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Nematodes—A Threat to Ornamental Plants in the Nursery and Landscape

Plant-parasitic nematodes can be a severe problem associated with field production of woody ornamentals in nurseries as well as with growth of landscape plants in the southeastern United States and other areas of the country. In a recent survey of North Carolina nurseries that grow Japanese holly (*Ilex crenata* Thunb.) in field plantings, parasitic nematodes were detected on 4–100% of the plants sampled (9). Nematodes induce severe damage to ornamentals and other crops on coarse-textured sandy soils, particularly during droughts, because of the low water-holding capacity of these soils. Nematode pests also occur in sandy clay loam soils in the Piedmont and in loam soils in the mountain valleys across the Southeast where ornamentals are grown.

In earlier surveys (10,13,14), nematologists associated a number of different plant-parasitic nematodes with woody ornamental species. As subsequent research has shown, predicting which ornamental will be damaged by a particular nematode species is extremely difficult. In many instances, an ornamental may tolerate rather high nematode densities in the root zone without showing any apparent aboveground symptoms. In other cases, however, the ornamental may be severely damaged by rather low densities of a particular nematode. The factors responsible for such divergent plant responses are not fully understood.

Microplot Studies

Research at North Carolina State University has focused on determining the specific nematode species involved in decline of woody ornamentals common to the region and on identifying ornamental species and cultivars tolerant to nematodes. Most of the current work has been done in a loamy sand soil with microplots (4) that permit soil fumigation, infestation with greenhouse-grown inoculum of a selected nematode species, and spring planting of the test crop (Fig. 1). A primary advantage of microplot studies is the degree of control the researcher has in avoiding confounding effects that interplot dissemination of microorganisms might have on plant growth and development.

In our microplot studies with ornamentals, plant growth and nematode density are assessed in late spring and fall over a 3-year period. Initial and changing nematode densities over time can be correlated with plant growth to measure the influence of a nematode on an ornamental. Plants in nematode-free microplots serve as controls.

The range of symptoms observed on ornamentals parasitized by nematodes varies with plant species. The one common symptom among most ornamentals, however, is a general stunting, ie, nematode-parasitized plants do not grow as much as plants in the microplots without nematodes (Fig. 2). Plants affected by nematodes also develop symptoms of low vigor, including chlorosis and necrosis, defoliation, and twig dieback. During periods of drought, plants may die if a significant proportion of the root system has suffered dysfunction.

Four nematode species were primarily responsible for damage to ornamental plants in the microplot studies (1–3,7,8): lesion (*Pratylenchus vulnus* Allen & Jensen), ring (*Circonemella xenoplax* (Raski) Luc & Raski, syn. *Criconemoides xenoplax, Macroposthonia xenoplax*), root-knot (*Meloidogyne arenaria* (Neal) Chitwood), and stunt (*Tylenchorhynchus claytoni* Steiner). *Meloidogyne incognita* (Kofoid & White) Chitwood has also been encountered in nursery and landscape plantings. Other nematode genera, including dagger (*Xiphinema*), sheath (*Hemicycliophora*), needle (*Longidorus*), and false sheath (*Hemicriconemoides*), may be involved in decline of woody ornamentals, but these have yet to be studied under microplot conditions. The ornamentals tested in microplots to date and their responses to the four nematodes are listed in Table 1. This information is useful to extension specialists, county agents, and landscape designers as well as to nurserymen and consumers as a guide to plant selection for areas known to be infested with these nematodes.

Fig. 1. Organization of the microplot area used to study the dynamics of nematode-ornamental interactions. Sun-intolerant plants in the foreground are shaded with temporary lath during the growing season. Overhead irrigation (line running through center of figure) provides moisture during dry weather.

A number of nematode species proved to have little or no effect on ornamentals growing in microplots. The nematodes and ornamentals tested were: lance (*Hoplolaimus galeatus* Cobb) on Japanese holly; spiral (*Helicotylenchus dihystera* (Cobb) Sher) on aucuba, azalea, American boxwood, and Chinese, Japanese, and dwarf yaupon holly; and stubby root (*Paratrichodorus minor* (Colbran; Siddiqi) Loof) on aucuba and Chinese, Japanese, and dwarf yaupon holly (1,3,8). Although stunting was not observed in these combinations, these ornamentals tolerated high rates of nematode reproduction, particularly with *H. dihystera* and *P. minor*.

