Host Status of Selected Peach Rootstocks to *Meloidogyne mayaguensis*

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Abstract. Six commonly known peach rootstocks (i.e., Flordaguard, Guardian®, Halford, Lovell, Nemaguard, and Okinawa) were evaluated for their susceptibility to *Meloidogyne mayaguensis* in the greenhouse. All rootstocks were rated as either nonhosts (highly resistant) or poor hosts (resistant) of *M. mayaguensis*. Lovell generally supported greater numbers of *M. mayaguensis* eggs per plant and eggs per gram of dry root, whereas no nematode reproduction was noted on Flordaguard rootstock (nonhost). Root galling occurred on all six rootstocks. However, reproduction as measured by number of egg masses, eggs per plant, and eggs per gram of dry root was a better measure of host resistance than number of root galls per plant.

Root-knot nematodes (*Meloidogyne* spp.) are an important pathogen of peach [*Prunus persica* (L.) Batsch] in the United States. The three major *Meloidogyne* spp. [*M. arenaria* (Neal) Chitwood, *M. incognita* (Kofoid & White) Chitwood, and *M. javanica* (Treub) Chitwood] have been reported to cause damage to stone fruits in different parts of the world, but *M. incognita* and *M. javanica* are the predominant species reported on peach and plum. In a survey of South Carolina peach orchards, *M. incognita* and *M. javanica* were found in 95% and 5% of orchards sampled, respectively (Nyczepir et al., 1997). The Northern root-knot nematode, *M. hapla* Chitwood, develops poorly on *Prunus* spp. (Esmenjaud et al., 1994).

Meloidogyne mayaguensis Rammah and Hirschmann was originally obtained from galled roots of eggplant (*Solanum melongena* L.) from Puerto Rico in 1988 (Rammah and Hirschmann, 1988). In 2001, *M. mayaguensis* was detected in the continental United States

for the first time from samples collected from ornamental nurseries in South Florida (Brito et al., 2004). This highly virulent nematode pathogen is of concern to Florida's agricultural industry, because *M. mayaguensis* has been previously reported in West Africa to cause severe damage on root-knot nematode-resistant soybean 'Forrest' and sweetpotato 'CDH' cultivars (Fargette, 1987; Fargette et al., 1996) and on tomato 'Rossol', which contains the *Mi-1* nematode resistance gene (Prot, 1984). Brito et al. (2004) has since confirmed that *M. mayaguensis* isolates from Florida can also reproduce on tomato containing the *Mi-1* resistance gene. In south Florida, *M. mayaguensis* is known to be well established and to parasitize a number of different agricultural crops, including tropical fruit trees (Anon., 2003; Brito et al., 2004), demonstrating its polyphagous parasitic nature.

Concern with *M. mayaguensis* has arisen because of the increased interest in growing peaches in south and central Florida over the last 2 to 3 years. This renewed interest in growing peaches is the result of the release of new low-chill varieties developed at the University of Florida in Gainesville and because citrus growers are looking for an alternative crop to grow in place of citrus. In recent years, the Florida citrus industry has lost millions of trees to citrus canker (*Xanthomonas axonopodis* pv. *citri*) and is now encountering the more problematic bacteria disease known as citrus greening (*Liberibacter*

asiaticus) (Layden, 2006). Growing peaches in a *M. mayaguensis*-infested site may present a potential problem when trying to establish a new peach orchard, especially if peach is a good host to this new nematode pathogen in Florida. Root-knot nematodes can cause stunted growth, loss of vigor, and early defoliation of 1- to 2-year-old peach trees when recommended management practices are not followed. Furthermore, root-knot nematodes typically do more damage to peach trees grown in sandy soils, common in Florida, than in fine-textured soils found elsewhere in the southeastern United States.

The current preplant nematicide recommendations for managing *Meloidogyne* sp. in peach in the southeastern United States include the soil fumigants, 1,3-D (1,3-dichloropropene) and Vapam (metam sodium) (Horton et al., 2007). These are the only two soil fumigants available to peach growers since the recent ban (according to the 1992 Montreal Protocol) on methyl bromide's importation and manufacture in the United States and western Europe in Jan. 2005 (Clean Air Act, 1990). As a result of pre- and postplant nematicides being removed from the agricultural market, alternatives to chemical control methods are being investigated (i.e., rootstock resistance) (Batchelor, 2002).

