Host Suitability and Parasitism of Selected Strawberry Cultivars by *Meloidogyne hapla* and *M. incognita*

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ABSTRACT

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The relative susceptibility of 12 strawberry cultivars to *Meloidogyne hapla* and *M. incognita* was evaluated in the greenhouse. *M. hapla* parasitized and reproduced on all cultivars. Sumner, Albritton, Earlibelle, and Tennessee Beauty suffered biomass reduction in association with egg production. Earliglow may have some tolerance to *M. hapla*. None of the cultivars tested were parasitized by *M. incognita*. An undescribed *Meloidogyne* sp. was found on Sunrise planting stock. Sunrise roots parasitized with the unknown *Meloidogyne* sp. were parasitized by *M. incognita* after inoculation.

Additional key words: *Fragaria* × *ananassa*, resistance, root-knot nematode

Meloidogyne spp. causes one of the most destructive diseases of strawberry (*Fragaria* × *ananassa* Duch.) (14) and has been of major concern across the United States (1,3). Aboveground symptoms include wilting during hot days, stunting, and chlorosis, and fruit yields are substantially suppressed. Root galls, the diagnostic symptom, are formed near the root tips, and abundant branching occurs at and above the galls. Disease control measures include preplant soil fumigation, planting nematode-free plant stock, weed control, and good cultural practices (3,5,11).

The principal root-knot nematode parasitizing strawberry is *Meloidogyne hapla* Chitwood (4,5,9,12,15). *M. incognita* (Kofoid & White) Chitwood, *M. javanica* (Treub) Chitwood, and *M. arenaria* (Neal) Chitwood could not successfully establish a host-parasitic relationship in the United States (15), but *M. javanica* did infect this plant in Israel (13,16) and Zimbabwe (10). We present information on the relative susceptibility of selected strawberry cultivars to *M. hapla* and *M. incognita*.

MATERIALS AND METHODS

Twelve of the most widely grown North Carolina strawberry cultivars were obtained from J. M. Goodson, certified grower, Mt. Olive, NC. Plants were transplanted into 10-cm-diameter clay pots containing a sterilized mixture of builder's sand-soil (1:1, v/v). Plants were watered daily, and a 20-20-20 (NPK) soluble fertilizer (W. R. Grace & Co., Allentown, PA) was applied weekly at about 2.5 g/L of water (100 ml/pot). Greenhouse temperatures were maintained at 25–30 C with a 15-hr photoperiod.

Inoculum of *M. hapla* and *M. incognita* came from infected tomatoes (*Lycopersicon esculentum* Mill. 'Rutgers') maintained in continuous culture in a greenhouse. Eggs of *M. hapla* and *M. incognita* were extracted from the tomato roots using an NaOCl method (8). One week after the strawberry plants were transplanted, the upper third of potting soil was removed, 100 ml of water containing 5,000 eggs was applied to the soil containing roots, and the soil was replaced. The experimental design was a 14 × 3 factorial test arranged in a randomized complete block with six replicates. Total plant fresh weight, root fresh weight, number of galls and eggs per root system (8), and number of juveniles

Table 1. Biomass production (g) of 11 strawberry cultivars parasitized by *Meloidogyne hapla*

	Fresh plant weight (g)		Fresh root weight (g)	
Cultivar	Control	*M. hapla*	Control	*M. hapla*
Albritton	48.1	32.1	29.8	21.8[a]
Apollo	38.1	32.7	17.4	15.8
Atlas	37.9	28.1[a]	19.4	16.3
Catskill	15.7	15.4	10.5	10.5
Delite	37.7	28.8	16.8	15.0
Earlibelle	46.5	30.0[b]	29.3	19.2[b]
Earliglow	65.8	49.4	42.1	31.8
Prelude	28.2	27.6	14.3	15.2
Sumner	57.4	38.3[b]	29.8	20.2[a]
Surecrop	45.9	28.8[b]	26.8	17.4[b]
Tennessee Beauty	37.7	23.0[a]	19.8	12.8[b]

[a] Significant at $P = 0.05$.
[b] Significant at $P = 0.02$.

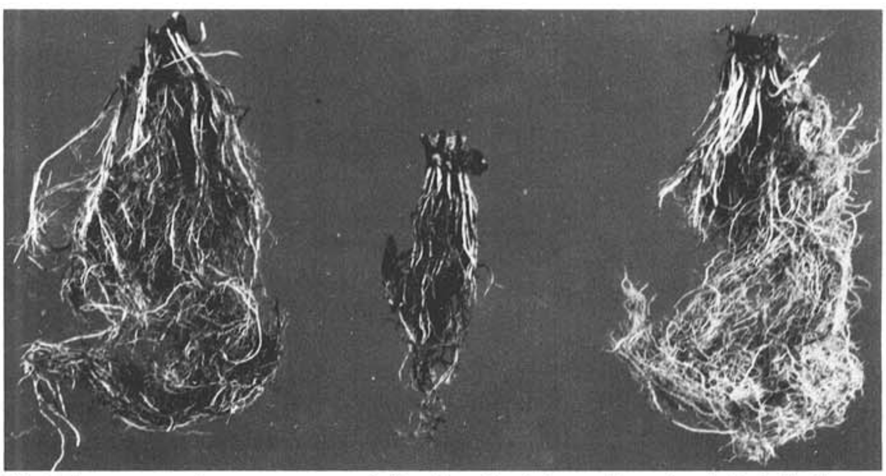

Fig. 1. Surecrop strawberry root systems (left) uninoculated, (center) inoculated with *Meloidogyne hapla*, and (right) inoculated with *M. incognita*.