One of the difficulties in predicting whether or not decline of a particular ornamental will occur with a given nematode species is the observation that high populations of nematodes known to be parasitic on other crops may be tolerated without symptom development on a given ornamental. For instance, American boxwood (*Buxus sempervirens* var. *globosum* L.) tolerated up to 2,500 *H. dihystera* per 500 cm^3 of soil in the root zone without apparent damage (8). Conversely, the same ornamental was damaged severely by an initial nematode density of as few as 175 *P. vulnus* per 500 cm^3. Thus, only empirical testing of a given ornamental and a selected nematode can answer the question of whether or not decline will occur.

Use of assays for nematode density as a predictor of previous nematode damage on ornamentals with decline symptoms may lead to erroneous assumptions. It is difficult to relate density to observed decline in cases of an intolerant response

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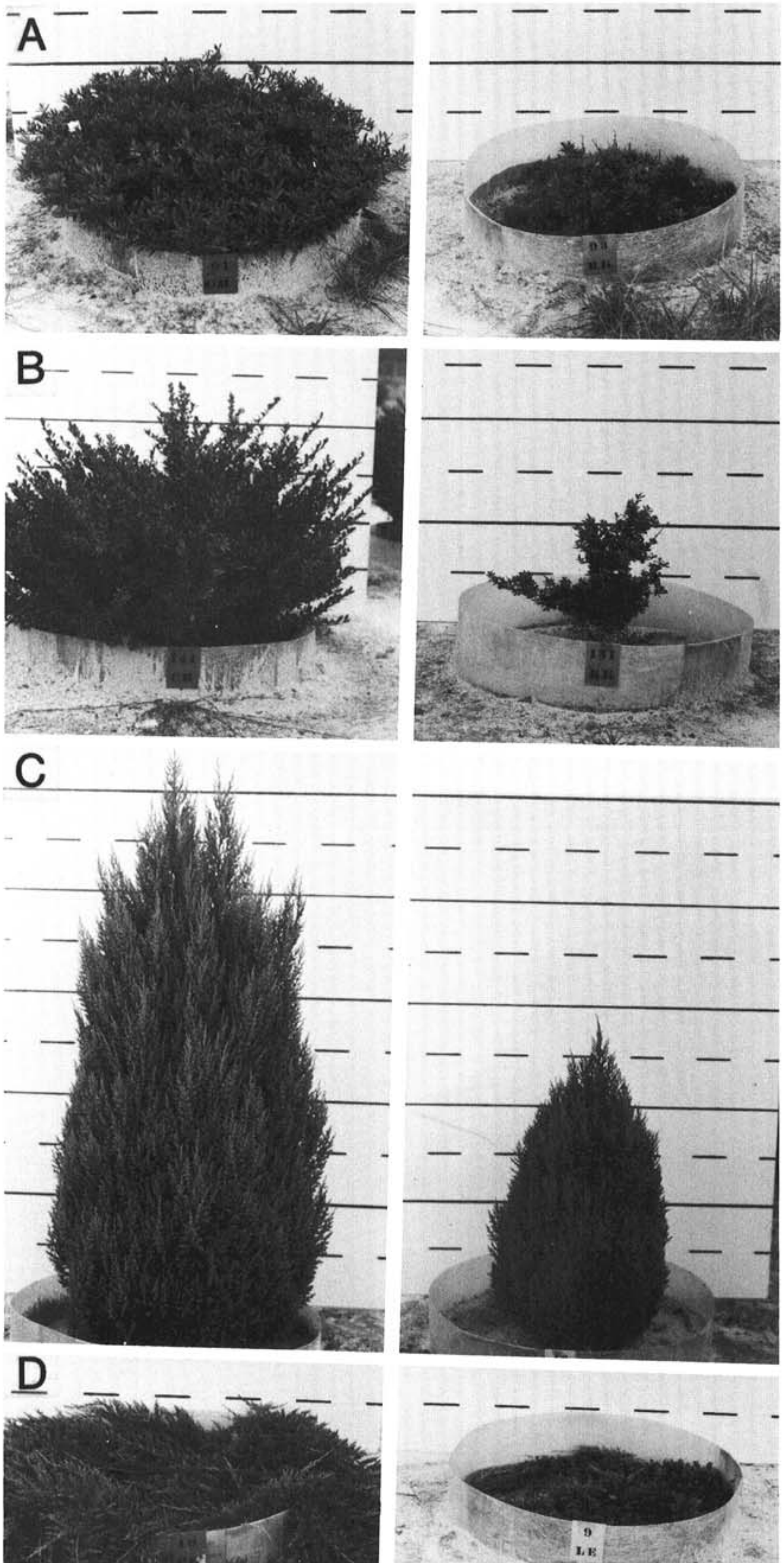