In the Southeast, Guardian® peach rootstock is recommended over Nemaguard as the rootstock of choice, because trees on Guardian® rootstock have exhibited resistance/tolerance to select isolates of *Meloidogyne* spp. and have a higher survival rate on peach tree short life sites than Nemaguard (Nyczepir et al., 1999, 2006; Okie et al., 1994). Peach rootstock susceptibility to *M. mayaguensis* is unknown. The objective of this research was to evaluate the host susceptibility of common peach rootstocks to *M. mayaguensis*.

Materials and Methods

Inoculum source and production. A population of *M. mayaguensis* (isolate N01-00304), originally isolated from an unidentified ornamental plant in Florida, and *M. incognita* isolated from peach in Georgia were both maintained on tomato (*Solanum esculentum* Mill. cv. Rutgers) in the greenhouse. Root-knot nematode egg inoculum was extracted from tomato roots using NaOCl solution (Hussey and Barker, 1973).

Host susceptibility. The experiment was conducted in an air-conditioned greenhouse at the USDA-ARS, Southeastern Fruit & Tree Nut Research Laboratory in Byron, GA. Greenhouse facilities were in compliance with APHIS standards in evaluating *M. mayaguensis*. Nine-day-old Flordaguard, Guardian® (i.e., advanced line SC 3-17-7), Halford, Lovell, and Nemaguard peach seedlings or 2-week-old 'Rutgers' tomato were planted in 10-cm diameter plastic pots containing ≈450 cm³ sand-vermiculite medium (50:50 by volume). These particular peach rootstocks were evaluated in this study because of their known host reaction to some of the more common *Meloidogyne* spp. found

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in the Southeast and are summarized in Table 1 (Nyczepir and Beckman, 2000; Nyczepir et al., 1999, 2006; Nyczepir and Esmenjaud, 2007; Nyczepir and Halbrecht, 1993). Tomato was included because it is a known susceptible host to *M. mayaguensis* and to ascertain inoculum viability. Five days later (22 Mar. 2006), plants were inoculated with ≈ 3000 *M. mayaguensis* eggs/450 cm³ of medium. Approximately 1500 eggs were pipetted directly into each of two holes (2.5 cm deep), one on either side of the plant stem. The holes were covered and additional water applied to settle the potting medium around the eggs. Treatments were replicated 10 times in a randomized complete block design on benches in the greenhouse.

Included within the same greenhouse were Nemaguard (known to be resistant) and Lovell (known to be susceptible) peach seedlings inoculated with *M. incognita* eggs. *Meloidogyne incognita* was included to confirm host resistance/susceptibility reaction by a known peach nematode pathogen. Two replications each of 'Rutgers' tomato were inoculated with *M. incognita* eggs to determine inoculum viability.

Peach seedlings were watered daily and fertilized as needed with Osmocote (14N-14P-14K). The greenhouse tempera-

tures ranged from 21 to 37 °C. The study was ended after 114 d (14 July 2006) and the following data were collected: number of egg masses per root system, number of eggs per root system, number of root galls per root system, and dry root weight (dried at 70 °C in aluminum foil until no more loss in weight occurred). Root systems were also rated for number of egg masses produced (Taylor and Sasser, 1978). The egg mass index consisted of a 0 to 5 scale with 0 = no egg masses, 1 = one to two egg masses, 2 = three to 10 egg masses, 3 = 11 to 30 egg masses, 4 = 31 to 100 egg masses, and 5 = more than 100 egg masses. Host susceptibility was determined according to the egg mass index rating scale as follows: 0 = nonhost (highly resistant), 1 to 2 = a poor host (resistant), and ≥ 3 = a good host (susceptible). The test was repeated once. Modifications were made in the second test that included inoculation of 12-day-old peach seedlings with 1000 *M. mayaguensis* or *M. incognita* eggs/450 cm³ of medium and the addition of Okinawa peach rootstock; the study was ended after 115 d after inoculation (i.e., 20 Mar. 2007 to 13 July 2007).