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Table 2. Host suitability of 11 strawberry cultivars to *Meloidogyne hapla*[w]

Cultivar	Mean no. of galls[x]	Cultivar	Mean no. of eggs[y]	Cultivar	Mean no. of juveniles[z]
Earlibelle	622 a	Albritton	16,593 a	Earlibelle	1,652 a
Albritton	491 b	Sumner	13,440 ab	Albritton	1,512 a
Delite	339 c	Apollo	10,573 bc	Earliglow	933 b
Tennessee Beauty	285 cd	Earlibelle	9,227 bcd	Atlas	778 bc
Catskill	242 cde	Delite	8,673 bcd	Sumner	623 bcd
Prelude	212 def	Tennessee Beauty	6,907 cde	Apollo	578 bcde
Apollo	195 def	Prelude	5,140 def	Surecrop	558 bcde
Atlas	166 ef	Catskill	2,173 efg	Prelude	475 cdef
Earliglow	138 ef	Atlas	1,630 fg	Delite	355 defg
Sumner	120 f	Surecrop	1,165 fg	Tennessee Beauty	245 efg
Surecrop	112 f	Earliglow	793 fg	Catskill	187 fg

[w]Means followed by same letter are not significantly different ($k = 100$) according to Waller-Duncan k-ratio t test.
[x]Mean number of galls per root system ($P = 0.01$).
[y]Mean number of extracted eggs per root system ($P = 0.01$).
[z]Mean number of extracted juveniles from potting soil ($P = 0.01$).

per pot (2) were determined 3 mo after transplanting. Data were subjected to analysis of variance. A paired t test was performed for testing differences between control and treatment biomass. The Waller-Duncan k-ratio t test was applied for testing differences in gall, egg, and juvenile production.

Sasser (15) rated susceptibility of various strawberry cultivars, among them Catskill, on the basis of abundance of mature females and egg masses. Our study expanded this approach by observing differences in plant biomass production and host suitability. Catskill was included as a susceptible check.

Table 3. Mean number of galls and eggs produced by *Meloidogyne hapla* per gram of strawberry root[z]

Cultivar	Mean no. of galls/g of root	Cultivar	Mean no. of eggs/g of root
Earlibelle	32 a	Albritton	761 a
Catskill	23 b	Apollo	669 ab
Delite	23 b	Sumner	665 ab
Albritton	22 b	Delite	578 ab
Tennessee Beauty	22 b	Tennessee Beauty	540 bc
Prelude	14 c	Earlibelle	480 bcd
Apollo	12 c	Prelude	338 cde
Atlas	10 cd	Catskill	207 de
Surecrop	6 d	Atlas	100 e
Sumner	6 d	Surecrop	67 e
Earliglow	4 de	Earliglow	25 e

[z]Means followed by same letter are not significantly different ($k = 100$) according to Waller-Duncan k-ratio t test.

RESULTS AND DISCUSSION

M. hapla parasitized and reproduced on all cultivars tested. This reproduction was associated with damage to Sumner, Albritton, Earlibelle, Surecrop (Fig. 1), Atlas, Delite, and Tennessee Beauty (Table 1). Inoculated Earliglow plants produced more biomass than most uninoculated cultivars. Biomass production of Catskill and Prelude was unaffected by the nematode.

Host suitability ranged from poor to excellent (Tables 2 and 3). Generally, southern cultivars supported a higher level of *M. hapla* reproduction than northern cultivars. Of the southern cultivars, Sumner, Albritton, Earlibelle, and Tennessee Beauty suffered biomass reduction in association with egg production. In addition, Albritton and Earlibelle sustained among the most severe galling and supported the highest numbers of juveniles. Biomass production in Atlas was suppressed and allowed little egg production. The biomass of Apollo was relatively unaffected by the nematode, but reproduction by *M. hapla* was high. This cultivar's reaction fits the definition of tolerance. The northern cultivars, Catskill, Earliglow, and Surecrop, supported relatively low egg production, particularly Earliglow. Delite, however, sustained high egg production.

None of the cultivars tested was a host for *M. incognita*. Sunrise plants were contaminated by an undescribed *Meloidogyne* sp. at the end of this study. Speciation of the *Meloidogyne* sp. is being attempted. *M. incognita* and *M. hapla* also were identified in galls interspersed on Sunrise roots in pots inoculated with these nematodes. This phenomenon may be an interaction whereby infection by one root-knot species (the unknown *Meloidogyne* sp.) will allow infection by another species (*M. incognita*) that normally does not parasitize strawberry. Tobacco (*Nicotiana tabacum* L. 'NC95'), for instance, loses its resistance to race 1 of *M. incognita* after infection with *M. arenaria* or *M. hapla* (7). Factors involved with overcoming immunity as opposed to resistance are unknown.

Dickstein and Krusberg (6) rated the responses of 33 strawberry cultivars to *M. hapla* on the basis of a root galling index. The results of our study and that of Szczygiel (17) indicate that such ratings may be misleading. A cultivar with moderate galling per gram of root (Apollo) showed no significant weight change, whereas others with light galling per gram of root (Sumner, Surecrop) responded with significant weight reductions.

The successful infection of these strawberry cultivars by *M. hapla* provides a major impetus for adequate root-knot management programs. Results suggest that use of Earliglow or Apollo would be advantageous in an integrated pest control program, whereas Sumner, Albritton, Earlibelle, Tennessee Beauty, Atlas, Delite, and Surecrop may be less productive in infested fields. The possibility of a new *Meloidogyne* sp. interacting with strawberries followed by possible loss of immunity to other *Meloidogyne* sp. lends importance to the use of nematode-free planting stock. Further tests should be conducted to determine if *M. hapla* or another species can cause an immune strawberry cultivar to be infected by a species that is normally a nonparasite.

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