Fig. 2. Comparison of plant size of nematode-infected (right) and control (left) plants after 29 months in microplots. (A) Dwarf gardenia infected with *Meloidogyne arenaria*. (B) Compacta holly infected with *M. arenaria*. (C) Spiny Greek juniper infected with *Pratylenchus vulnus*. (D) Blue Rug juniper infected with *P. vulnus*. (Reprinted from [7])

in which the nematode density decreases dramatically by the second and third year. For example, in an intolerant response with *M. arenaria* on three cultivars of *I. crenata*, a dramatic decrease in nematode density occurred between 12 and 24 months after planting (2). Consequently, in sampling nematode density at various times after planting, only initial density was correlated with plant decline in a stepwise regression model.

Factors Affecting Ornamental Plant Response to Nematodes

Plant age. Most microplot experiments begin with ornamentals that have been grown in 3.75- or 7.5-L containers for a season after propagation (2-year-old plants). This age is typical for plants that will be grown to specimen size in field production or transplanted directly into the landscape by the consumer. Effect of plant age on decline was compared on 1- and 2-year-old plants of *I. crenata* 'Helleri.' The 1-year-old plants were inoculated with *C. xenoplax* in the greenhouse in July, grown until the following May, then transplanted to fumigated field plots. Healthy 2-year-old plants were transplanted into soil infested with *C. xenoplax* in microplots. After 3 years, the Helleri plants inoculated at 1 year were markedly less vigorous than the plants inoculated at 2 years (Fig. 3). The 1-year-old plants were more severely damaged because *C. xenoplax* had more time to become established in the root zones under more favorable greenhouse conditions. In addition, after transplanting, the 1-year-old plants were under greater stress than the 2-year-old plants because of the well-established nematode population plus the smaller root system to support plant growth.

Threshold densities for damage to ornamentals. Experiments that describe the relationship between initial nematode density and subsequent plant damage in annual crops have demonstrated a threshold density below which yield or plant growth is not affected (5,6). Linear regression and quadratic models have been utilized to predict this relationship (6,12). Do threshold density relationships also hold for decline of perennial ornamentals? The answer is a qualified "probably not." Even at the lowest initial densities (five eggs per 500 cm^3 of soil), *M. arenaria* caused stunting of Rotundifolia plants, a somewhat tolerant Japanese holly cultivar (Fig. 4). Thus, nematodes capable of attacking a particular ornamental become established in the root zone and in time reach densities that may result in severe decline. Therefore, nurserymen should set a zero tolerance for nematodes on susceptible ornamentals by employing appropriate control measures.

Polyspecific populations of nematodes. Does rate of decline of ornamentals inoculated with two different parasitic nematodes increase in an additive or synergistic manner? Microplot studies with *M. arenaria* and *T. claytoni* populations added to the same plot with either a nematode-susceptible (*I. crenata* 'Rotundifolia') or a nematode-tolerant (*I. cornuta* Lindl. 'Dwarf Burfordi') holly demonstrated that decline (difference in growth between inoculated and control plants) was no greater than the effect of the most damaging species alone (Table 2). Also, *M. arenaria* and *T. claytoni* in combination failed to break the resistance of the resistant cultivar. Nematode density on the resistant cultivar declined for *M. arenaria* but remained stable for *T. claytoni* over the 24-month experiment. Apparently, the number of infection sites or the amount of disease induced by the different nematode species in the same root zone is limited by some as yet undescribed phenomena. From an ecological standpoint, however, the possibility of competition for infection sites is known to limit disease development in certain fungal pathogens and may play a role here.