Data were subjected to analysis of variance with the general linear models procedure of SAS (SAS Institute, Cary, NC). For the *M. mayaguensis* tests, appropriate pre-planned single degree-of-freedom comparisons were then used to detect differences between treatment means for 'Rutgers' tomato versus combined peach rootstock means following a significant *F* test. Means within peach rootstocks were analyzed using Fisher's protected least significant difference test. For *M. incognita* tests, analysis of variance was performed to determine rootstock effect on nematode reproduction and root galling. Only significant differences ($P \leq 0.05$) are discussed unless stated otherwise.

Results and Discussion

'Rutgers' tomato (known susceptible) supported greater reproduction of *M. maya-*

guensis than all peach cultivars combined as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram of dry root (Table 2). Individual rootstocks would either be rated as highly resistant (nonhost) or resistant (poor host) to *M. mayaguensis* infection based on the number of egg masses recovered (zero to three egg masses), although some rootstocks supported limited reproduction. Lovell (known susceptible to *M. incognita*) generally supported greater reproduction of *M. mayaguensis* than Nemaguard, Guardian®, and Flordaguard as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram of dry root in most of the tests ($P \leq 0.05$) (Table 2). Although differences among Lovell, Nemaguard, Guardian®, and Flordaguard rootstocks were not significant ($P > 0.05$) for number of eggs per plant and eggs per gram of dry root in test 2, greater numbers of eggs per plant and eggs per gram of dry root were detected on Lovell roots than on the other three stocks as observed in test 1. Also, Flordaguard was the only rootstock that did not support *M. mayaguensis* reproduction in both tests. This is of particular interest to the Florida peach industry because Flordaguard is also known to be resistant/tolerant to *M. floridensis* (Nyczepir et al., 2006; Sherman et al., 1991), a root-knot nematode that is known to attack Nemaguard rootstock.

Evaluating peach rootstocks for nematode resistance under greenhouse conditions can be challenging. It can be argued that greenhouse results may not provide a reliable prediction of performance as under field conditions. However, if the appropriate control treatment(s) is included within the greenhouse experiment and results substantiate those of previous reports, then one would have to consider the greenhouse data credible.

Lovell (known to be susceptible) supported greater reproduction of *M. incognita* than Nemaguard (known to be resistant) as indicated by number of egg masses per plant, number of eggs per plant, and number

Table 1. Reaction of peach rootstocks to root-knot nematode (*Meloidogyne* spp.).^z

Rootstock	Nematode ^y			
	Ma	Mi	Mj	Mf
Flordaguard	— ^x	R	—	R ^w
Guardian®	—	R	R/S	S
Halford	—	S ^v	—	—
Lovell	S	S	S	S
Nemaguard	R	R	R/S	S
Okinawa	R	R	R	S

^zNyczepir and Beckman, 2000; Nyczepir et al., 1999, 2006; Nyczepir and Esmenjaud, 2007; Nyczepir and Halbrecht, 1993.

^yMa = *Meloidogyne arenaria*; Mi = *M. incognita*; Mj = *M. javanica*; Mf = *M. floridensis*.

^x— = unknown reaction.

^wHost reaction: R = resistance; S = susceptible.

^vA. P. Nyczepir, personal communication.

Table 2. Susceptibility of selected peach and tomato cultivars to *Meloidogyne mayaguensis* and (or) *M. incognita* grown in the greenhouse after 114 (test 1) and 115 d (test 2), respectively (n = 10).^z

Plant species ^y	Cultivar	Egg masses per plant		Eggs per				Galls per plant	
		Test 1	Test 2	Plant		Gram of dry root		Test 1	Test 2
				Test 1	Test 2	Test 1	Test 2		
<i>Meloidogyne mayaguensis</i>									
Tomato	Rutgers	20 ^x	79 ^x	57,875 ^x	50,500 ^x	168,490 ^x	58,847 ^x	75 ^x	100 ^x
Peach	Lovell	3 a	2 a	70 a	50 a	34 a	19 a	100 a	81 a
	Halford	2 a	<1 b	45 ab	45 a	26 a	13 a	100 a	44 b
	Nemaguard	<1 b	0 b	5 bc	0 a	2 b	0 a	100 a	9 c
	Guardian [®]	0 b	<1 b	0 c	5 a	0 b	1 a	60 c	15 c
	Flordaguard	0 b	0 b	0 c	0 a	0 b	0 a	77 b	4 c
	Okinawa	— ^w	0 b	—	0 a	—	0 a	—	3 c
	Combined peach	1	<1	24	17	12	6	87	26
<i>Meloidogyne incognita</i> ^v									
Peach	Lovell	25 a	42 a	1,335 a	5,150 a	630 a	1,618 a	99 a	98 a
	Nemaguard	2 b	0 b	30 b	0 b	16 b	0 a	53 b	4 b

