

# Current Distribution of Five Major *Meloidogyne* Species in the United States

S. A. WALTERS, Former Research Technician, and K. R. BARKER, Professor, Department of Plant Pathology, North Carolina State University, Raleigh 27695-7616

## ABSTRACT

Walters, S. A., and Barker, K. R. 1994. Current distribution of five major *Meloidogyne* species in the United States. *Plant Dis.* 78:772-774.

The distribution of five major *Meloidogyne* spp. in the United States was determined from information collected from an extensive literature review and through personal communication with several nematologists. The most widespread species is *M. hapla*, which occurs in all states except Alaska. *M. incognita*, *M. arenaria*, and *M. javanica* are found primarily in southern and coastal states, sometimes along both east and west coasts. *M. incognita* is the second most widely distributed species. *M. chitwoodi* occurs primarily in the Pacific Northwest and Rocky Mountain states; Virginia is the only eastern state in which this species is found. With the exception of Alaska, all states have at least one of the species within its borders.

Root-knot nematodes (*Meloidogyne* spp.) are important pathogens of numerous plants, including most food crops. *Meloidogyne* is the most economically destructive genus of plant-parasitic nematodes in the world (13). Still, the importance of root-knot nematodes on crop production is often overlooked or underestimated, because damage is usually not definitive until roots and/or soil are examined.

Distribution of *Meloidogyne* spp. is based on the ability of these obligate root parasites to become established and overwinter in a geographic area. Overwintering is determined by the minimal and maximal temperatures reached and the amount of time that these temperatures remain at these extremes. The principal factor in limiting the capacity of *M. incognita* (Kofoid & White) Chitwood, *M. arenaria* (Neal) Chitwood, and *M. javanica* (Treub) Chitwood to overwinter is the average temperature during the coldest month of the year. These three species cannot survive if the temperature averages below 3 C during the coldest month (18). Warmer temperatures ( $\geq 24-27$  C) limit the occurrence of *M. hapla* (18). Some of the more southern species, e.g., *M. incognita*, *M. arenaria*, and *M. javanica*, transported to northern areas on transplants (e.g., tomatoes) or other soil and plant materials succumb to the low temperatures in the field during the winter months, but they may survive from year to year in greenhouses and are often a problem (10).

Five species of root-knot nematodes are of great economic importance in the United States. The northern root-knot nematode (*M. hapla* Chitwood), the most widespread species of the five in

the United States, is well adapted to cool climates (17,18) and is the most common *Meloidogyne* spp. above 35° latitude in the United States (17). *M. incognita*, *M. arenaria*, and *M. javanica* are adapted to the warm, subtropical climates of the southeastern and southwestern United States. The Columbia root-knot nematode (*M. chitwoodi* Golden, O'Bannon, Santo, & Finley) is also a cool climate species that is primarily found in the Pacific Northwest (12). The last comprehensive report concerning root-knot nematode distribution in the United States was published in 1984 (2). Much new information on the distribution of these root parasites has been obtained since that report, warranting a report on the current distribution of these five major *Meloidogyne* spp. in the United States.

## MATERIALS AND METHODS

An extensive literature review was initially conducted to obtain information on root-knot nematode distribution within the United States. Subsequently, certain nematologists were contacted via mail and/or telephone to inquire about the known distribution of *Meloidogyne* spp. in their respective states or regions. This was done only if there was little information on the distribution of root-knot nematodes in their states or regions. Information was collected and summarized from these sources. It is difficult to develop a concise report on distribution of root-knot nematode species that includes states with no nematologists. This paper reflects the efforts of the nematologists contacted, as well as our own efforts, in the development of a revised and updated distribution of five major *Meloidogyne* spp. in the United States. The key crops affected by each nematode species for given regions also are discussed. In this study, the United States was divided into four regions based on the administrative regions of

the U.S. Department of Agriculture: northeastern, southern, north central, and western (3). Root-knot nematode distribution will be discussed by these regions.