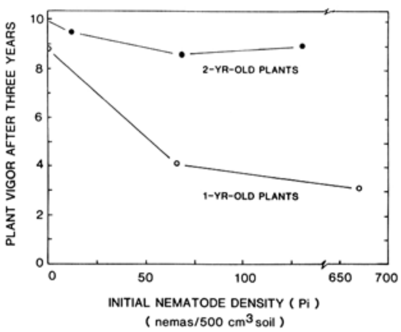


Fig. 3. Relationship among initial density (Pi) of *Criconemella xenoplax* at inoculation, plant age, and decline of *Ilex crenata* 'Helleri' after 3 years in microplots. Plant vigor rating: 0 = dead, 10 = symptom-free.

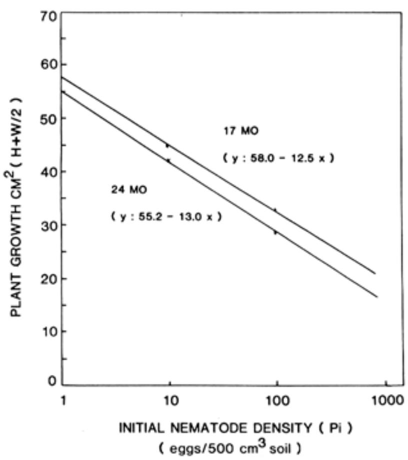


Fig. 4. Relationship of initial density (Pi) of *M. arenaria* to decline of *Ilex crenata* 'Rotundifolia' at 17 and 24 months after planting in microplots.

Control of Nematodes

Ornamental plant selection and cultural practices. Research of nematode-host reactions in microplots has provided information on tolerant and intolerant ornamentals (Table 1). Utilization of tolerant ornamentals in planning landscapes should avoid many of the problems encountered when susceptible ornamentals are planted on nematode-infested sites. When ornamentals in an existing planting develop decline symptoms, cultural practices such as mulching and watering during droughts may extend the life of the planting, but replacement with tolerant or resistant species may be necessary for long-term control.

Table 1. Nematode-host response for ring (*Criconemella xenoplax*), root-knot (*Meloidogyne arenaria*), lesion (*Pratylenchus vulnus*), and stunt (*Tylenchorhynchus claytoni*) nematodes on woody ornamentals tested in microplots

Ornamental Cultivar	Nematode-host response[a]			
	Ring	Root-knot	Lesion	Stunt
Aucuba japonica	. . .[b]	S	. . .	S
Buxus microphylla (Japanese boxwood)	R	S	I	R
B. sempervirens (American boxwood)	T	T	I	T
B. sempervirens (English boxwood)	. . .	R	I	T
Camellia japonica	. . .	R	. . .	T
C. sasanqua	R	R	. . .	T
Gardenia jasminoides				
Radicians	R	I	R	R
Ilex cornuta (Chinese holly)				
Dwarf Burfordi	T	R	. . .	T
Rotunda	S	I	. . .	S
I. crenata (Japanese holly)				
Compacta	R	S	R	R
Convexa	T	I	. . .	T
Helleri	S	I	. . .	S
Rotundifolia	S	I	. . .	S
I. vomitoria var. *nana* (yaupon holly)	R	R	. . .	T
Juniperus conferta				
Shore	S	R	R	T
J. excelsa stricta				
Spiny Greek	R	R	I	R
J. horizontalis				
Blue Rug	T	R	I	T
Ligustrum sp.	R	R	. . .	T
Nandina domestica	R	R	. . .	T
Photinia fraseri	R	R	. . .	T
Rhododendron indicum				
Formosa azalea	R	R	. . .	T
R. obtusum				
Hershey Red azalea	. . .	R	. . .	S

[a]T = tolerant (nematode reproduction greater than initial density and host not stunted); R = resistant (nematode reproduction less than initial density and host not stunted); S = susceptible (nematode reproduction greater than initial density and host stunted); I = intolerant (nematode reproduction less than initial density and host stunted).
[b]Not tested in microplot experiments.

