HOST STATUS OF SELECTED CULTIVATED PLANTS TO *MELOIDOGYNE MAYAGUENSIS* IN FLORIDA

J. A. Brito,[1]* J. D. Stanley,[1] M. L. Mendes,[2] R. Cetintas,[3] and D. W. Dickson[2]

[1]Florida Department of Agriculture and Consumer Services, Division of Plant Industry, P.O. Box 147100, Gainesville, FL 32614-7100, U.S.A; [2]University of Florida, Entomology and Nematology Department, Gainesville FL 32611-0620, U.S.A; and [3]Department of Plant Protection, University of Kahramanmaras Sutcu Imam, Kahramanmaras, 46060, Turkey. *Corresponding author: britoj@doacs.state.fl.us

ABSTRACT

Brito, J. A., J. D. Stanley, M. L. Mendes, R. Cetintas, and D. W. Dickson. 2007. Host status of selected cultivated plants to *Meloidogyne mayaguensis* in Florida. Nematropica 37:65-71.

In 2001, *Meloidogyne mayaguensis* was found for the first time in Florida, where it occurs in 14 counties. In Florida, this root-knot nematode has been found infecting many ornamental plants and has shown the ability to reproduce on plants carrying genes that confer resistance to other root-knot nematode species such as the *Mi-1* gene in tomato and the *N* gene in bell pepper. The reproductive potential and host preference of one *M. mayaguensis* isolate from Florida were assessed in two host range studies carried out in a greenhouse. Fourteen cultivated plants were used in this study. Each plant was inoculated with 5000 eggs. Tomato 'Rutgers' was used as a control for inoculum viability. Good hosts for *M. mayaguensis* were broccoli 'Waltham', cabbage 'Early Jersey', cowpea 'Iron Clay', eggplant 'Black Beauty', horse bean, mustard 'Florida Broad Leaf', okra 'Clemson Spineless', sweet basil, watermelon 'Crimson Sweet', yellow squash 'Crook Neck' and zucchini. Cowpea 'Iron Clay", which is resistant to three root-knot nematode species, was heavily infected by *M. mayaguensis*. Overall gall and egg mass indices for good hosts ranged from 2.8 to 5.0 and 3.3 to 5.0, respectively. Two carrot cultivars ('Royal Chantenay' and 'Imperator') and collard sustained very little or no nematode reproduction.

Key words: herbs, host status, *Meloidogyne mayaguensis*, root-knot nematode, vegetables.

RESUMEN

Brito, J. A., J. D. Stanley, M. L. Mendes, R. Cetintas, y D. W. Dickson. 2007. Susceptibilidad de algunas plantas cultivadas a *Meloidogyne mayaguensis* en Florida. Nematropica 37:65-71.

En 2001, se encontró *Meloidogyne mayaguensis* por primera vez en Florida, en donde se halla en 14 condados. En Florida, se ha observado este nematodo agallador infectando muchas plantas ornamentales y se ha demostrado su habilidad de reproducirse en plantas que contienen genes que confieren resistencia a otros nematodos agalladores, como el gen *Mi-1* en tomate y el gen *N* en pimiento. Se evaluó el potencial reproductivo de un aislamiento de *M. mayaguensis* de Florida en dos estudios realizados en el invernadero. Se utilizaron 14 plantas cultivadas, y se inoculó cada planta con 5000 huevos. Tomate 'Rutgers' fue el control de viabilidad del inóculo. Se encontró que brócoli 'Waltham', repollo 'Early Jersey', caupí 'Iron Clay', berenjena 'Black Beauty', canavalia, mostaza 'Florida Broad Leaf', *Abelmoschus esculentus* 'Clemson Spineless', albahaca, sandía 'Crimson Sweet' y dos variedades de *Cucurbita pepo* fueron buenos hospedantes de *M. mayaguensis*. El caupí 'Iron Clay", resistente a tres otras especies de nematodos agalladores, fue altamente susceptible a *M. mayaguensis*. En general, los índices de agallamiento y de masas de huevos para los hospedantes susceptibles variaron de 2.8 a 5.0 y de 3.3 a 5.0, respectivamente. Dos cultivares de zanahoria ('Royal Chantenay' e 'Imperator') y *Brassica oleracea* var. acephala fueron altamente resistentes.

Palabras clave: hierbas, susceptibilidad, *Meloidogyne mayaguensis*, nematodo agallador, hortalizas.

