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Parasitism of Woody Ornamentals by *Meloidogyne hapla*

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Abstract: *Meloidogyne hapla* is the dominant root-knot nematode found in Tennessee woody ornamental nurseries. In greenhouse tests, *M. hapla* produced galls and formed egg masses on roots of *Abelia* ×*grandiflora, Cornus florida, Hydrangea paniculata grandiflora, Photinia* ×*fraseri, Spiraea* ×*bumalda, Spiraea* ×*vanhouttei*, and *Viburnum carlesii*. Galls on *H. grandiflora* and *V. carlesii* were mostly large and fusiform. Galls on *C. florida* were spherical and usually terminal, whereas those on the other species were minute. Lateral roots grew from galls on all susceptible plants. Two *Acer* spp., two *Buxus* spp., three *Ilex* spp., five *Prunus* spp., three *Rhododendron* spp., *Euonymus alata, Ligustrum sinense, Magnolia* × *soulangiana, Nandina domestica*, and nine conifer species were nonhosts or very poor hosts.

Key words: *Meloidogyne hapla*, northern root-knot nematode, nursery, quarantine, host–parasite relationship.

The woody ornamental–floriculture industry is one of the most rapidly growing segments of agriculture in the United States. In Tennessee this group of crops ranks third in value behind soybean and tobacco (3). In the foreseeable future, the economic value of nursery and greenhouse crops in Tennessee is projected to rank second behind soybean (2). A high percentage of Tennessee's nursery production is sent to other states; for example, Tennessee growers produce approximately 50% of the dogwoods and 25% of the red maples grown in the Southeast (Witte, unpubl.). Plants to be shipped to other states are subject to inspection for pests and diseases, including nematode symptoms and signs on roots. Plants judged diseased or infected cannot be shipped legally out of the state.

The potential for damage of many woody ornamental plants by nematodes is not well known. In a survey of 92 dogwood, maple, or peach sites spread among 25 nurseries in south-central Tennessee, Niblack and Bernard (15) found 57 species of plant-parasitic nematodes, of which two were species of root-knot nematodes. *Meloidogyne hapla* Chitwood occurred in 21 sites, whereas *M. incognita* (Kofoid & White) Chitwood was found at only one site. Densities of *M. hapla* were significantly correlated with tree age.

Our knowledge of *M. hapla* as a parasite of woody ornamental plants is limited. Chitwood (5) noted specimens from *Abelia* × *grandiflora* (Andre) Rehd. (glossy abelia) in his original description of *M. hapla*. Hutchinson et al. (11) reported *Viburnum tomentosum* Thunb. to be a host of *M. hapla*, and Viglierchio (22) found that *M. hapla* reproduced on plants from two of five seedlots of *Pinus ponderosa* Laws. *Meloidogyne hapla* infected and reproduced on *Prunus mahaleb* L. (Mahaleb cherry) at a high rate but was less successful on a cultivar of *Prunus cerasifera* Ehrh. (cherry plum) (20). Several experimental studies have been conducted on infection and maturation of *M. hapla* on various holly species (9,10,18). *M. hapla* was able to invade and gall roots of *Forsythia intermedia* Zab. (16) but did not mature. This nematode has been associated with many other woody ornamental plants (1,7,19).

The objective of this study was to determine the ability of *M. hapla* to parasitize and reproduce upon woody ornamental plants commonly grown in commercial Tennessee nurseries.

Materials and Methods

Nursery-grade plants 2–3 years old were obtained from Panter Nursery and Greenhouse, McMinnville, Tennessee. Root sys-

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TABLE 1. Galling and reproduction of *Meloidogyne hapla* on selected woody ornamental plants.

