Susceptibility of Japanese Boxwood, Dwarf Gardenia, Compacta (Japanese) Holly, Spiny Greek and Blue Rug Junipers, and Nandina to Four Nematode Species

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ABSTRACT

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Microplots were used to study the susceptibility of Japanese boxwood, dwarf gardenia, Compacta (Japanese) holly, Spiny Greek and Blue Rug junipers, and nandina to *Criconemella xenoplax, Meloidogyne arenaria, Pratylenchus vulnus*, and *Tylenchorhynchus claytoni* over 29 mo. *M. arenaria* caused severe stunting of dwarf gardenia and Compacta holly. Root galling was heavy on these plants as well as on Japanese boxwood, where stunting was not significant. *M. arenaria* did not reproduce on the other ornamentals. *P. vulnus* stunted Japanese boxwood and both junipers, but only Blue Rug juniper developed necrotic foliar symptoms. Nematode densities were greater in May than in October for *P. vulnus* on the junipers. *M. arenaria* eggs and *P. vulnus* juveniles were found in greater numbers in roots than in soil on susceptible hosts. Xylem potentials were higher in *P. vulnus*-infected junipers than in control plants during drought periods but not during wet periods. Nandina was tolerant to *T. claytoni* and a nonhost to the other nematode species tested.

Decline of woody ornamentals caused by plant-parasitic nematodes is a serious problem in landscape plantings and in field-grown nursery stock in the southeastern United States. Recently, host susceptibility studies under microplot conditions have helped to elucidate certain host-nematode combinations that resulted in plant damage (1–3,5). In addition, research has demonstrated that certain cultivars are tolerant or resistant to the nematode species tested. For example, *Ilex cornuta* 'Burfordi' DeFrance and *I. vomitoria* var. *nana* Ait. (dwarf yaupon) were not damaged by *Criconemella xenoplax* (Raski) Luc & Raski (syn. *Criconemoides xenoplax, Macroposthonia xenoplax*), *Meloidogyne arenaria* (Neal) Chitwood, or *Tylenchorhynchus claytoni* Steiner (3), the three most damaging species in addition to *Meloidogyne incognita* (Kofoid & White) Chitwood and *Pratylenchus vulnus* Allen & Jensen in microplot studies in North Carolina (5).

This paper reports the results of further microplot experiments with several additional ornamentals and four nematode species.

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MATERIALS AND METHODS

Microplots and inocula. Fiberglass microplots (76 cm diameter) established at the Central Crops Research Station, Clayton, NC, were fumigated with methyl bromide (1,445 kg/ha) on 10 April 1979. Plastic covers were removed after 7 days, and the soil was thoroughly mixed in each microplot with a shovel 7 days later. The soil was a well-drained sand (91% sand, 3.3% clay, and 5.7% silt) with a pH of 5.5.

Nematode inocula of *Criconemella xenoplax, Meloidogyne arenaria, T. claytoni*, and *P. vulnus* were increased in the greenhouse as previously described (1–3,5). Soil in the microplots was infested 31 days after fumigation with a monospecific population by lining a 30 × 30 cm central depression in each microplot with a 5-cm-thick layer of inoculum that resulted in a nematode population of 0.5 nematodes per cubic centimeter for *C. xenoplax*, 3.3/cm^3 for *T. claytoni*, and 4.3/cm^3 for *P. vulnus*. An *M. arenaria* population of 2/cm^3 was obtained by mixing 0.22 L of inoculum throughout the microplot (88 L).

Host culture, experimental design, and sampling. Ten-month-old liners of *Buxus microphylla* var. *japonica* Rehd. & Wils. (Japanese boxwood); *Gardenia jasminoides* 'Radicans' Thunb. (dwarf gardenia); *Ilex crenata* 'Compacta' Thunb. (Japanese holly); *Juniperus excelsa* var. *stricta* Gord. (Spiny Greek juniper); *J. horizontalis* Moench (Blue Rug juniper); and *Nandina domestica* Thunb. were potted in sand:soil:peat (1:1:1, v/v) in 7.5-L containers and fertilized with 15 cm^3 of slow-release granular 19-6-12. Plants were irrigated daily (0.6 cm/day) in a nursery area during the 1977 and 1978 growing season. Three-year-old plants were transplanted to the microplots immediately following nematode infestation, using five replicates of each ornamental-nematode combination in a randomized complete block design. Each microplot received 100 cm^3 of slow-release 19-6-12 each spring. Plants were irrigated during dry periods. Weeds were

