Root Knot Nematodes

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Introduction

In the fall of 2001, several horseradish roots, collected from an experimental field at Collinsvile, Illinois, were found infected with a root knot nematode (*Meloidogyne* sp.). In the spring of 2002, horseradish roots collected from a commercial field also were found infected with a root knot nematode. The sets (seeds) planted in both the experimental and commercial fields had been grown in southern Missouri. Based on the morphological characteristics the isolated nematode from horseradish roots has been identified to be *Meloidogyne incognita* (southern root knot nematode). Currently, however, the investigations are being conducted to determine the pathogenicity of the isolated root knot nematode from horseradish roots and confirm its identification.

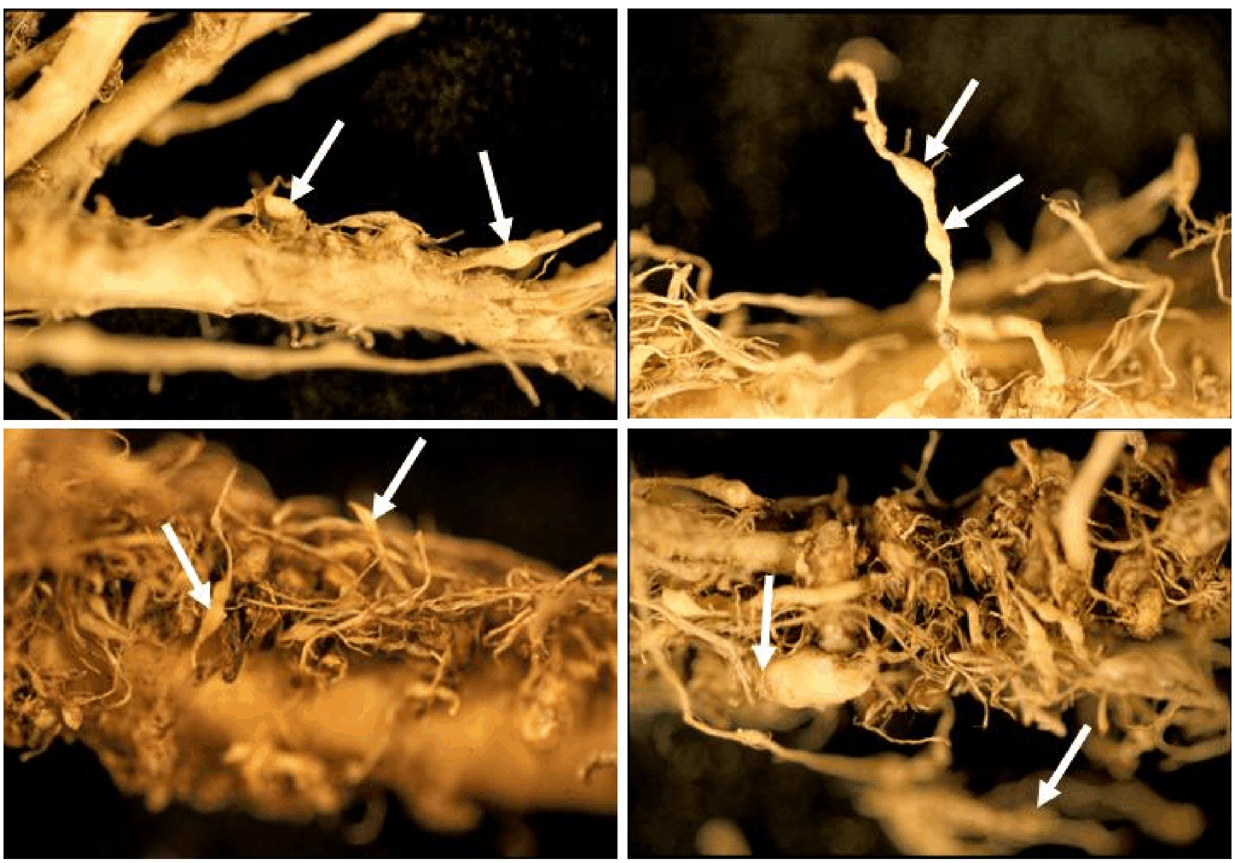

Fig.1. Root knot caused by a *Meloidogyne* sp. on horseradish roots (*M. Babadoost*)

First, we thought that, due to low temperatures during winter in central Illinois, *M. incognita* could not overwinter in Collinsvile area. But, the presence of the nematodes in the roots planted in 2001 and harvested in the spring of 2002 indicated that this nematode can, indeed, overwinter in the horseradish growing areas of Illinois. This observation alerts us to prevent any introduction of root knot nematodes to new fields in the area.