## RESULTS

**Northeastern region.** *M. hapla* is the most common species in the northeastern United States. Although this nematode can be found in every state in this region (8; J. A. LaMondia, *personal communication*), it was only recently (1991) found in Maine (6). This parasite attacks a wide assortment of crops in this region, including strawberry (20; J. A. LaMondia, *personal communication*), vegetables (L. R. Krusberg, J. A. LaMondia, S. A. Johnston, and N. S. Hill, *personal communications*), tobacco (J. A. LaMondia, *personal communication*), soybean (L. R. Krusberg, *personal communication*), and perennial ornamental flowers (J. A. LaMondia, *personal communication*).

*M. chitwoodi* has not been reported in this region (Fig. 1A), and *M. incognita*, *M. arenaria*, and *M. javanica* are limited to the southerly states in this region (Fig. 1B) (8). *M. incognita* has been reported in Delaware, Maryland, New Jersey, New York, Pennsylvania, Connecticut, and West Virginia (8,16; J. D. Eisenback and L. R. Krusberg, *personal communications*). Although the importance of *M. incognita* often is overlooked in this region, it is a parasite of soybean, field and sweet corn, many vegetables, peaches, and many annual and perennial ornamentals on the southeastern shore of Maryland (L. R. Krusberg, *personal communication*). *M. arenaria* has been found in New Jersey, New York, and West Virginia (8), and *M. javanica* has been reported in Maryland, Delaware, and New Jersey (Fig. 1B) (8,16; J. D. Eisenback, *personal communication*). Both *M. incognita* and *M. javanica* have been found in ornamental nurseries in New Jersey but probably were introduced from southern states and cannot survive the northern winters (16).

**Southern region.** Root-knot nematodes are a major economic problem of crop production in this region because of the warm climate and sandy soils. The southern region includes 13 states and extends from Virginia north to Kentucky and west to Texas. *M. hapla*, *M. incognita*, *M. arenaria*, and *M. javanica* are found in every state in this region except Kentucky, Tennessee, and Oklahoma (15,19; J. D. Eisenback, E. C.

McGawley, G. L. Windham, W. C. Nesmith, and E. C. Bernard, *personal communications*). *M. incognita* occurs in every state in the southern region, whereas *M. arenaria* has not been detected in Tennessee or Kentucky and *M. javanica* has not been detected in Kentucky or Oklahoma (Fig. 1B). Although *M. incognita* has been detected on tobacco in Kentucky (18), this species is most commonly found in fields containing vegetable transplants from other southern states. If root-knot disease persists for more than a year, however, the responsible species is most likely *M. hapla* (W. C. Nesmith, *personal communication*). *M. incognita*, *M. javanica*, and *M. hapla* have been reported in Tennessee (2). The two most common root-knot nematode species in Oklahoma are *M. incognita* and *M. hapla* (J. L. Jacobs, *personal communication*), although *M. arenaria* occurs on peanut (14). Virginia is the only southern region state in which *M. chitwoodi* has been reported (Fig. 1A) (J. D. Eisenback, *personal communication*). The root-knot nematodes found in the southern region are parasites of a wide range of hosts, including woody ornamentals, annual and perennial flowers, fruit and nut crops, field crops, vegetable crops, and grasses (15).

**North central region.** *M. hapla* is found in all 12 states in this region, which extends from Ohio northwest to North Dakota and south to Kansas (2; T. O. Powers, T. L. Niblack, and J. D. Smolik, *personal communications*). *M. hapla* causes extensive damage to nursery stock

in this region (1) and in North and South Dakota is considered a problem only on nursery crops (J. D. Smolik, *personal communication*). However, *M. hapla* parasitizes a wide assortment of crops in this region besides ornamentals. In Wisconsin, this species is a pathogen on potato, carrot, ginseng, and strawberry (A. E. MacGuidwin, *personal communication*). *M. hapla* attacks soybean in Missouri (T. L. Niblack, *personal communication*) and many other states in the north central region (11) but is ignored because the soybean cyst nematode (*Heterodera glycines* Ichinohe) is so damaging to this crop.