Species and cultivar	Gall index	Egg mass index
Angiosperms		
Lycopersicon esculentum Mill. 'Rutgers' (Tomato)	5	5
Abelia × grandiflora (Andre) Rehd. (Glossy Abelia)	4.8 (4–5)	4.6 (3–5)
Acer palmatum Thunb. (Japanese Maple)	0	0
A. saccharum Marsh. (Sugar Maple)	0	0
Buxus harlandii Hance (Korean Boxwood)	1.2 (0–3)	0.2 (0–1)
B. sempervirens L. (Boxwood)	0.2 (0–1)	0
Cornus florida L. (Flowering Dogwood)	5	5
Euonymus alata (Thunb.) Sieb. 'Compacta' (Burning Bush)	0	0
Hydrangea paniculata grandiflora Sieb. (Old Fashioned Snowball)	5	4.8 (4–5)
I. × attenuata Ashe 'Foster No. 2' (Foster No. 2 Holly)	0.2 (0–1)	0
I. crenata Thunb. 'Hetzii' (Hetz Japanese Holly)	0	0
I. × 'Nellie R. Stevens' (Nellie R. Stevens Holly)	0.4 (0–2)	0
Ligustrum sinense Lour. 'Variegatum' (Variegated Chinese Privet)	2.8 (2–3)	0.6 (0–3)
Magnolia × soulangiana Soul.-Bod. 'Alexandrina' (Alexandrina Saucer Magnolia)	0	0
Nandina domestica Thunb. (Nandina)	3	0
Photinia × fraseri Dress. (Fraser Photinia)	5	4.6 (4–5)
Prunus cerasifera Ehrh. 'Atropurpurea' (Purpleleaf Plum)	0.2 (0–1)	0
P. cistena Hansen (Purpleleaf Sandcherry)	0	0
P. glandulosa Thunb. (Flowering Almond)	0.2 (0–1)	0
P. serrulata Lindl. 'Kwanzan' (Kwanzan Cherry)	0	0
P. × yedoensis Matsumura (Yoshino Cherry)	0	0
Rhododendron catawbiense Michx. 'Boursalt' (Boursalt Catawba Rhododendron)	0	0
R. 'Cannon's Double' (Cannon's Double Deciduous Azalea)	0	0
R. 'Girard's Rose' (Girard's Rose Azalea)	0	0
Spiraea × bumalda Burvenich 'Froebelii' (Froebel Spirea)	5	4.6 (4–5)
S. × vanhouttei (Briot) Zabel (Vanhoutte Spirea)	5	5
Viburnum carlesii Hemsl. (Korean Spice Viburnum)	4.4 (4–5)	4.2 (4–5)
Gymnosperms		
Juniperus chinensis L. 'Hetzii Glauca' (Blue Hetz Juniper)	0	0
J. horizontalis Moench 'Plumosa' (Andorra Juniper)	0	0
J. conferta Parl. 'Blue Pacific' (Blue Pacific Shore Juniper)	0	0
Metasequoia glyptostroboides Hu & Cheng (Dawn Redwood)	0	0
Pinus strobus L. (White Pine)	0	0
P. virginiana Mill. (Virginia Pine)	0	0
Thuja occidentalis L. 'Globosa' (Globe Arborvitae)	0	0
T. occidentalis 'Pyramidalis Nigra' (Dark Green Pyramid Arborvitae)	0	0
Tsuga canadensis (L.) Carr. (Canadian Hemlock)	0	0

Indices based on counts: 0 = no galls or egg masses; 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 = more than 100 galls or egg masses per root system.
Numbers are the means of five replicates, followed by ranges in parentheses.

tems were inspected visually for nematode symptoms, then plants were transplanted into steam-sterilized loamy sand in 20-cm-d pots and placed on greenhouse benches. Thirty-five taxa were used (Table 1). The experiment was arranged in a randomized block design with six replications. Tomato (*Lycopersicon esculentum* Mill. 'Rutgers') was included in the experiment as a control. A culture of *M. hapla*, originally obtained from dogwood rhizosphere soil in Warren County, Tennessee, was increased on tomato. Two months after transplanting of ornamentals, eggs of *M. hapla* were harvested from tomato roots via a sodium hypochlorite method (8). Six holes, 7.5 cm deep, were made with a glass rod in each pot, and 10,000 eggs in 20 ml water were delivered so that most of the suspension ran into the holes. Holes were then filled with soil. Forty-four days after infestation, one replicate was harvested and roots were stained with acid fuchsin (4) in order to observe the presence of nematodes.

Seventy days after infestation, the remaining five replicates were harvested. Galling on each root system was rated according to a 0–5 system (21), where 0 = no galls per root system, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls per root system. Root systems were then immersed in a Phloxine B solution (6) to stain egg masses, which were counted and rated with the same rating system as for galling. Galls were collected from plants and fixed in FAA, dehydrated in a tertiary butanol series, embedded in paraffin, and sectioned 10 μm thick. Sections were stained with Safranin O, Aniline Blue, and Orange G (14).

Scientific and common names of plants are given according to McClintock and Leiser (13) and Rehder (17).

Results

Seven of the thirty-five plants tested supported high (4.0) levels of galling and reproduction (Table 1). *Ligustrum sinense* Lour. and *Nandina domestica* Thunb. were moderately galled, but reproduction was very poor or absent. In *L. sinense* and *N. domestica* nematode-induced galls, *M. hapla* usually enlarged following penetration but failed to form typical giant cells in the plant roots. Six other species were slightly galled and did not support reproduction. Of five *Prunus* spp., only two plants exhibited galling; no reproduction was observed. The nine conifer species tested were nonhosts. No nematodes were observed in the acid fuchsin-stained roots of nonhosts.