Root Knot Nematodes

Root-knot disease is caused by various species of *Meloidogyne.* There are several species of root-knot nematodes found in Illinois, including *M. hapla, M. incognita, M. arenaria, M. javanica,* and *M. naasi*. They attack more than 2,000 different kinds of plants, including most vegetables, fruit crops, field crops, ornamentals, and weeds. The most important species in Illinois are *M. hapla* and *M. incognita*, which have the widest host ranges of any of the root-knot nematodes.

Root-knot nematodes damage plants by devitalizing root tips and causing formation of swellings of the roots. These effects not only deprive plants of nutrients but also disfigure and reduce the market value of many root crops. When susceptible plants are infected at the seedling stage, losses are heavy and may result in complete destruction of the crop.

Symptoms

Root knot nematodes usually are detected first in localized areas within a field. The aboveground symptoms are reduced growth and fewer, small, pale green, or yellowish leaves that tend to wilt in warm weather. The presence of root-knot nematodes cannot be diagnosed by aboveground symptoms alone.

Characteristic symptoms of the disease appear on the underground parts of the plants. Infected roots swell at the point of invasion and develop into the typical root-knot galls that are two
to several times as large in diameter as the healthy root (Fig. 1). Several infections take place along the same root, and the developing galls give the root a rough, clubbed appearance. By carefully digging affected plants and shaking the soil from the root systems, one can see the abnormal swellings on the roots. Roots infected by certain species of the nematode develop, in addition to galls, several short root branches that rise from the upper part of the gall and result in a dense, bushy root system. Usually, infected roots remain smaller, show various stages of necrosis, and develop rotting, particularly late in the season.

If a grower finds plants with these symptoms, he/she should notify his nearest Extension adviser at once. For final diagnosis, the adviser may need to collect plants showing the symptoms and send samples to the Plant Clinic, 1401 W. St. Mary’s Road, Urbana, IL

61802 without delay (see RPD 1100, "Collecting and Submitting Soil Samples for Nematode Analysis," Department of Crop Sciences, University of Illinois).

The Pathogen

The male and female root-knot nematodes are easily distinguishable morphologically (Fig. 2). The males are wormlike and about 1.2 to 1.5 mm long by 30 to 36 µm in diameter. The females are pear shaped and about 0.40 to 1.30 mm long by 0.27 to 0.75 mm wide.

Each female lays approximately 500 eggs in a gelatinous substance produced by the female. The first- and second-stage juveniles are wormlike and develop inside each egg. The second-stage juvenile emerges from the egg into the soil. This is the only infective stage of the nematode. If it reaches a susceptible host, the juvenile enters the root, becomes sedentary, and grows thick like a sausage. The nematode feeds on the cells around its head by inserting its stylet and secreting saliva into the cells. The saliva stimulates cell enlargement and also liquefies part of the contents of the cells, which are then withdrawn by the nematode through its stylet.

The nematode then undergoes a second molt and gives rise to the third-stage juvenile, which is stouter and lacks a stylet. The third-stage juvenile goes through the third molt and gives rise to the fourth-stage juvenile, which can be distinguished as either male or female. A male fourth-stage juvenile undergoes the fourth and final molt and emerges from the root as the wormlike adult male, which becomes free-living in the soil. The fourth-stage female juvenile continues to grow in thickness and somewhat in length, undergoes the fourth and final molt, and becomes an adult female, which appears pear shaped. The female continues to swell and, with or without fertilization by a male, produces eggs that are laid in a gelatinous protective coat. The eggs may be laid inside or outside the root tissues, depending on the position of the female. Eggs may hatch immediately, or a few of them may overwinter and hatch in the spring.

A life cycle is completed in 25 days at 27 °C, but it takes longer at lower or higher temperatures. When the eggs hatch, the infective second-stage juveniles may migrate from within galls to adjacent parts of the root and cause new infections in the same root, or they may emerge from the root and infect other roots of the same plants or roots of other plants.

The greatest numbers of root-knot nematodes are usually in the root zone from 5 to 25 cm below
the surface. The ability of root-knot nematodes to move on their own power is limited, but they can be spread by water or by soil clinging to farm equipment or otherwise transported into uninfested areas.