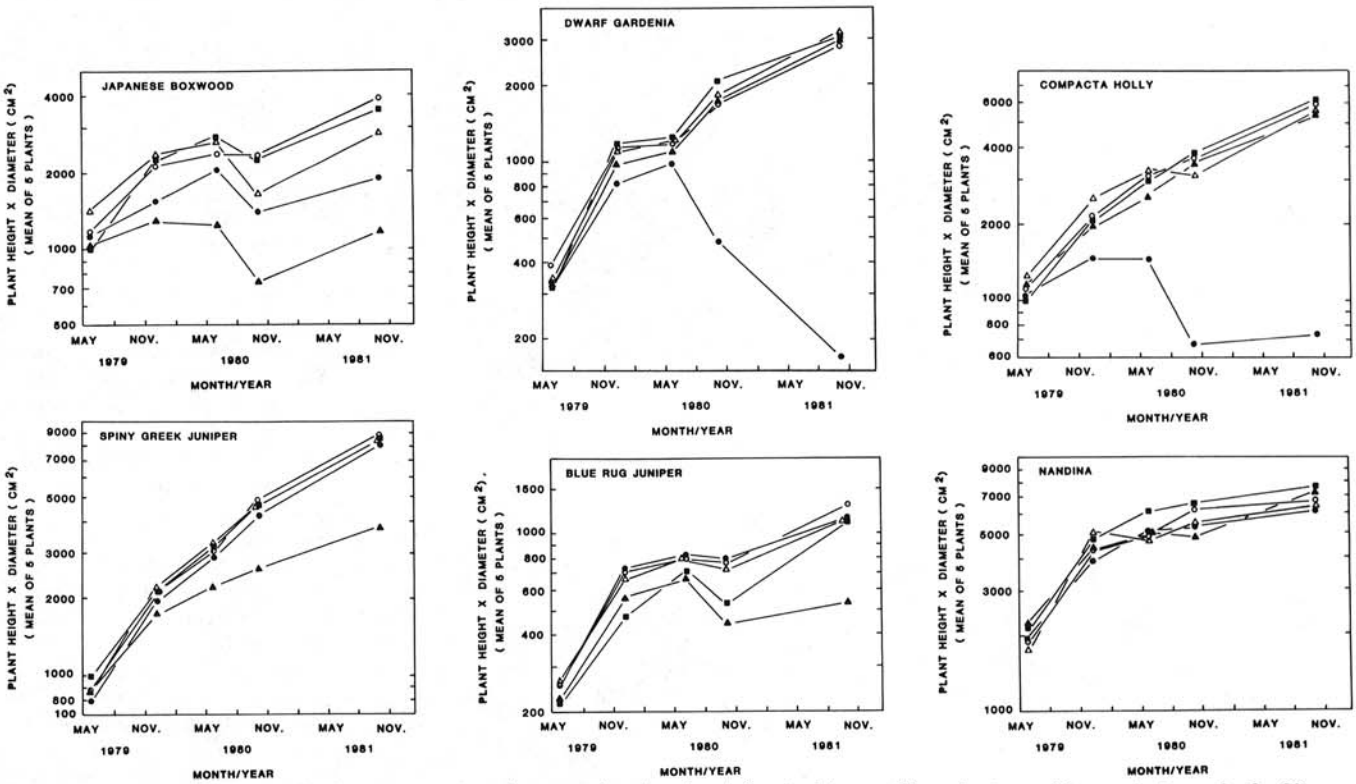

Fig. 1. Increment growth curves for six ornamental species grown in microplots infested with one of four plant-parasitic nematode species for 29 mo. Nematode key: *Criconemella xenoplax* (■), *Meloidogyne arenaria* (●), *Pratylenchus vulnus* (▲), *Tylenchorhynchus claytoni* (○); control (△).

controlled by hand and with preemergence and postemergence herbicides.

Microplots were sampled to determine nematode populations in spring and fall by collecting and bulking 10 soil cores (2 cm diameter × 30 cm deep) around the drip line of each plant. Nematodes in the bulked samples (soil and roots) were elutriated and counted (6,8). For *M. arenaria* counts, elutriated roots were extracted for egg counts by the method of Byrd et al (7) and combined with larvae counts from soil. For *P. vulnus* counts, elutriated roots were placed in a Baermann funnel in a mist chamber, and collected larvae were counted daily over a 10-day period. Rates of reproduction were calculated as the ratio of the population at sampling time (Ps) to the initial population (Pi). Although microplots were sampled five times in 29 mo, only representative data at 5, 17, and 29 mo are presented. Plant growth was estimated after new growth in the spring and after frost in the fall by recording plant height and diameter (4).

