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Response of Some Common Annual Bedding Plants to Three Species of *Meloidogyne*[1]

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Abstract: Twelve ornamental bedding plant cultivars were grown in soil infested with isolates of *Meloidogyne incognita* race 1, *M. javanica,* or *M. arenaria* race 1 in a series of tests in containers in a growth room. Root galling (0–5 scale) and eggs/plant were evaluated 8–10 weeks after soil infestation and seedling transplantation. Snapdragon, *Antirrhinum majus* cv. First Ladies, was extensively galled and highly susceptible (mean gall rating ≥4.2 and ≥14,500 eggs/plant), and *Celosia argentea* cv. Century Mix and *Coleus blumei* cv. Rainbow were susceptible (>1,500 eggs/plant) to all three *Meloidogyne* isolates. Response of *Petunia* × *hybrida* varied with cultivar and nematode isolate. Little or no galling or egg production from any *Meloidogyne* isolate was observed on *Ageratum houstonianum* cv. Blue Mink, *Lobularia maritima* cv. Rosie O'Day, or *Tagetes patula* cv. Dwarf Primrose. Galling was slight (mean rating ≤2.0) but varied with nematode species on *Dianthus chinensis* cv. Baby Doll Mix, *Salvia splendens* cv. Bonfire, and *Vinca rosea* cv. Little Bright Eye. *Verbena* × *hybrida* cv. Florist was heavily infected (gall rating >4.0 and ≥7,900 eggs/plant) by *M. javanica* and *M. arenaria* but was nearly free of galling from *M. incognita. Zinna elegans* cv. Scarlet was nearly free of galling from *M. incognita* and *M. arenaria* but was susceptible (mean gall rating = 2.9; 3,400 eggs/plant) to *M. javanica.*

Key words: Ageratum houstonianum, Antirrhinum majus, Celosia argentea, Coleus blumei, Dianthus chinensis, flowers, *Lobularia maritima, Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica,* nematode, ornamental, *Petunia* × *hybrida, Salvia splendens, Tagetes patula, Verbena* × *hybrida, Vinca rosea, Zinnia elegans.*

Annual ornamentals are widely used in outdoor plantings in Florida and other southeastern states. Relatively little is known about their susceptibility to plant-parasitic nematodes, particularly root-knot nematodes (*Meloidogyne* spp.), which are a major problem on agricultural crops in the region. The susceptibility of bedding plants to root-knot nematodes must be recognized to avoid damage or unintentional buildup of high nematode population densities.

Of the bedding plants commonly used in Florida, marigolds (*Tagetes* spp.) have been the most studied nematologically. Marigolds can be effective in reducing population densities of root-knot nematodes (2,4, 7,12), yet efficacy varies with nematode species and marigold cultivar (12–14). Several nematicidal compounds have been isolated from marigolds (8,9).

Much less information is available on the response of other bedding plants to *Meloidogyne* spp. Zinnia (*Zinnia elegans*) exhibited some galling in response to *M. incognita,* but galling incidence increased when *Z. elegans* was infected with Zinnia mosaic virus (11). Snapdragon (*Antirrhinum majus*) is a suitable host for some species of root-knot nematodes (16) and may show wilting or other damage symptoms (6). Coleus (*Coleus blumei*) and celosia (*Celosia argentea*) can be so severely damaged by root-knot nematodes that chemical control has been considered as an option (1,3). Goff (6) conducted extensive studies of the relatively susceptibilities of annual bedding plants to root-knot nematodes, but unfortunately his work was conducted at a time when the species and races of root-knot nematodes were unknown. Very recently, Walker et al. (18) examined the effects of *M. incognita* race 3 on 32 cultivars representing 10 different bedding plant species.

The objective of our research was to determine the response of several bedding plants commonly grown in north Florida

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to isolates of three root-knot nematodes: *M. incognita* race 1, *M. javanica,* and *M. arenaria* race 1.

Materials and Methods

Three separate experiments were conducted, each with a different *Meloidogyne* isolate. The bedding plants used represented several plant families and, in a previous study (6), showed a range of susceptibility to an unknown species of root-knot nematode (Table 1). Individual seeds were planted in 5-cm × 5-cm plastic trays in a mix of ⅔ builder's sand and ⅓ steam sterilized soil (92% sand, 3% silt, 5% clay; pH 6.0; 1.3% organic matter). One to 3 weeks after planting, seedlings were transplanted (one/pot) into the same soil mix in 12.5-cm-d plastic pots with a capacity of approximately 825 cm^3 soil. One week after transplanting, the soil was infested with *Meloidogyne* second-stage juveniles (J2).

