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Sensitivity of Bedding Plants to Southern Root-knot Nematode, *Meloidogyne incognita* Race 3[1]

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Abstract: Thirty-two cultivars of 10 commonly-grown bedding plants, representing eight families, were evaluated for their response to infection by the root-knot nematode, *Meloidogyne incognita* race 3, under greenhouse conditions. Four ageratum cultivars, two marigold, and two salvia cultivars were rated resistant after exposure for 8 weeks. Four begonia, four celosia, one dianthus, one verbena, one vinca, and three pansy cultivars were susceptible. Three salvia, one begonia, one gerber, one verbena, and three vinca cultivars were slightly susceptible with an average of ≤1 gall per plant. Nematodes, at two initial population densities, affected the dry weights of only a few cultivars. The diversity of annual bedding plant germplasm available may provide adequate sources of resistance to this race of root-knot nematode.

Key words: Ageratum houstonianum, Begonia × *florens, Catharanthus roseus, Celosia plumosa, Dianthus chinensis, Gerbera jamesonii,* nematode, ornamental, resistance, *Salvia splendens, Tagetes erecta, Tagetes patula, Verbena* × *hybrida, Viola wittrockiana.*

Annual bedding plants are one of the major segments of the floriculture industry that has experienced rapid expansion during the last decade. In the United States, their value was nearly $300 million in the early 1980's, but the projected value for the 1990's is in excess of $600 million. A recent magazine survey (4) listed the top four bedding plant firms with sales over $52 million for 1992. In Georgia, bedding plant sales amount to 34% of the state's $154 million floriculture business (6,12).

The popularity of these colorful annuals in the landscape, however, can be diminished by diseases and pests, including root-knot nematodes, *Meloidogyne* spp. Host resistance to pathogens is a major strategy for developing plant health care programs, and only limited information (10), except for marigolds (1,2,5,8) and impatiens (13), is available on susceptibility of bedding plants to root-knot nematodes. Therefore, the objective of this research was to evaluate the sensitivity of 32 commonly-grown bedding plant cultivars to race 3 of the southern root-knot nematode, *Meloidogyne incognita,* one of the most common root-knot species.

Materials and Methods

Each bedding plant cultivar listed in Table 1, except begonia, was seeded directly in three plastic 6-cellpacks (Kord Model 1206, Kord Products Ltd., Brampton, ON, Canada), containing steam-pasteurized soil and Fafard No. 3 mix (Conrad Fafard, Inc., Agawam, MA 01001) (2:1). The dimensions of each cell were 3.8 cm wide × 3.8 cm long × 5.7 cm deep (holds 50 cm^3 of soil mix). Begonia seeds were planted in 7-cm-d plastic pots containing the same mix, then transplanted to the plastic cellpacks at approximately the 2-cm seedling stage. *Meloidogyne incognita* race 3 eggs were obtained from eggplant (*Solanum melongena*) cultivar Black Knight by the sodium hypochlorite method (7). When the seedlings were 4-6 cm tall, nematode eggs were added at two densities: 50 or 200 eggs per cell. Uninfested plants were maintained as controls.

The six cells in each cellpack served as multiple samples and were not considered true replicates. These samples, however, provided the necessary degrees of freedom to test the main effects in the model. Given the space limitations, this was the best experimental design to accommodate all the cultivars. The cultivars (cellpacks) were randomized within the infestation

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TABLE 1. Mean dry weights (mg) per cell† of bedding plant species and cultivars exposed to southern root-knot nematode, *Meloidogyne incognita* race 3, at two infestation levels.