Xylem water potential was determined in a pressure bomb (Model 3005, Soil Moisture Equipment Co., Santa Barbara, CA) after 26, 26.5, and 27 mo for the junipers only. Shoots 15–20 cm in length and of similar maturity were used for determinations. Samples were taken from the same location on each plant. Values from five plants were averaged for each determination. The sampling dates reflected conditions of moderate drought, drought, and adequate moisture, respect-

Table 1. Rate of reproduction of four nematode species on six ornamental species over a 29-mo period in microplots

Crop Nematode	Pi[a] (no./500 cm³)	Rate of reproduction (Ps[b]/Pi) Months after planting 5	17	29
Japanese boxwood				
Criconemella xenoplax	240	0.1	0	0.1
Meloidogyne arenaria	1,000	0.8	2.7	2.9
Pratylenchus vulnus	2,150	0.3	0.6	0.2
Tylenchorhynchus claytoni	1,650	0.2	0.1	0.1
Dwarf gardenia				
C. xenoplax	240	0.1	0.1	0
M. arenaria	1,000	5.6	3.2	0.4
P. vulnus	2,150	0.1	0	0
T. claytoni	1,650	0.1	0.3	0.1
Compacta holly				
C. xenoplax	240	0.9	0.1	0.2
M. arenaria	1,000	0.4	0.3	3.1
P. vulnus	2,150	0.1	0	0
T. claytoni	1,650	0.3	0.3	0.3
Spiny Greek juniper				
C. xenoplax	240	0.4	0	0
M. arenaria	1,000	0.2	0	0.1
P. vulnus	2,150	0.9	0.5	0.6
T. claytoni	1,650	0.3	0.4	0.1
Blue Rug juniper				
C. xenoplax	240	0.6	3.4	3.1
M. arenaria	1,000	0	0.2	0
P. vulnus	2,150	0.2	0.1	0.1
T. claytoni	1,650	0.1	0.2	0.1
Nandina				
C. xenoplax	240	0.3	0	0
M. arenaria	1,000	0	0.1	0
P. vulnus	2,150	0	0	0
T. claytoni	1,650	0.8	0.9	0.2

[a] Pi = Initial nematode density.
[b] Ps = Nematode density at a given sampling date.