Root-knot nematode isolates were maintained in a greenhouse on tomato (*Lycopersicon esculentum* cv. Rutgers). Nematode isolates were developed from single egg masses collected several years earlier from various sites in Florida. The identity of each isolate was verified with a differential host test (17). Four days before initiation of an experiment, eggs of a given nematode isolate were extracted from tomato roots in 0.525% NaOCl (10). Extracted eggs were incubated at 22 C on modified Baermann trays (15) for collection of J2, which were delivered into two holes (2 cm deep) in the soil at the base of the plant.

Nematode inoculum densities and starting times of the three experiments varied. Pots infested with *M. incognita* race 1 each received 1,500 J2 on 11 January 1993 and were harvested 8 March. The *M. javanica* experiment began on 16 March with 500 J2/pot and was terminated on 25 May. The test with *M. arenaria* was initiated 10 June with 500 J2/pot and was harvested 19 August.

Depending on the experiment, 11 or 12 bedding plant genera replicated five or six times were used. In all cases, pots were arranged on raised benches in a randomized complete block design and maintained in a temperature-controlled growth room at 24 ± 1 C. Plants were maintained on a 14-hour light and 10-hour dark photoperiod at a light intensity of 9,700 lux. Plants were

Table 1. Ornamental bedding plants used in inoculation experiments with *Meloidogyne incognita* race 1, *M. javanica,* or *M. arenaria* race 1.

Bedding plant	Common name	Cultivar†	Family	Source‡	Previous rating of infections§
Ageratum houstonianum	Ageratum	Blue Mink	Compositae	Northrup-King	None
Antirrhinum majus	Snapdragon	First Ladies	Scrophulariaceae	Ferry-Morse	Heavy
Celosia argentea	Celosia	Century Mix	Amaranthaceae	Northrup-King	Very heavy
Coleus blumei	Coleus	Rainbow	Labiatae	Ferry-Morse	Heavy
Dianthus chinensis	Dianthus	Baby Doll Mix	Caryophyllaceae	Northrup-King	Light
Lobularia maritima	Alyssum	Rosie O'Day	Cruciferae	Northrup-King	Very light
Petunia × hybrida	Petunia	Dwarf Bedding‖	Solanaceae	Ferry-Morse	Light
Salvia splendens	Scarlet sage, salvia	Bonfire	Labiatae	Northrup-King	Very light
Tagetes patula	Marigold	Dwarf Primrose	Compositae	Burpee	None
Verbena × hybrida	Verbena	Florist	Verbenaceae	Ferry-Morse	Light
Vinca rosea	Periwinkle	Littke Bright Eye	Apocynaceae	Northrup-King	Very light
Zinnia elegans	Zinnia	Scarlet	Compositae	Northrup-King	Very light

† Cultivars used in the present experiments. Cultivars have no relationship to the last column in this table, because cultivars were not identified in a previous test (6).

‡ Seed sources: Northrup-King Lawn and Garden Co., Minneapolis, MN; Ferry-Morse Seed Co., Fulton, KY; W. Atlee Burpee and Co., Warminster, PA.

§ Infection of the plant species rated in tests by Goff (6), but plant cultivars and root-knot nematode species were not identified.

‖ *Petunia × hybrida* cv. Color Parade Hybrid Mix (Northrup-King) was used in the test with *Meloidogyne incognita* instead of cv. Dwarf Bedding.

watered as needed and fertilized every 2 weeks with 3.8 g/liter of a 20:20:20 (total $N:P_2O_5:K_2O$) soluble fertilizer. No pesticides were applied during these experiments.

At the harvest of each experiment, root systems were washed free of soil, and galls and egg masses were rated on a 0–5 scale: 0 = galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = >100 galls or egg masses per root system (17). Four observers rated each plant, and the average root-gall and egg-mass indices were recorded. Because gall and egg mass numbers were similar on almost all plants, only gall indices are reported. Data were subjected to analysis of variance, followed by mean separation (at $P = 0.05$) with Duncan's multiple-range test or the Student-Newman-Keuls test (5). Because mean separations by the two tests were nearly identical, only the Student-Newman-Keuls results are presented. Following ratings of galls and egg masses, the root systems of plants from all replications of each plant genus were combined, and eggs were extracted in 1.05% NaOCl (10) for 1 minute. Because egg data were pooled across replications, they were not analyzed statistically.

Results

Meloidogyne incognita experiment: Ageratum (*Ageratum houstonianum*), marigold (*Tagetes patula*), periwinkle (*Vinca rosea*), and salvia (*Salvia splendens*) were free of galling by *M. incognita* race 1, and galling by this nematode on verbena (*Verbena* × *hybrida*) and zinnia was extremely low (Table 2). Snapdragon and celosia were the most susceptible to *M. incognita.* Despite relatively few galls and egg masses, 1,960 eggs/plant were produced on coleus. In contrast, few eggs (260/plant) of *M. incognita* were produced on petunia (*Petunia* × *hybrida* cv. Color Parade Hybrid Mix) and none on dianthus (*Dianthus chinensis*). Although egg masses present on the other hosts were well-developed, those on petunia appeared less mature (few eggs), and immature females without eggs were observed on dianthus.