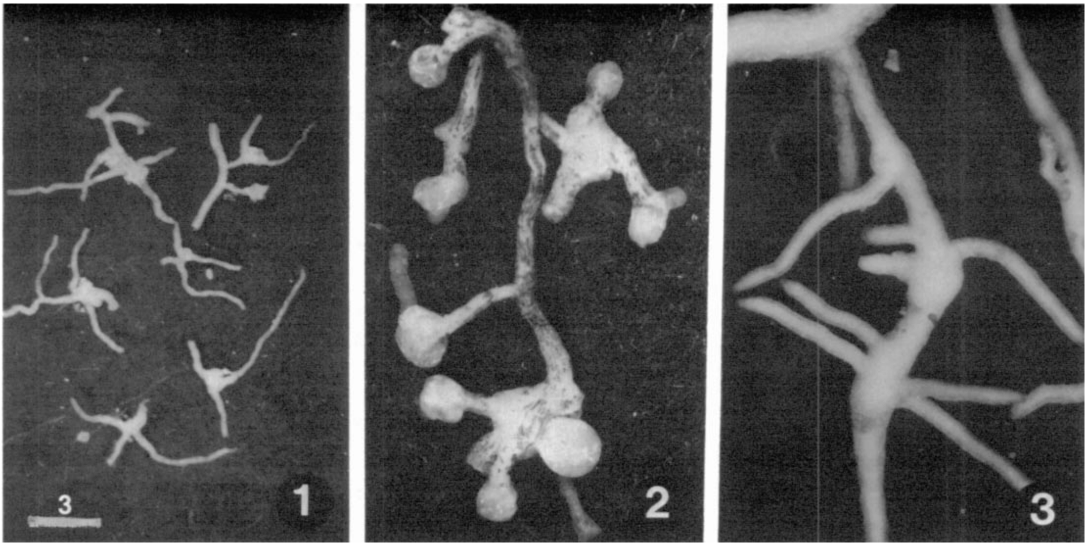
The size and ease of detection of galls differed widely among susceptible species. In *Abelia* × *grandiflora*, *Photinia* × *fraseri*, and the two *Spiraea* spp., galls were minute and difficult to detect without close examination or staining of egg masses with Phloxine B (Fig. 1). On *Cornus florida* L., galls were spherical and often terminal, occurring on most root tips (Fig. 2). Galls on *Hydrangea paniculata* Sieb. and *Viburnum carlesii* Hemsl., which have thick, fleshy roots, were mostly spindle shaped and intercalary (Fig. 3). Lateral root formation typical of *M. hapla*-induced galls was produced on all suitable hosts.

Discussion

Meloidogyne hapla is the predominant species of root-knot nematode in the nursery production regions of Tennessee (15). Although it was not capable of infecting or reproducing on most of the plants tested in this study, it does have the potential to cause damage to several of the most important nursery crops. The small size of galls on some species may make *M. hapla* infections difficult to recognize. On abelia, photinia, and the two spireas, galls may be easily overlooked by regulatory inspectors untrained in recognition of *M. hapla*-induced symptoms. Staining of egg masses with Phloxine B would be an effective means of determining root infections on these species but only if egg masses were present.

Galls produced on roots of dogwood were different in appearance from those usually reported for *M. hapla* (21). The nematode was an effective parasite of root tips, frequently producing spherical galls on root tips. Lateral roots arising from galled regions were usually terminally galled. This gall morphology is also quite different from that reported for *M. incognita* on dogwood (12), where galls were mostly spindle shaped and intercalary.

The findings of this study, that *M. hapla* failed to reproduce on three holly cultivars and produced only a few recognizable galls, tend to support the concept that *M. hapla* is not usually a significant parasite of hollies. Sasser et al. (18) found three *Ilex crenata* cultivars and an *I. cornuta* cultivar to be highly resistant to *M. hapla*. These results differed from those of Haasis et al. (9) and Heald (10), in which *I. crenata* was found to be susceptible to *M. hapla*. Heald suggested that the differing results probably were due to the use of different *M. hapla* isolates and variations in plant selection. Such variability has implications for certification of plants. A slightly or mod-



FIGS. 1–3. Galling of selected woody ornamental plants by *Meloidogyne hapla.* 1) *Abelia ×grandiflora.* 2) *Cornus florida.* 3) *Viburnum carlesii.* Bar = 3 mm.

erately galled plant that does not support reproduction probably should not be denied certification. Contradictory evidence on the susceptibility of *M. hapla* could be resolved with expanded experiments using hollies from several sources and *M. hapla* isolates from various geographical locations. *Rhododendron* taxa were not parasitized by *M. hapla*; however, the first author found galls and mature females on the roots of a diseased azalea submitted to the Tennessee Agricultural Extension Service for diagnosis (unpubl.). Thus it seems likely that some rhododendron or azalea cultivars are susceptible to *M. hapla.*

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