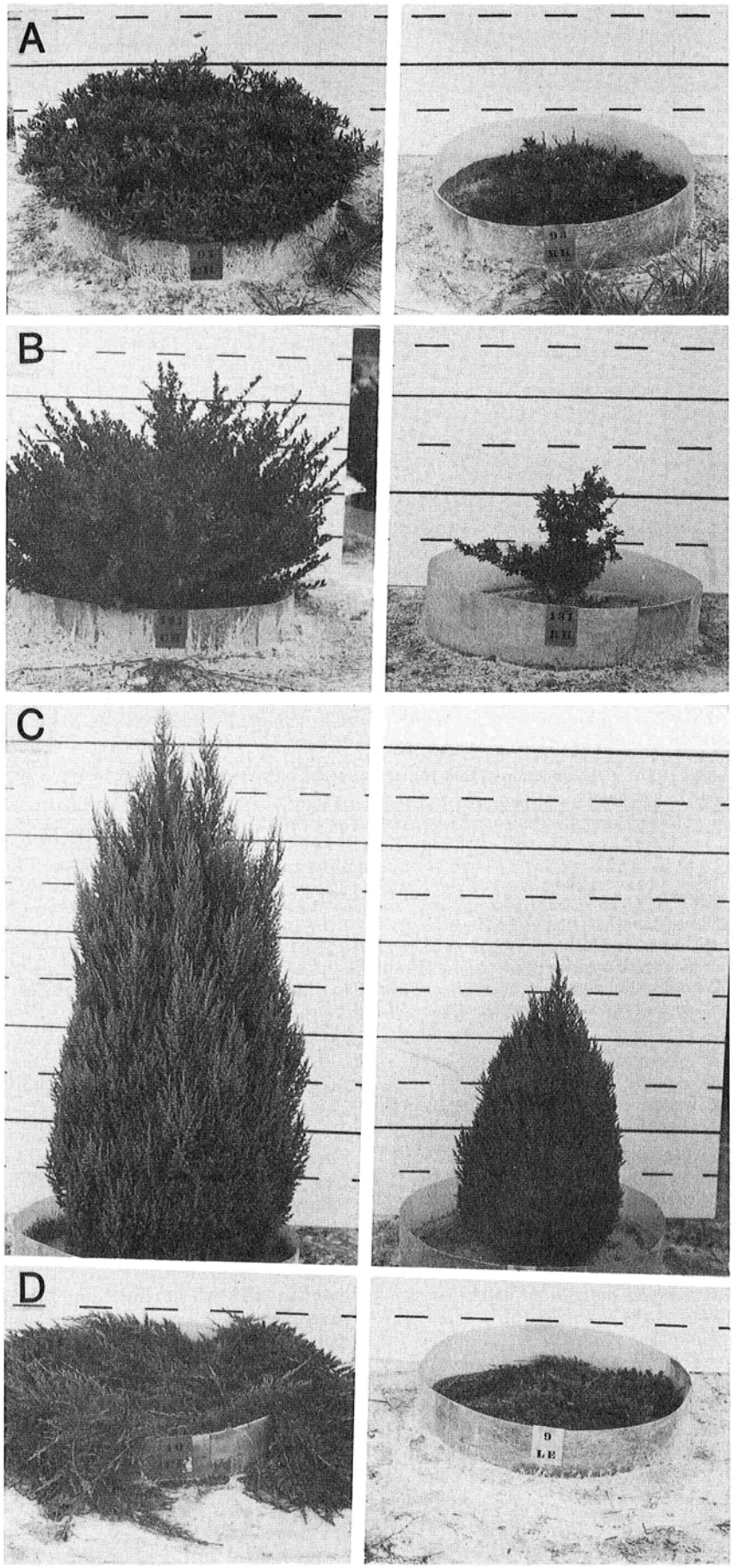

Fig. 2. Comparison of plant size of nematode-infected **(right)** and control **(left)** plants after 29 mo in microplots. **(A)** Dwarf gardenia infected with *Meloidogyne arenaria*. **(B)** Compacta holly infected with *M. arenaria*. **(C)** Spiny Greek juniper infected with *Pratylenchus vulnus*.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

ively. No irrigations or rain occurred between the first and second sampling dates, whereas 10 cm of rain fell between the second and third sampling period.

RESULTS AND DISCUSSION

Japanese boxwood. Although uniform plants were selected for transplanting, Japanese boxwood transplanted into microplots with *C. xenoplax* were smaller ($P = 0.05$) than the control plants. However, initial size differences were overcome by the end of the first growing season. All other ornamentals tested were uniform in size at transplanting. During the experiment, only *P. vulnus* caused stunting in Japanese boxwood, but this was not apparent until 17 mo after transplanting (Fig. 1A). Foliar symptoms other than stunting were not visible. The dip in the increment plant growth curves in October 1980 was partly caused by variations in estimating plant size between enumerators.

Rates of reproduction (Ps/Pi) for *C. xenoplax* and *T. claytoni* were very low on Japanese boxwood so that nematode populations declined gradually in the root zone (Table 1). *P. vulnus*, however, maintained a 0.6 rate of reproduction after 17 mo and became established in the root zone. Greatest numbers of *P. vulnus* were associated with the roots in the soil cores as determined by daily counts from roots in Baermann funnels maintained in a mist chamber over a 10-day period.

M. arenaria became well established in the Japanese boxwood root zone as the reproductive rate approached 3.0 after 29 mo (Table 1). Heavy galling was evident on the root system of excavated plants. Although growth of plants was not different ($P = 0.05$) from control plants at 29 mo, the severity of stunting in *M. arenaria*-infected plants may become significant over time (Fig. 1A).

Dwarf gardenia. Growth of dwarf gardenia was stunted only by *M. arenaria* (Figs. 1B and 2A). Plants infected with this nematode seemed to be more predisposed to winter dieback than were control plants. During the late summer of 1980, four of five plants died, accounting for the drop in the increment growth curve and rate of nematode reproduction (Table 1). However, *M. arenaria* remained established in the roots of the remaining plant. Greatest numbers of *M. arenaria* (eggs) were associated with the root fraction of the soil core in dwarf gardenia as well as each of the other ornamentals attacked by *M. arenaria*. Low rates of reproduction were found for *C. xenoplax, T. claytoni*, and *P. vulnus* on dwarf gardenia, and none of these nematodes became established in the root zone.

Compacta holly. Within 7 mo of transplanting, growth of Compacta holly was stunted by *M. arenaria* when compared with control plants ($P = 0.01$; Fig. 2B). Two plants died during the

summer of 1980, resulting in a negative slope of the increment growth curve (Fig. 1C). No chlorosis was observed on stunted Compacta plants, unlike that reported for other cultivars of *I. crenata* (2). Stunted plants had less branching, and new growth each season was greatly restricted compared with control plants. Severe galling was observed on the roots.