^zInitial population density of *Meloidogyne mayaguensis* (FL_N0100304-isolate) and *M. incognita* (GA peach-isolate) in tests 1 and 2 was 3000 and 1000 eggs/450 cm³ sand-vermiculite medium, respectively.

^yMeans within a plant species and column followed by the same letter are not different by least significant difference ($P \leq 0.05$).

^xThe single degree-of-freedom comparison between the means for tomato versus combined peach cultivars was highly significant ($P \leq 0.05$).

^w— = not included.

^vMean separation within columns followed by the same letter are not different by analysis of variance ($P \leq 0.05$).

of eggs per gram of dry root in the two experiments ($P \leq 0.05$) (Table 2). Although differences between the two rootstocks were not significant ($P > 0.05$) for number of eggs per gram of dry root in test 2, greater numbers of eggs per gram of dry root were detected on Lovell roots than on Nemaguard as observed in test 1. The host reaction of Lovell versus Nemaguard rootstock to *M. incognita* in the current tests substantiates previous reports (Nyczepir et al., 1999; Nyczepir and Halbrecht, 1993) indicating that the two rootstocks and *M. incognita* are reliable control treatments under the current greenhouse conditions when evaluating rootstock reaction to *M. mayaguensis*. Reproduction on tomato by *M. incognita* as measured by eggs per plant was 16,250 (test 1) and 28,125 (test 2), thus indicating viable nematode inoculum. It is also important to note that gall formation in Nemaguard roots parasitized by *M. incognita* was more abundant (i.e., 13-fold greater) in test 1 than test 2. Nemaguard is generally resistant to this peach nematode pathogen; however, Brooks and Olmo (1961) noted that 25% of Nemaguard seedlings exhibited some root galling by *M. incognita*. It was later determined that Nemaguard segregates in a ratio of 3 immune to 1 susceptible (Sharpe et al., 1969) partially explaining gall formation on this rootstock. Another possible explanation for increased root galling in test 1 versus test 2 may be the result of differences in soil temperature. It has been reported that more root galls were produced by *M. incognita* in soil temperatures at 30 °C than 25 °C (Wehunt, 1972). It is thought that possibly the mechanism for nematode resistance in Nemaguard is compromised at the higher temperatures. Although daily ambient temperatures were not recorded during the entire experiment, it was noted that the ambient temperatures ranged from 21 to 35 °C, which may have been high enough to allow root gall formation in Nemaguard. It is interesting to note that a similar phenomenon in root galling caused by *M. mayaguensis* was observed in Lovell, Halford, Nemaguard, Guardian®, and Flordaguard in test 1 versus test 2. It is also interesting to note that although *M. mayaguensis* produced root galls on Nemaguard, Guardian®, Flordaguard, and Okinawa, the galls were generally associated with low or undetectable numbers of egg masses, eggs per plant, and (or) eggs per gram of dry root. One possible explanation for increased root galling, but no or low reproduction, may be the result of the inhibition of nematode development and failure of the majority of nematodes to complete the life cycle. Such

a phenomenon was previously reported for *M. javanica* and *M. incognita* on Nemaguard and Guardian® peach, respectively (Meyer, 1977, 1978; Nyczepir et al., 1999). Reproduction as measured by number of egg masses and eggs per plant and eggs per gram of dry root was a better measure of host resistance than number of root galls per plant. Peach appears to be a poor host to *M. mayaguensis*; however, additional long-term field studies are needed to evaluate the effect of different *M. mayaguensis* isolates on growth of Flordaguard in various locations throughout Florida.

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