Table 2. Comparison of effects of single and mixed populations of *Meloidogyne arenaria* and *Tylenchorhynchus claytoni* on growth of nematode-susceptible (*Ilex crenata* 'Rotundifolia') and nematode-tolerant (*I. cornuta* 'Dwarf Burfordi') hollies after 24 months in microplots

Initial nematode density per 500 cm^3 of soil	Growth[a] (cm^2) after 24 months	
	Rotundifolia	Dwarf Burfordi
Meloidogyne arenaria		
1,000 eggs	1,648	3,436
500 eggs	2,170	4,082
Tylenchorhynchus claytoni		
2,000 nematodes	3,448	3,161
1,000 nematodes	2,454	3,572
M. arenaria + *T. claytoni*		
500 eggs + 1,000 nematodes	1,721	3,630
Control	5,061	3,992
LSD ($P = 0.05$)	2,216	609

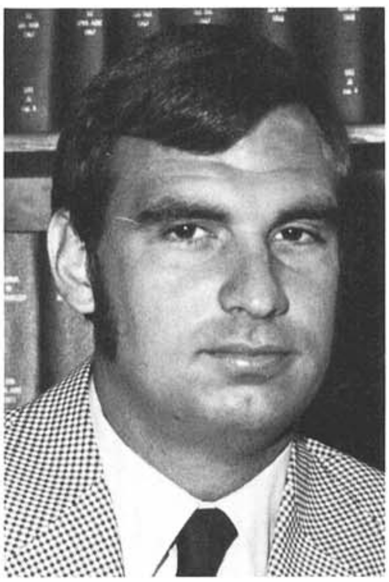
[a]Average plant height × average plant width.

Nematicides. *Preplant treatments.* Nurserymen preparing a field site for planting have the option of including a preplant nematicide or fumigant. Use of a nematode advisory service to assay soil samples from the field site would assist the nurseryman in deciding whether or not such treatment is needed. However, the future status of nematicides such as ethylene dibromide (EDB) may impose constraints on the use of preplant nematicides, since alternative materials such as methyl bromide are many times more costly on a per-acre basis.

Postplant treatments. Eradication of nematodes on established ornamentals is an extremely difficult problem and one for which nurserymen and consumers continue to seek advice. The loss of dibromochloropropane (DBCP) through labeling restrictions has left a void in the effective control of nematodes on established ornamentals. Experiments with some the current restricted-use nematicides, including aldicarb, ethoprop, fensulfothion, and oxamyl, have given neither consistent eradication of *Meloidogyne* pests nor acceptable plant-growth response. Part of the reason for inconsistent results with postplant nematicides may be application to heavily infected root systems on plants with severe decline. Most of these nematicides are effective primarily against penetration and have only limited activity against established endoparasitic species. A more realistic strategy may be to protect root systems from initial infection as is done with annual crops. Such treatments probably would need to be followed by periodic postplant applications if effective materials are labeled.

Biological control of nematodes on ornamentals. A useful control strategy for the future may be development of delivery systems that utilize antagonists of nematode pests. Research with bacteria and fungi antagonistic to various nematodes has shown promise on some annual crops (11). However, the development and utilization of biological control systems for ornamentals is, in general, a strategy that is largely unexplored at present.

Integrated control. A combination of tactics may be useful in minimizing nematode problems on woody ornamentals. This strategy involves identification of any parasitic nematodes in the planned planting site; submission of soil samples to a nematode advisory service can provide the grower with this information. Selection of the most tolerant ornamentals should be an important consideration also. Preplant soil fumigation should be used where susceptible ornamentals must be grown. Use of transplant stock free from parasitic nematodes cannot be overemphasized. Good management practices, including fertilizing, mulching, and watering, may limit damage done by nematodes. In the future, use of biocontrol agents and new nematicides hopefully will provide even more effective control of nematodes on woody ornamentals.



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