*M. incognita* and *M. arenaria* also occur in certain states in the north central region (Fig. 1B). *M. incognita* is found in the delta region (southeast corner) of Missouri on cotton and soybean (T. L. Niblack, *personal communication*) and has been reported in southern Illinois and southern Indiana, although it is rarely found today (1). In southern Indiana, *M. incognita* is associated with tomato, carrot, and melon (J. M. Ferris, *personal communication*). Both *M. incognita* and *M. arenaria* are commonly found in home gardens in Kansas (1).

**Western region.** This 12-state region is the most diverse of the four regions in geography and climate because of the variations in elevation. All five major *Meloidogyne* spp. occur in this region. *M. hapla* occurs in all states except Alaska (2,4,9,12; E. C. Bernard, G. D. Griffin, M. A. McClure, G. S. Santo, and S. H. Thomas, *personal communications*). In Hawaii, *M. hapla* occurs only

at higher elevations (D. P. Schmitt, *personal communication*). Literature reports (9,12) and personal communications (G. D. Griffin, M. A. McClure, and G. S. Santo) indicate that this nematode is primarily an economic problem of potatoes in this region, even though it parasitizes a wide assortment of crops, including alfalfa (M. A. McClure and G. S. Santo, *personal communications*).

*M. incognita*, *M. javanica*, and *M. arenaria* occur in only a few states in this region (Fig. 1B). Distribution of these species is restricted, since most states in this region are somewhat mountainous with low minimal temperatures during the winter months. *M. incognita* occurs in New Mexico (S. H. Thomas, *personal communication*), Arizona (2; M. A. McClure, *personal communication*), California (2), Oregon (2,9), Washington (9), and Hawaii (D. P. Schmitt, *personal communication*). In New Mexico, *M. incognita* (host race 3) is a parasite of cotton and appears to have been introduced with cotton 100–150 yr ago, since root-knot was observed only after the introduction of cotton (S. H. Thomas, *personal communication*). *M. incognita* is a parasite of cotton, vegetables, grapes, and ornamentals in Arizona (M. A. McClure, *personal communication*). In limited areas of Washington and Oregon, *M. incognita* can be found on potatoes (9). *M. javanica* and *M. arenaria* have been reported only in California (2,5), Hawaii (D. P. Schmitt, *personal communication*), and Arizona (M. A. McClure, *personal communication*).

