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Rotylenchulus reniformis on Greenhouse-grown Foliage Plants: Host Range and Sources of Inoculum[1]

J. L. STARR[2]

Abstract: Two sources of inoculum of reniform nematodes, *Rotylenchulus reniformis,* were identified for infestation of ornamental foliage plants in commercial greenhouses. These were water from a local canal system and rooted cuttings purchased from other sources. Eight ornamental plant species were identified as good hosts for the reniform nematode, with each species supporting a reniform population density equal to or greater than that supported by 'Rutgers' tomato and a reproduction factor of greater than 1.0. Nine other plant species were identified as poor hosts.

Key words: Araucaria excelsia, Asparagus densiflorus sprengeri, Beaucarnea recurvata, Brassaia actinophylla, Brassaia arboicola, Chamaedorea elegans, Chlorophytum comosum variegatum, Codiaeum variegatum pictum, commercial greenhouse, *Dieffenbachia camille, Dieffenbachia compacta, Dracaena draco, Dizygotheca elegantissima, Ficus benjamina, Ficus elastia robusta, Ficus lyrata, Lycopersicon esculentum,* ornamental foliage plants, *Philodendron selloum, Radermachera sinica,* reniform nematode, reproduction factor, *Rotylenchulus reniformis, Sansevieria trifasciata, Spathiphyllum* spp., *Syngonium podophyllum albovirens.*

The reniform nematode *Rotylenchulus reniformis* causes economic loss to cotton (13), soybean (10), and sweetpotato (2), and occurs throughout the southern United States (4,5), including the Lower Rio Grande Valley of Texas (LRGV; 11). Resident populations of the nematode have not been reported from the western states of Arizona, California, or New Mexico. These states have quarantine regulations with regard to shipment of soil and (or) plants contaminated with the reniform nematode to prohibit the introduction of the nematode.

The LRGV is a center for the production of greenhouse-grown ornamental foliage plants. Over the past two years, several shipments of foliage plants from the LRGV to California, Arizona, and New Mexico were found to be contaminated with reniform nematodes. The resultant destruction of these plants by regulatory officials was a substantial economic loss to producers. Additional economic loss will occur if Texas producers are unable to eliminate the reniform nematode contamination of ornamental plants produced for interstate commerce.

One objective of this study was to determine sources of inoculum for infestation of greenhouses with reniform nematodes. Many greenhouses in the LRGV obtain water from a canal system known locally as the resaca. Larger greenhouse complexes (those with $\geq$ 625,000 m^2 space) use up to 10^6 liters of water per day. Because the resaca system receives surface runoff from fields infested with reniform nematodes and because irrigation water previously has been shown to be a means of distributing nematodes (3), the resaca was considered to be a likely source of inoculum for greenhouses in the LRGV. A second likely source of inoculum was considered to be the rooted cuttings that Texas growers purchase from other companies.

Another objective of this study was to determine the host status of commonly grown ornamental foliage plants relative to the reniform nematode. Although hundreds of plant species have been reported as hosts of the reniform nematode (1,6,8) little is known concerning the host status of many ornamental foliage plants.

Materials and Methods

Sources of inoculum: To determine if reniform nematodes were present in resaca water, a filter system with an exclusion limit of 5 μm was installed on a water line from

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[2] Department of Plant Pathology and Microbiology, Texas Agricultural Experiment Station, College Station, TX 77843.

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the resaca to a commercial greenhouse in Brownsville, Texas. The filter was a cloth bag 18 cm d × 30 cm long. Five separate samples of resaca water were collected by passing from 37,000 to 300,000 liters of water through the filter. Two samples were collected on 18 May 1989, two on 28 September 1989, and the last on 31 October 1989. Nematodes were recovered from the filter by turning the filter inside out and incubating overnight in a 20-liter bucket of water. Residue collected in the bucket was concentrated on a 20-cm-d sieve with 25-μm pores. Nematodes were extracted from the concentrated residue by centrifugation (7).

In a second experiment, 40 pots each of four plant species (Table 1) in 25-cm-d pots plus 40 15-cm-d pots of one plant species (*Ficus lyrata*) were placed in a commercial greenhouse. The growth medium was a nematode-free mixture of peat (75%) and vermiculite (25%). Ten pots of each plant species or pot size were assigned to one of four treatments. The treatments were as follows: (1) pots placed on polyethylene sheeting on the ground and watered with city tap water, (2) pots on the polyethylene and watered with resaca water, (3) pots placed on raised benches and watered with city tap water, and (4) pots on raised benches and watered with resaca water. At 2, 4, and 6 months after initiation of the experiment, two 2.5-cm-d cores were removed from each pot. At each sampling date, 10 cores representing five pots of a single plant species–pot size were composited, giving a total of 40 samples, 2 from each plant species–pot size–treatment combination. Nematodes were extracted from 100-cm³ aliquots of each sample by incubation on a Baermann funnel for 48 hours.