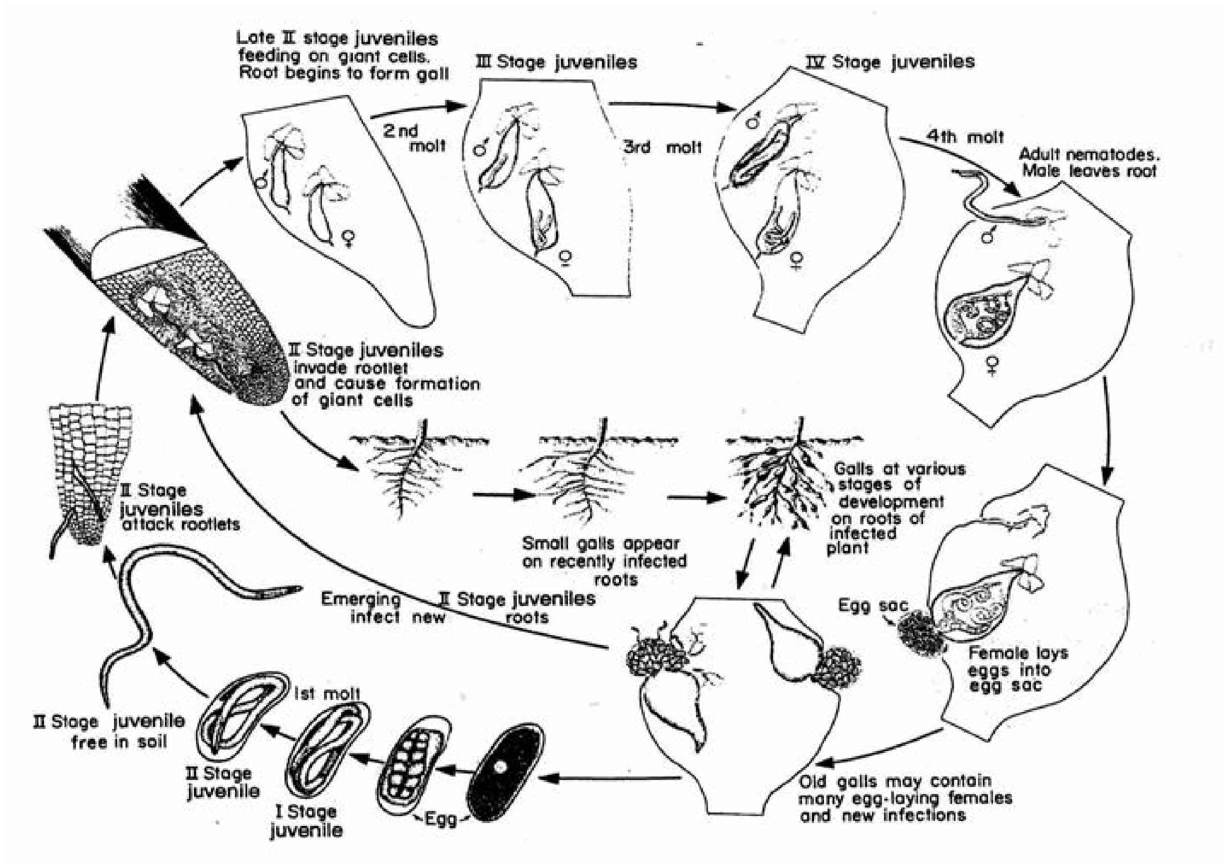

Fig. 2. Disease cycle of root knot caused by *Meloidogyne* species (G.N. *Agrios*)

Development of Disease

Infective second-stage juveniles usually enter roots behind the root tip and push their way between or through cells until they reach positions behind the growing point. There they become permanently established with their head in the developing vascular cylinder (Fig. 2). In older roots the head is usually in the pericycle. Cortical cells near the point of entry begin to enlarge, as sometimes do cells of the pericycle and endodermis near the path of the juveniles. Two or three days after the juvenile has become established, some of the cells around its head begin to enlarge. Their nuclei divide, but no cell walls are laid down. The existing walls between some of the cells break down and disappear, and the protoplasmic contents of several coalesce, giving rise to giant cells. Enlargement and coalescing of cells continues for 2 to 3 weeks, and the giant cells invade the surrounding tissues irregularly.

In the early stages of gall development the cortical cells enlarge in size; during the later stages, they also divide rapidly. Swelling of the root also results from excessive enlargement and division of all types of cells surrounding the giant cells and from enlargement of the nematode. As the females enlarge and produce their egg sacs, they push outward, split the cortex, and may become exposed on the surface of the root or remain completely covered, depending on the position of the nematode in relation to the root surface.

Disease Complex

In addition to the disturbance caused to plants by the nematode galls themselves, damage to infected plants is frequently increased by certain parasitic fungi, which can easily attack the weakened root tissues and the hypertrophied, undifferentiated cells of the galls. *Meloidogyne* species are known to interact with both *Verticillium* and *Fusarium* fungi. Moreover, some fungi, for example, *Pythium, Fusarium,* and *Rhizoctonia*, grow and reproduce much faster in the galls than in other areas of the root, thus inducing an earlier breakdown of the root tissues.