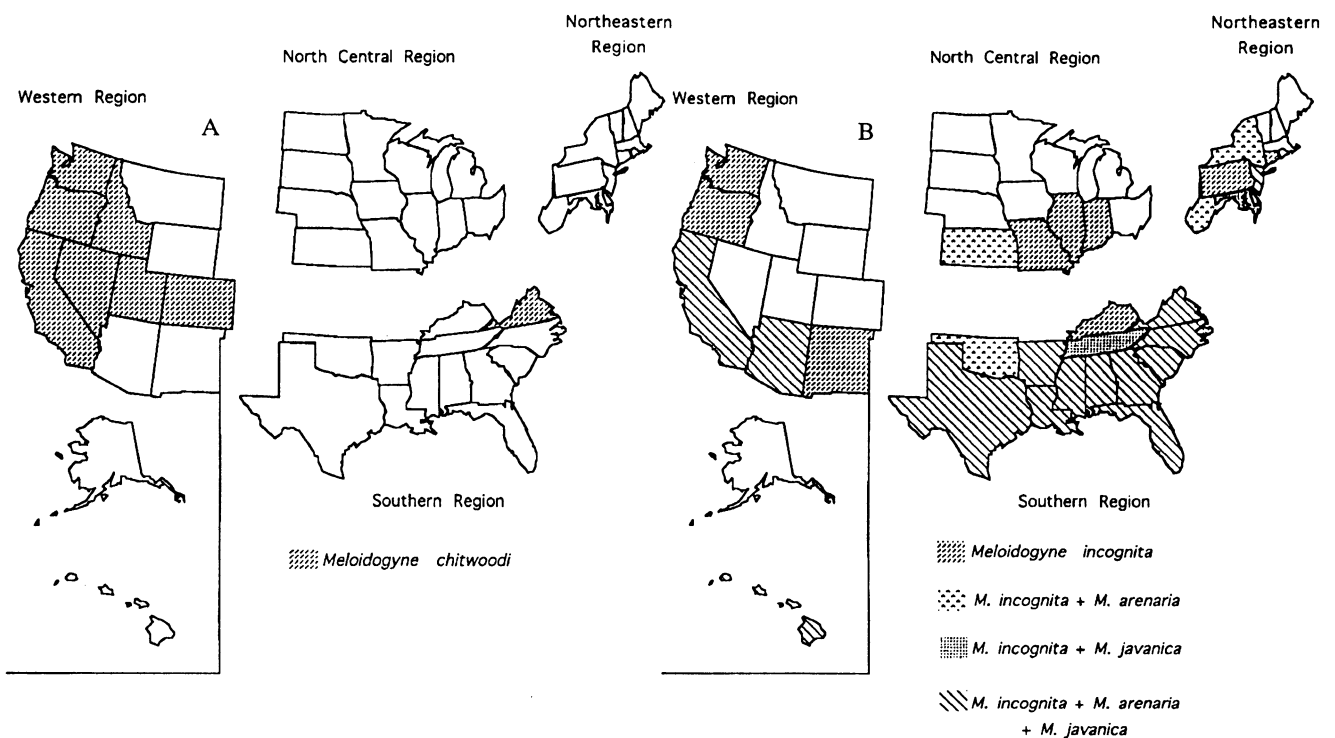


Fig. 1. The distribution of four major *Meloidogyne* species in the United States: (A) *M. chitwoodi* and (B) *M. incognita*, *M. arenaria*, and *M. javanica*.

The recently described *M. chitwoodi* is found in seven states in the western region and in only one, Virginia, outside this region (Fig. 1A). *M. chitwoodi* attacks many crops but is primarily a pathogen of potato in Washington, Oregon, California, Idaho, Colorado, Utah, and Nevada (9,12; G. D. Griffin and G. S. Santo, *personal communications*).

## DISCUSSION

Because *M. hapla* can withstand high and low temperature extremes (found from Florida into southern Canada), it is widely distributed in all states except Alaska. *M. incognita*, *M. arenaria*, and *M. javanica* are found mainly along the southern tier of the contiguous states but also in states along the east and west coasts (Fig. 1B). *M. incognita* is the second most widely distributed root-knot nematode species in the United States. *M. arenaria* and *M. javanica* are similar in distribution. These two species are found along the mid-Atlantic to southern Atlantic coast and west to states bordering the Gulf of Mexico and Mexico, with the exception of New Mexico. *M. chitwoodi* occurs in the Pacific Northwest and Rocky Mountain states but also has been reported in Virginia (Fig. 1A). None of the five *Meloidogyne* spp. discussed here are found in Alaska (4; E. C. Bernard, *personal communication*), and at least one or more occur in all other states.

This report should be a useful guide in determining which root-knot nematode species is present in a specific state. In many cases, however, a particular species is assumed to be present because of the climate, especially in more northerly areas. *M. incognita* and *M.*

*arenaria* could possibly overwinter in areas on the southern fringe of these northerly areas, including Connecticut, New York, New Jersey, Pennsylvania, Delaware, West Virginia, Ohio, Indiana, Illinois, and Kansas. Nevertheless, accurate identification of *Meloidogyne* spp. is necessary to implement effective management programs. The emerging molecular technology for nematode identification, including DNA probes and species-specific isozymes (esterase, malate dehydrogenase), should facilitate progress in this endeavor (7).

## ACKNOWLEDGMENTS

The research reported in this publication was funded in part by the North Carolina Agriculture and Life Sciences Research Service, North Carolina State University, Raleigh, and USAID/USDA/OICD grant 58-319R-1-008.