To determine if root cuttings obtained from other producers were a source of inoculum for reniform nematodes, 131 samples were collected from 10 shipments of rooted cuttings. These cuttings came from six different sources, all from outside Texas, and represented nine plant species. Each sample consisted of the soil and roots from six cuttings collected from two trays, each tray containing 24–96 cuttings. Nematodes were extracted from each sample by incubating 100 cm³ of soil and associated roots on a Baermann funnel for 48 hours.

TABLE 1. Effect of water source and pot placement on contamination of greenhouse-grown ornamental foliage plants with *Rotylenchulus reniformis*.

	Nematodes/100 cm³			
	City water		Resaca water	
Plant species	Bench	Ground	Bench	Ground
	25-cm-d pots			
Ficus lyrata	4	1	3	1
Radermachera sinica	0	0	0	0
Philodendron selloum	1	0	0	0
Brassaia actinophylla	2	2	0	1
	15-cm-d pots			
Ficus lyrata	2	0	1	4
Means	1.8	1.0	0.8	1.2

Values are nematode population densities at six months after establishing water source and pot placement treatments. Pots were on raised benches (bench) or polytheylene sheeting on the ground (ground).

Host status: Seventeen ornamental plant species in 15-cm-d pots with a peat (75%) and vermiculite (25%) growth medium were inoculated with 1,680 mixed life stages of *R. reniformis* per pot. The reniform nematode population was originally isolated from cotton and maintained on *Lycopersicon esculentum* cv Rutgers in the greenhouse. Inoculum was obtained by incubating soil and roots from greenhouse cultures on Baermann funnels for 48 hours. Rutgers tomato was included in this test as a nematode-susceptible control. All plants were maintained on a greenhouse bench (temperature 20–26 C) in a randomized complete block design with eight replications. Plants were harvested by replication at 16–20 weeks after inoculation. Roots of each plant were cut into segments 3 to 5 cm long and mixed with the soil from the corresponding pot. Nematode population densities were determined by incubating a 100 cm³ aliquot of each soil-root fragment sample on a Baermann funnel for 48 hours. Reproduction factors (9) were calculated by dividing final nematode population den-

TABLE 2. Frequency of contamination with plant-parasitic nematodes in rooted cuttings of ornamental foliage plants.

Plant species	Proportion infested†	Nematode species detected‡				
		Praty	Mel	Helico	Tylen	Rotyl
	Shipment 1 (origin: Florida)					
Syngonium podophyllum albovirens	2/8	−	−	+	+	−
Dieffenbachia camille	3/7	+	−	+	+	−
D. compacta	2/4	+	+	+	+	−
	Shipment 2 (origin: Florida)					
Ficus lyrata	3/4	+	−	−	−	−
	Shipment 3 (origin: Florida)					
D. camille	4/4	+	+	−	−	−
D. compacta	2/4	+	−	−	−	−
S. p. albovirens	5/8	+	−	−	−	−
F. lyrata	2/7	+	−	−	−	−
	Shipment 4 (origin: Florida)					
Spathiphyllum spp.	6/12	+	+	−	−	−
	Shipment 5 (origin: Florida)					
Spathiphyllum spp.	0/2	−	−	−	−	−
F. lyrata	0/5	−	−	−	−	−
	Shipment 6 (origin: Tennessee)					
D. camille	3/6	+	−	−	−	−
D. compacta	1/6	+	−	−	−	−
S. p. albovirens	0/6	−	−	−	−	−
	Shipment 7 (origin: California)					
D. camille	1/6	+	−	−	−	−
D. compacta	0/6	−	−	−	−	−
F. lyrata	0/6	−	−	−	−	−
	Shipment 8 (origin: Florida)					
Spathiphyllum spp.	0/6	−	−	−	−	−
	Shipment 9 (origin: Florida)					
Spathiphyllum spp.	3/4	−	−	−	−	+
	Shipment 10 (origin: Florida)					
Beaucarnea recurvata	0/2	−	−	−	−	−
Dizygotheca elegantissima	1/6	+	−	−	−	−
Araucaria excelsa	0/10	−	−	−	−	−
Totals	41/131	27	10	3	6	3
Mean population density§		40	4	21	5	15
Max. population density§		428	16	54	12	32

† Samples with nematodes/total number of samples.
‡ Praty = *Pratylenchus*, Mel = *Meloidogyne*, Helico = *Helicotylenchus*, Tylen = *Tylenchorhynchus*, and Rotyl = *Rotylenchulus reniformis*; + = present; − = absent.
§ Nematode population densities are numbers per 100 cm³ soil.

sities per 100 cm³ by the initial density (168 nematodes/100 cm³). All nematode population count data were subjected to analysis of variance using the SAS general linear model procedure (12).