Means of Spread

Only males and second-stage larvae of root-knot nematodes are able to move through the soil. This movement, however, is limited to several inches a year and is unimportant when compared with other ways in which the nematodes can be disseminated. Natural means of spread include water, wind, and wildlife. Water transport of eggs and larvae during downpours and floods may involve long distances. Wildlife moving through infested fields carry these stages in moist soil clinging to their bodies or feet. Wind is probably important only after plowing when infected roots are brought to the soil surface. Man is unquestionably most important in spreading the disease. Nematodes are transported in infested soil clinging to vehicles, tools, equipment, and shoes and in infected plants. They can be carried from one end of the country to the other in roots of infected plants. Southern species frequently are carried northward into Illinois in fruit and vegetable transplants, ornamentals, and houseplants. If no measures are undertaken to control the nematodes in infested soil, on vehicles, and on cultivation and tillage equipment, water and wind will move soil containing eggs and larvae over larger areas of a field.

Meloidogyne incognita — Southern root-knot nematode

This species of root-knot nematode cannot withstand freezing and so is limited to soils that do not freeze. It often occurs on plants in the home, in greenhouses, and close to cellar foundations, where freezing conditions do not occur. The southern root-knot nematode is capable of overwintering in the field in parts of southern Illinois, particularly in sandy soils. It is the most frequently introduced species on transplants from the south. Although it may damage infected transplants and neighboring plants severely during the ensuing season, populations usually die out during the first winter in all but southern Illinois.

M. incognita causes damage to a number of crops including alfalfa, asparagus, beans, cabbage, cantaloupe, carrot, celery, chard, clovers, corn, cotton, cucumber, eggplant, grape, lespedezas, lettuce, okra, onion, peach, pepper, potato, radish, rhubarb, soybeans, spinach, squash, sweet potato, tobacco, tomato, turnip, vetches, and watermelon. Ornamentals commonly affected are abelia, African violet, azalea, begonia, boxwood, camellia, caltha, coleus, collinsia, daylily, dahlia, gardenia, geranium, hibiscus, hollyhock, iris, peperomia, petunia, prayer plant, rose, schefflera, and willow.

Control

Crop Rotation. Rotation with resistant or nonhost crops for two to three years generally provides excellent control of root-knot nematodes. It is important, however, to keep these crops free of weeds or volunteer plants susceptible to the species involved, since their presence nullifies the use of rotation.

Resistant Varieties. Use of resistant varieties is perhaps the best method of controlling root-knot nematodes. However, resistance may mail to provide protection against the nematode species, since numerous intraspecific races and biotypes are known to exist in nature.

Incorporation of Organic Matter. Although not a reliable control measure, incorporation of large amounts of slightly decayed plant material into the soil tends to suppress the development of root-knot nematode populations. It is thought that this material stimulates populations of bacteria, fungi, and other soil inhabitants that are antagonistic to nematodes. Unless additional fertilizer is added to soil, this method may cause nutrient imbalances that reduce plant growth.

Early Planting. Certain crops can develop at temperatures as low as 55°F (13°C). Root-knot nematodes reproduce slowly if at all at such temperatures. Thus, these crops can be grown at low temperatures through most of their cycle without suffering nematode infection. By planting as early as possible, infection is delayed and severe early season damage can be avoided.

Heat Treatment of Propagation Material. Plant parts infected with root-knot nematodes can be disinfected by placing them in hot water. The temperature and period of exposure involved depends on the plant being treated. The temperature must be controlled critically and is usually just below that which injures plant tissues. Temperatures of 112° to 115°F (44° to 46°C) and times varying from 10 to 30 minutes are used most commonly. Before large-scale treating, it is best to test a few plants to determine the temperature and time limits that the host can withstand without sustaining injury.

Plant Care. Since root-knot nematodes interfere with the proper absorption and translocation of moisture and nutrients in the infected plant, damage to many crops can be offset to some degree by maintaining proper soil moisture and nutrient levels. Protection from other stress factors such as cold, disease, and insect attack also lessens damage.

Chemical Control. Control of root-knot nematodes through the use of chemicals is highly effective and practical, particularly on a field basis and where crops of relatively high value are involved. It may be the only alternative where crop rotation cannot be practiced or resistant varieties are unavailable. Both fumigant and nonfumigant chemicals are available for nematode control. The Illinois Pest Control Handbook (revised annually) lists the chemicals registered for use in Illinois.

References

1. Agrios, G.N. 1997. Plant Pathology, 4th ed. Academic Press, New York.

2. Dale, E.I. 1993. Root Knot Nematodes. RPD No. 1101. Department of Crop Sciences, University of Illinois, Urbana-Champaign.