## LITERATURE CITED

1. Anonymous. 1968. Nematology in the north central region, 1956-66. Iowa State Univ. Agric. Home Econ. Exp. Stn Spec. Rep. 58.
2. Anonymous. 1984. Distribution of plant-parasitic nematodes in North America. Society of Nematologists Nematode Geographical Distribution Committee.
3. Anonymous. 1986. United States Department of Agriculture Manual for Cooperative Regional Research. U.S. Government Printing Office, Washington, DC.
4. Bernard, E. C., and Carling, D. E. 1986. Plant-parasitic nematodes in Alaskan soils. *Agroborealis* 18:24-29.
5. Goodell, P. B., and Ferris, H. 1981. Sample optimization for five plant-parasitic nematodes in an alfalfa field. *J. Nematol.* 13:304-313.
6. Huettel, R. N., Francl, L. J., Reise, R. W., Meyer, S. L. F., and Henn, R. A. 1991. Plant-parasitic nematodes in the potato growing areas of Maine. *Am. Potato J.* 68:345-354.
7. Hyman, B. C., and Powers, T. O. 1991. Integration of molecular data with systematics of plant parasitic nematodes. *Annu. Rev. Phytopathol.* 29:89-107.
8. Mai, W. F., Crittenden, H. W., and Jenkins, W. R. 1960. Distribution of stylet-bearing nema-

todes in the northeastern United States. *N.J. Agric. Exp. Stn. Bull.* 795.

9. Maloy, O. C., and Faulkner, L. R. 1976. Root knot in potatoes. *Wash. State Univ. Coop. Ext. Bull.* EM 2938.
10. Michigan State University Agricultural Experiment Station Research Report 419. 1981. Plant-parasitic nematodes of Michigan; with special reference to the genera of the Tylenchorynchinae (Nematoda).
11. Niblack, T. L. 1988. Soybean nematodes in the north central United States. Pages 87-91 in: *Soybean Diseases of the North Central Region*. T. D. Wyllie and D. H. Scott, eds. American Phytopathological Society, St. Paul, MN.
12. Nyczepir, A. P., O'Bannon, J. H., Santo, G. S., and Finley, A. M. 1982. Incidence and distinguishing characteristics of *Meloidogyne chitwoodi* and *M. hapla* on potato from the northwestern United States. *J. Nematol.* 14:347-353.
13. Sasser, J. N. 1989. *Plant-Parasitic Nematodes: The Farmer's Hidden Enemy*. North Carolina State University Graphics, Raleigh.
14. Society of Nematologists Crop Loss Assessment Committee. 1987. Bibliography of estimated crop losses in the United States due to plant-parasitic nematodes. *Ann. Appl. Nematol.* (suppl. to *J. Nematol.*) 1:6-12.
15. Southern Cooperative Series Bulletin 74. 1960. Distribution of plant-parasitic nematodes in the South.
16. Springer, J. K. 1964. Nematodes associated with plants in cultivated woody plant nurseries and uncultivated woodland areas in New Jersey. *N.J. Dep. Agric. Circ.* 429.
17. Taylor, A. L., and Sasser, J. N. 1978. *Biology, Identification and Control of Root-Knot Nematodes (Meloidogyne Species)*. North Carolina State University and USAID, Raleigh.
18. Taylor, A. L., Sasser, J. N., and Nelson, L. A. 1982. Relationship of Climate and Soil Characteristics to Geographical Distribution of *Meloidogyne* Species in Agricultural Soils. North Carolina State University and USAID, Raleigh.
19. Wehunt, E. J., Golden, A. M., and Robbins, R. T. 1989. Plant nematodes occurring in Arkansas. *Ann. Appl. Nematol.* (suppl. to *J. Nematol.*) 21:677-681.
20. Zuckerman, B. M., and Coughlin, J. W. 1960. Nematodes associated with some crop plants in Massachusetts. *Univ. Mass. Agric. Exp. Stn. Bull.* 521.