Meloidogyne javanica experiment: Ageratum, alyssum (*Lobularia maritima*), and marigold were free of galling from *M. javanica,* and galling on dianthus and periwinkle was very low (Table 2). More than 1,500 eggs/plant were produced on celosia, coleus, petunia, snapdragon, verbena, and

TABLE 2. Root gall indices and eggs per plant on bedding plants grown in soil infested with isolates of *Meloidogyne incognita* race 1, *M. javanica,* or *M. arenaria* race 1.

Bedding plant	*M. incognita* Root-gall rating†	*M. incognita* Eggs/plant‡	*M. javanica* Root-gall rating	*M. javanica* Eggs/plant	*M. arenaria* Root-gall rating	*M. arenaria* Eggs/plant
Ageratum	0 d	0	0 d	0	0.04 d	0
Alyssum	—	—	0 d	0	0 d	30
Celosia	2.80 b	12,900	1.50 c	5,060	3.13 b	13,500
Coleus	0.60 d	1,960	3.00 b	1,660	2.08 c	34,330
Dianthus	1.20 cd	0	0.20 d	60	0.04 d	160
Marigold	0 d	0	0 d	0	0.04 d	30
Periwinkle	0 d	0	0.20 d	20	2.04 c	15
Petunia	2.00 bc	260	0.80 cd	3,120	1.63 c	2,190
Salvia	0 d	0	0.10 d	1,000	—	—
Snapdragon	4.20 a	26,140	4.95 a	14,500	4.25 a	15,420
Verbena	0.20 d	100	4.06 a	7,900	4.42 a	60,670
Zinnia	0.20 d	200	2.90 b	3,400	0.04 d	70

† Root galling was rated on a 0–5 scale: 0 = 0 galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 = >100 galls per root system (17). Gall rating data are means of five (*M. incognita, M. javanica*) or six (*M. arenaria*) replications. Means in columns followed by the same letter do not differ ($P \leq 0.05$) by the Student-Newman-Keul's test.

‡ Egg numbers are totals extracted from all replications together divided by the number of replications (one plant per replication).

zinnia. Salvia was almost free of egg masses (mean rating = 0.10), but those present contained numerous eggs.

Meloidogyne arenaria experiment: Very low levels of root galling by *M. arenaria* race 1 were observed on ageratum, alyssum, dianthus, marigold, and zinnia (Table 2). Moderate levels of galling (mean ratings = 1.63 to 2.08) occurred on coleus, petunia, and periwinkle, fairly heavy galling (mean rating = 3.13) on celosia, and severe galling (mean rating >4.0) on snapdragon and verbena. More than 60,000 eggs/plant were produced on verbena.

Discussion

It is difficult to compare our results with previous work (6) in which neither root-knot nematode species nor bedding plant cultivars were identified. However, Goff's (6) ratings of susceptibility (Table 1) appear to be closest to our results with *M. incognita* race 1 (Table 2). Our results with *M. javanica* on zinnia and verbena were quite different from those obtained by Goff (6).

Snapdragon, celosia, and coleus were good hosts (>1,500 eggs/plant) for all three of the *Meloidogyne* isolates tested, and petunia was a moderately good host (260–3,120 eggs/plant) to all. In contrast, ageratum, alyssum, and marigold were poor hosts to all isolates. Dianthus, periwinkle, and salvia were generally poor hosts (gall rating ≤2.0; ≤1,000 eggs/plant) but showed some variation depending upon the root-knot nematode species. The responses of verbena and zinnia varied greatly among the three nematode species. It would be necessary to know the species of *Meloidogyne* present in a site before planting zinnia or verbena if nematode buildup and potential damage is a concern. If the *Meloidogyne* spp. present are unknown or a mixed population, then bedding plants such as ageratum, alyssum, or marigold, which were poor hosts to the *Meloidogyne* spp. tested, would be better choices.

Our results provide initial guidelines for selecting bedding plants that minimize buildup from *Meloidogyne* spp. However, our information is limited to only the single cultivar (two for petunia) tested for each of the 12 bedding plant species. These cultivars are widely available and used in Florida, but data are needed on many other cultivars. In addition, many other bedding plant species must be examined for their responses to a range of *Meloidogyne* spp. As such information becomes available, it will become easier to design plantings of bedding plants that can coexist with the root-knot nematodes present in a given site.

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