RESULTS

Sources of inoculum: All samples of the resaca water contained free-living nematodes (10 to 526 nematodes/sample). One sample of approximately 100,000 liters collected on 28 September 1989 contained three immature females of the reniform nematode. No other plant-parasitic nematodes were observed in these samples.

In the greenhouse test comparing water sources (resaca vs. city tap water) and pot placement (raised benches vs. on the

ground), low numbers of reniform nematodes were observed in all treatments and on all plants except *Radermachera sinica* (Table 1). Population densities did not increase during the course of this experiment, and there was no effect of water source or pot placement on reniform population density.

Thirty-one percent of the samples of rooted cuttings were infested with plant-parasitic nematodes (Table 2). Seven of the nine plant species examined were infested. Reniform nematodes were found in one shipment of *Spathiphyllum* sp. *Pratylenchus* was the most commonly occurring genus; other genera detected were *Meloidogyne, Helicotylenchus,* and *Tylenchorhynchus.*

Host status: Eight of the 17 ornamental plant species supported a population density of reniform nematodes that was equal to or greater than that of the susceptible Rutgers tomato (Table 3). There was a clear separation of good hosts (those species with a reproduction factor of ≥ 1.4) from poor hosts (those species with a reproduction factor of ≤ 0.4) in this test.

TABLE 3. Reproduction of *Rotylenchulus reniformis* on ornamental foliage plants in a greenhouse test.

Plant species	Nematodes/ 100 cm³	RF†
Chlorophytum comosum variegatum	627	3.73
Ficus elastica robusta	489	2.91
Philodendron selloum	468	2.78
Brassaia actinophylla	261	1.55
Radermachera sinica	261	1.55
Sansevieria trifasciata	256	1.52
Beaucarnea recurvata	254	1.51
Lycopersicon esculentum	250	1.49
Brassaia arboricola	236	1.40
Dracaena draco	55	0.33
Asparagus densiflorus sprengeri	36	0.21
Ficus lyrata	12	0.07
Scindapus aureus	10	0.06
Ficus benjamina	9	0.05
Codiaeum variegatum pictum	7	0.06
Chamaedorea elegans	2	0.02
Syngonium podophyllum albovirens	1	0.01
Dieffenbachia compacta	1	0.01
LSD ($P = 0.05$)	232	0.91

Values are means of eight replications; initial inoculum concentration was 168 mixed life stages of *R. reniformis* per 100 cm³.

† RF = reproductive factor = final density divided by initial density.

DISCUSSION

Although the resaca, a major source of water for commercial greenhouses in the LRGV, was found to be contaminated with reniform nematodes, it is difficult to estimate the importance of this source of inoculum. Given that the nematode was detected once at a low population density, the probability of a reniform nematode population becoming established in a greenhouse when as few as 30 nematodes per day ([3 nematodes/10^5 liters] × [10^6 liters/day]) are being introduced into the greenhouse is unknown. When one considers that there are several thousand pots in most commercial greenhouses, many of which will contain poor hosts or nonhosts, it is likely that the nematode would have to be introduced on numerous occasions before it would become established. The probability of the nematode becoming established in a greenhouse would increase with increasing levels of the nematode in the resaca. It is likely that the levels of nematodes in the resaca would be influenced by proximity to reniform-infested fields, the frequency and duration of run-off events from the infested fields, and the nematode population density in the field at the time of the run-off event.

An additional factor influencing the probability of reniform nematodes becoming established in a greenhouse is the host status of the plants being grown. Only 8 of 17 species tested were good hosts of reniform nematode in this study. The relatively low total reproduction on tomato, the susceptible standard, may have been due to the cool greenhouse temperatures, or the potting medium may not have been optimal for nematode reproduction. Optimal temperature for reproduction of reniform nematode on soybean is 25–29 C (10).

Because no difference due to treatment was observed in the greenhouse test on ef-

fect of water source and pot placement, it was concluded that the plants used were contaminated prior to initiation of the test. Subsequent examination of rooted cuttings purchased from other commercial sources found these to be a source of inoculum of reniform and other nematodes. The most surprising aspect of this finding was that the cuttings contaminated with plant-parasitic nematodes were propagated by tissue culture techniques. Such cuttings, under normal production systems, may be maintained in a greenhouse for up to two months before being shipped to a finishing operation such as those in the LRGV. This is apparently sufficient time for the cuttings to become infested with plant-parasitic nematodes.

Reniform nematode contamination of final products is a serious problem for the producers of greenhouse-grown ornamental foliage plants in the LRGV, especially those attempting to satisfy markets in other states. Two sources of inoculum for contamination of greenhouses in the LRGV were identified. To prevent introduction of nematodes via the resaca water, some growers are installing water filtration systems with an exclusion limit of 5 μm. It should be possible to prevent introduction of nematodes on rooted cuttings by instituting a rigorous inspection system. This should eventually induce primary producers of cuttings to work to eliminate nematode contamination from their production systems.

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