the soil around their root zones should eliminate much of the nematode population. Clean soil can then be put in its place. In the greenhouse, infected stock should not be used for propagation. All pots, benches and tools must be thoroughly disinfected before reuse.

Early planting
Some susceptible vegetable crops, such as radishes, lettuce, and spinach, can be grown when temperatures are relatively cool and root knot nematode reproduces slowly, if at all. Thus, these crops can be planted early and harvested before RKN can cause significant damage.

Soil treatment
Disinfesting soil by heat is often practical in greenhouses or for a small quantity of potting soil for use in the home garden. It is highly effective and eliminates many other potentially dangerous soil organisms as well. Steam is most efficient, but the temperature should reach 180°F for 30 minutes or 160°F for 1 hour to kill all nematodes in the soil.

Chemical control
Fumigation of soil can be used as a management tool in commercial plantings. Metam-sodium (Vapam, Sectagon) and 1,3-dichloropropene (Telone) are labeled for commercial use. These fumigants, properly used, reduce the nematode population greatly, but only temporarily; nematode populations will return to damaging levels within a season in sites replanted to a susceptible crop. Soil fumigants are dangerous to people and animals and should be used with extreme caution. Regulations governing use of fumigants are stringent and must be followed carefully; failure to comply could result in significant penalties to producers. A summary of these regulations can be found on the University of Georgia Commercial Vegetable Web page listed in "Additional Resources."

Non-fumigant nematicides/insecticides are labeled for commercial use, and can be applied pre- and post-planting for suppression of root-knot nematode. All non-fumigant nematicides, like the fumigants, are dangerous chemicals and should be used with caution. Refer to the *Vegetable Production Guide for Commercial Growers* (ID-36) for a list of registered products.

Biological control
Products based on microbes or plant extracts are marketed for use in suppressing root-knot and other nematodes. Examples include DiTera, a fungal antagonist of nematodes, and Ecozin, an extract of the neem tree. These materials are applied to soil and provide moderate levels of control; however,

such products are generally not as effective as conventional nematicides.

Solarization

The process of trapping the sun's energy to heat soil and inactivate weed seed, pathogens, and pests (including nematodes) is called "solarization." Solarizing soil involves covering the desired area with clear plastic during the sunniest part of the year for a period of 4 to 8 weeks. This allows heat to penetrate deeply enough to kill noxious organisms. Although generally more effective against soil fungi than nematodes, solarization is a simple way to reduce nematode populations without chemicals. See "Additional Resources" for more information on solarization.

Nematode-suppressive crops

Another effective, non-chemical practice for managing nematodes involves the planting of crops that will suppress the development of these soil pests. Such crops reduce nematode populations in soil by depriving them of food or by releasing chemicals into soil that inhibit their reproduction and development. Nematode-suppressive crops include marigolds, chrysanthemums, castor bean, partridge pea, velvet bean, vetch, rapeseed, and sesame. More information on these crops and their cultivation can be found in the "Additional Resources" section below.

Additional Resources

The University of Kentucky publications listed below are available at County Extension offices, as well as on the Internet.

- Home Vegetable Gardening, ID-128 (University of Kentucky)
http://www.ca.uky.edu/agc/pubs/id/id128/id128.pdf
- Vegetable Production Guide for Commercial Growers, ID-36 (University of Kentucky)
http://www.ca.uky.edu/agc/pubs/id/id36/id36.htm
- Nematode Suppressive Crops, ANR-856 (Alabama Cooperative Extension System)
http://www.aces.edu/pubs/docs/A/ANR-0856/ANR-0856.pdf
- Soil Fumigant Regulations (University of Georgia)
http://caes.uga.edu/commodities/fruits/veg/fumigant.html
- Soil Solarization for Gardens and Landscapes (University of California)
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74145.html

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Photos: Edward Sikora, Auburn University (Fig. 1) and Gerald Holmes, Valent USA Corp., (Fig. 6), Bugwood.org.; Kenneth Seebold (Figs. 2, 3, & 4) and John Hartman (Fig. 5), University of Kentucky

Revised from the original fact sheets, Root Knot Nematode in Gardens and Commercial Vegetables (PPA-20) by J.R. Hartman and W.C. Nesmith, issued in 1984; and Root Knot Nematode (PPA-20) by J.R. Hartman and C.A. Kaiser, issued in 1982.