As Compacta plants declined, rate of reproduction of *M. arenaria* decreased (Table 1) because of lack of nematode infective sites. This intolerant response has been noted on other cultivars of Japanese holly infected with *M. arenaria* (2). Rate of reproduction increased markedly during the last sampling period, but this may reflect sampling variation in which a heavily galled root was taken in a soil core from one plant, raising the overall combined count. Nematode densities were near zero in the other four plots.

T. claytoni and to a lesser extent *C. xenoplax* became established in the root zone of Compacta, although neither caused stunting and the rate of reproduction was about 0.25 after 29 mo (Table 1). This differed from other data, where both nematodes stunted other cultivars of Japanese hollies and the rate of reproduction generally exceeded 1.0 (1). Reproduction of *P. vulnus* in the Compacta root zone decreased sharply, with values near 0 after 5 mo.

Spiny Greek and Blue Rug junipers. Both juniper cultivars responded similarly to the four nematode species. Size differences in plants parasitized by *P. vulnus* became apparent ($P = 0.01$) after 12 and 17 mo for Spiny Greek and Blue Rug juniper, respectively, compared with the controls (Figs. 1D and E and 2C and D). Necrosis of Blue Rug foliage was also evident. No other nematode tested affected the growth of either juniper.

Rate of reproduction of *P. vulnus* in the roots of Spiny Greek and Blue Rug junipers varied from 0.57 to 0.09 after 29 mo, respectively (Table 1). Apparently, the more vigorously growing Spiny Greek juniper provided more root system for reproduction of *P. vulnus* than did Blue Rug. An anomaly in recovery of *P. vulnus* was demonstrated when counts were higher in May each season than in October (Fig. 3). This relationship is the opposite for recovery of most other nematodes. Either a large hatch of eggs occurred in the spring prior to sampling or the nematode was unable to migrate out of roots because of an imposed dormancy in October. Root and soil samples for *P. vulnus* taken in May may be more useful for nematode advisory recommendations than fall samples.

Xylem water potential values varied among sampling dates, reflecting differences in soil moisture conditions. At 26 mo after transplanting, xylem potential readings ranged from −7.6 to −10.2 bars for Spiny Greek and −10.3 to −11.4 bars for Blue Rug, with no differences between control and nematode-infected plants. At 26.5 mo, xylem potentials of *P. vulnus*-infected plants increased to −18.0 bars for Spiny Greek and −15.5 bars for Blue Rug. These values were significantly greater than the control plants. Nematode-infected plants that were not stunted at 26.5 mo had similar values compared with the control. Xylem potentials had dropped to about −5 bars for *P. vulnus*-infected and control plants of both cultivars following rainfall at the 27-mo sampling. The xylem potential data demonstrated that plants severely stunted because of nematode infection were under greater water stress during drought periods than nematode-free plants but that when soil moisture was adequate, both nematode-infected and nematode-free plants were at the same water potential.

C. xenoplax became well established in the root zone of Blue Rug but not of Spiny Greek. Reproduction rates were above 3.0 after 17 and 29 mo on Blue Rug, even though no plant stunting was observed. *M. arenaria* failed to become established in the root zone of either juniper.

Nandina. No differences in growth of nandina were observed between the four nematode species tested and the control plants after 27 mo (Fig. 1F). Only *T. claytoni* became established in the root zone of nandina, with reproductive rates of 0.94 and 0.20 at 17 and 29 mo, respectively. Apparently, nandina is a nonhost for *C. xenoplax, M. arenaria,* and *P. vulnus* and is tolerant to *T. claytoni.*

Conclusions. Only the *M. arenaria*-dwarf gardenia and Compacta holly interactions and the *P. vulnus*-Japanese boxwood, Blue Rug, and Spiny Greek juniper interactions suppressed plant growth. Possibly plant stress was not sufficient in the tested plants for *C. xenoplax* and *T. claytoni* to affect growth. However, xylem potential measurements were useful in demonstrating that *P. vulnus*-infected junipers were under a greater water stress than nematode-free plants when soil moisture was limiting. Our results demonstrate the continued need for microplot and field experiments to determine specific nematode-host interactions because damaging relationships are not predictable for a given nematode on widely varying species of ornamentals.

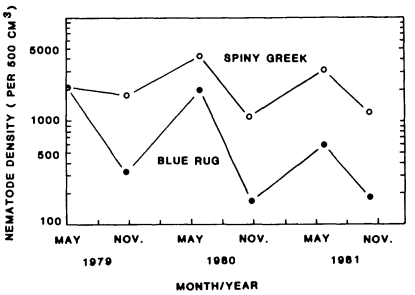

Fig. 3. Nematode density of *Pratylenchus vulnus* on Spiny Greek and Blue Rug junipers over 29 mo in microplots.

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