Species	Cultivar	*M. incognita* eggs/50 cm³		
		0	50	200
Ageratum (*Ageratum houstonianum*)	Blue Blazer	1,172 a	1,108 a	1,103 a
	Blue Danube	1,257 a	1,125 a	980 a
	Hawaii White	1,787 a	1,060 b	1,032 b
	Royal Delft	1,453 a	747 a	1,017 a
Begonia (*Begonia* × *florens*)	Cocktail Gin	687 a	550 a	608 a
	Cocktail Vodka	1,118 a	572 a	710 a
	Party Love	304 b	582 a	353 b
	Pizzazz Deep Rose	416 a	268 a	395 a
	Encore White Bronze	388 a	307 b	263 b
Celosia (*Celosia plumosa*)	Apricot Brandy	867 a	837 ab	725 b
	Castle Scarlet	612 a	627 a	855 b
	Fireglow	1,293 a	1,238 a	957 a
	Kimono Cream	473 a	470 a	520 a
Dianthus (*Dianthus chinensis*)	Princess Scarlet	525 a	937 a	740 a
Gerber (*Gerbera jamesonii*)	Nain-Crimson	630 a	355 a	485 a
Marigold (*Tagetes patula* and *T. erecta*)	French, Golden Gate	1,365 a	1,190 a	1,297 a
	Hybrid, Inca Gold	2,087 a	1,692 a	1,733 a
Pansy (*Viola wittrockiana*)	Coronation Gold	450 a	333 a	260 a
	Jolly Joker	1,015 a	823 a	968 a
	Padparadja	810 a	857 a	942 a
Salvia (*Salvia splendens*)	Carabiniere Red	824 a	658 a	763 a
	Hotline Red	1,032 a	963 a	923 a
	Hotline White	1,157 a	1,295 a	1,152 a
	Rhea	1,213 a	962 a	1,078 a
	Victoria Blue	1,077 a	1,060 a	1,175 a
Verbena (*Verbena* × *hybrida*)	Deep Blue	855 a	970 a	915 a
	Showtime Blaze	610 a	830 a	583 a
Vinca (*Catharanthus roseus*)	Carpet Dawn	567 a	535 a	636 a
	Cooler Grape	1,203 a	1,055 a	1,313 a
	Little Blanche	1,035 a	758 b	935 ab
	Little Delicata	968 a	1,020 a	970 a
	Polka Dot	823 b	1,300 a	978 b

Data are means of six samples (cells) per population level.
Mean values with the same letters across rows are not significantly different ($P = 0.05$) by Duncan's multiple-range test.
† Plants from cell were blotted dry; dry weights were obtained after oven-drying at 70 C for 2 weeks.

levels on benches in a pad-cooled greenhouse with temperatures ranging from 22 to 32 C.

The plants were watered daily and fertilized weekly with 2.5 g/liter of Peters (20-20-20) water soluble fertilizer (Grace-Sierra Horticulture Products Co., Milpitas, CA). Six to 8 weeks following infestation, all plants were removed from each cell, the root systems washed entirely free of the growing medium, and the roots examined under a binocular stereoscope for nematode galling. The number of galls and total number of plants per cell were recorded. Plants from each cell were blotted dry; dry weights were obtained after oven-drying at 70 C for 2 weeks.

After the total number of root-galls was determined for each cultivar at each population density, the mean number of galls per plant was calculated and a simple rating scale devised for the susceptible–resistant response of each cultivar. Bedding plant cultivars that did not develop any root-knot nematode galls were classified as resistant (11); those with a mean value of ≤ 1.0 gall/plant were rated as slightly susceptible, and those with >1.0 galls/plant were rated as susceptible. Data were subjected to analysis of variance and

means were separated by Duncan's multiple-range test.

Results and Discussion

Bedding plants differed significantly in dry weights because different species produce various amounts of vegetative growth. However, the mean dry weights between nematode-infested and uninfested plants of the same cultivar varied ($P = 0.05$) in only six cultivars (Table 1). Although an effort was made to plant the same number of seeds for each cultivar in every cell, slight discrepancies were found in the number of plants at the end of the experiment. Therefore, any significant differences in plant dry weights between the uninfested and infested series should be considered with caution because of different plant populations (Table 2).

Cultivars varied significantly ($P = 0.01$) in their susceptibility to the root-knot nematode at initial population densities of 50 and 200 nematode eggs per cell (1 and 4 eggs/cm^3) (Table 2). All four cultivars of ageratum, two cultivars of marigold, and two cultivars of salvia were ranked as re-

Table 2. Mean number of root galls and infection ratings for bedding plant species and cultivars exposed to southern root-knot nematode, *Meloidogyne incognita* race 3, at two infestation densities.

		Mean no. galls (*M. incognita*/50 cm^3)		Rating (*M. incognita*/50 cm^3)	
Plant	Cultivar	50	200	50	200
Ageratum	Blue Blazer	0.0 f†	0.0 f	R (26)‡	R (27)
	Blue Danube	0.0 f	0.0 f	R (29)	R (28)
	Hawaii White	0.0 f	0.0 f	R (30)	R (23)
	Royal Delft	0.2 f	0.0 f	R (29)	R (31)
Begonia	Cocktail Gin	0.7 fe	5.0 de	SL (18)	S (14)
	Cocktail Vodka	0.0 f	0.5 f	R (12)	SL (17)
	Party Love	1.8 cdef	3.5 de	SL (12)	S (13)
	Pizzazz Deep Rose	0.7 fe	2.5 ef	SL (09)	S (12)
	White Bronze	2.3 bcdef	5.8 cde	SL (19)	S (14)
Celosia	Apricot Brandy	3.5 bcd	10.8 b	S (28)	S (29)
	Castle Scarlet	2.2 bcdef	6.5 cd	S (26)	S (28)
	Fireglow	6.8 a	17.5 a	S (30)	S (29)
	Kimona Cream	4.0 b	11.8 b	S (23)	S (20)
Dianthus	Princess Scarlet	1.3 cdef	5.7 cde	S (11)	S (10)
Gerbera	Nain-Crimson	0.5 ef	0.5 f	SL (06)	SL (03)
Marigold	Fr. Golden Gate	0.0 f	0.0 f	R (26)	R (25)
	Hyb. Inca Gold	0.0 f	0.0 f	R (29)	R (23)
Pansy	Coronation Gold	1.0 ef	5.5 cde	SL (16)	S (07)
	Jolly Joker	3.0 bcde	5.3 cde	S (45)	S (26)
	Padparadja	3.7 bc	8.8 bc	S (24)	S (16)
Salvia	Carabiniere Red	0.0 f	0.3 f	R (16)	SL (19)
	Hotline Red	0.0 f	2.3 ef	R (25)	SL (25)
	Hotline White	0.5 ef	0.7 f	SL (29)	SL (20)
	Rhea	0.0 f	0.0 f	R (26)	R (28)
	Victoria Blue	0.0 f	0.0 f	R (24)	R (22)
Verbena	Deep Blue	0.2 f	2.7 ef	SL (19)	SL (20)
	Showtime Blaze	2.7 bcde	4.5 de	S (07)	S (04)
Vinca	Carpet Dawn	0.5 ef	2.8 ef	SL (17)	SL (14)
	Cooler Grape	0.7 ef	5.0 de	SL (30)	SL (23)
	Little Blanche	0.5 ef	0.7 f	SL (29)	SL (30)
	Little Delicata	1.2 def	1.0 f	SL (22)	SL (22)
	Polka Dot	0.0 f	0.7 f	R (36)	SL (24)

† Mean number of galls per six samples. Mean values with the same letters within columns are not significantly different ($P = 0.05$) by Duncan's multiple-range test.

‡ Rating based on mean number of galls per plant: R = none (resistant); SL = ≤1.0 per plant (slightly susceptible); S = ≥1.0 per plant (susceptible). Total number of plants observed given in parentheses.

sistant to *M. incognita* race 3 because no galls were observed at either infestation level after 8 weeks of growth. At the highest infestation level, certain cultivars of vinca (Carpet Dawn and Little Delicata), begonia (cv. Cocktail Vodka), gerbera (cv. Crimson), and salvia, (cv. Carabinere Red) did not differ ($P = 0.05$) from three resistant species (ageratum, marigold, salvia) when the mean number of galls were compared with Duncan's multiple-range test. The fact that several of these bedding plants were rated resistant at the lowest and slightly susceptible at the highest infestation level suggests that similar relationships between nematode reproduction and population density, as proposed by Seinhorst (9) for other hosts, may also exist for these bedding plants. However, since the criterion used for classifying plants as resistant was the complete absence of galls, the above-mentioned cultivars were rated as slightly susceptible.

Although root-knot nematodes are the most widespread and destructive of all pathogenic nematodes, causing a 5 to 10% loss in major crops, their effects on bedding plants in one growing season may be considered minimal. Obviously, repeated planting of susceptible cultivars in the same location could increase nematode populations to levels that could adversely affect growth and flowering. Conversely, use of resistant cultivars over several seasons, in areas known to be infested, may lower nematode populations and result in better plant responses. However, complete reliance on this principle for nematode control may be conducive to other diseases or encourage selection of virulent nematode populations (3).

Our finding that approximately 25% of the cultivars evaluated were resistant to this race of *M. incognita* is comparable to the 30% given by Singh and Majeed (10), who evaluated 50 flowering annuals for their reaction to an unknown race of *M. incognita*. They suggested that those varieties with resistance could serve as breeding material from which to develop resistant varieties. More genera and cultivars should be evaluated against known races of the most common root-knot species before the breeding of new lines for commercial distribution begins. The diminishing emphasis on chemicals for nematode control because of environmental concerns increases the need for information on resistance by plant breeders, landscapers, extension personnel, and home gardeners.

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