INTRODUCTION

Meloidogyne mayaguensis Rammah and Hirschmann, 1988 was originally described from eggplant (*Solanum melongena*) collected in Puerto Rico. Pepper (*Capsicum annuum*), tomato (*Lycopersicon esculentum*) and watermelon (*Solanum melongena*) were listed as additional hosts (Rammah and Hirschmann, 1988). Fargette (1987) also reported the occurrence of a root-knot nematode causing severe damage in West Africa to soybean 'Forrest' and sweet potato 'CDH' which are both resistant to *M. incognita* and *M. javanica* (Fargette and Braaksma, 1990). Later, this nematode was identified as *M. mayaguensis* (Fargette *et al.*, 1996). In South America and the Caribbean Islands, this nematode has been reported as a pathogen of many crops including coffee and guava (Carneiro *et al.*, 2001; Decker and Fuentes 1989 Lima *et al.*, 2003; Molinari *et al.*, 2005; Moreira *et al.*, 2003; Rodriguez *et al.*, 2003; Torres *et al.*, 2005a; Torres *et al.*, 2005b; Willers, 1997).

In Florida, *M. mayaguensis* was first found in 2001 infecting unidentified ornamental plants (Brito *et al.*, 2004a). Since then, it has been found infecting several ornamental plants grown in nurseries and greenhouses and also guava, soybean, root-knot nematode susceptible and resistant vegetable crops, as well as weeds (Brito *et al.*, 2004b, c; Cetintas *et al.*, 2005; Levin, 2005; Levin *et al.*, 2004; Mendes *et al.*, 2005).

Knowledge of host status of plant species will be particularly useful in the selection of crops to be used in a crop rotation scheme in infested areas as well as when choosing a cover crop. *Meloidogyne mayaguensis* has the potential to be a very costly and damaging pathogen to Florida agriculture due to its ability to infect plants resistant to other *Meloiodgyne* spp., wide host range and establishment in both agricultural production areas throughout south Florida and many ornamental nurseries. The objectives of this study were to determine the reproductive potential and host preference of one isolate of *M. mayaguensis* from Florida to 14 cultivated plants including vegetable crops important to Florida agriculture. Preliminary results of this study have been reported (Brito *et al.*, 2003).

MATERIALS AND METHODS

An isolate (DPI: N01-00283) of *M. mayaguensis* originally obtained from a field population infecting an unidentified ornamental plant in Broward County, Florida, was used in this study. Nematodes were identified using esterase and malate dehydrogenase phenotypes, mtDNA analysis, and morphology (Brito *et al.*, 2004a). The isolate was reared on tomato 'Rutgers' in steam-pasteurized soil. The plant species and varieties used in this study were *Abelmoschus esculentus* 'Clemson Spineless' (okra), *Brassica oleracea* var. botrytis 'Waltham' (broccoli), *B. oleracea* 'Florida Broad Leaf' (mustard), *B. oleracea* var. acephala (collard), *B. oleracea* var. Esculenta (cabbage), *Canavalia ensiformis* (horse bean), *Citrullus lanatus* 'Crimson Sweet' (watermelon), *Cucurbita pepo* 'Yellow Crook Neck' (yellow squash), *Cucurbita pepo* (zucchini), *Daucus carota* 'Royal Chantenay' (carrot), *D. carota* 'Imperator' (carrot), *Ocimum basilicum* (sweet basil), *Solanum melongena* 'Black Beauty' (eggplant), *Vigna unguiculata* 'Iron Clay' (cowpea). The selected plant species included varieties with introgressed resistance to root-knot nematodes such as 'Iron Clay' cowpea. Tomato 'Rutgers' was used as a control for the viability of the inoculum, which was obtained by extracting eggs of the *M. mayaguensis* isolate from tomato roots using the 0.5% NaOCl method (Hussey and Barker, 1973) modified by Boneti and Ferraz, 1981. Seeds were sown in standard plastic seedling trays containing vermiculite and germinated in a greenhouse. Seedlings were transplanted to 16.0-cm-diam. clay pots containing pasteurized soil (89% sand, 3% silt, 5% clay; pH 6.1, 1.1% organic matter). Seedlings were inoculated with an initial nematode density (Pi) of 5,000 eggs/ plant at 1,000 eggs/ml in 5 equal holes 3.5-4.5 cm deep surrounding the root system. Plant species were set up in a completely randomized design in a greenhouse with six replications. The average temperatures in the greenhouse were 31 ± 3.5 (summer) and 23 ± 2.4°C (winter) for experiments 1 and 2, respectively. Plants were watered daily and fertilized once a week with Peter's fertilizer (20-20-20 with micronutrients) according to the manufacturer's instructions (United Industries Corp., St. Louis, MO). The root systems were collected 51 and 72 days after inoculation for experiments 1 and 2, respectively. At harvest, root systems from each experiment were removed from the pots and carefully washed to remove the soil, and rated for root galling and egg mass on a 0-5 scale, such that 0 = 0 galls or egg masses; 1 = 1-2 galls or egg masses; 2 = 3-10 galls or egg masses, 3 = 11-30 galls or egg masses; 4 = 31-100 galls or egg masses; and 5 = >100 galls or egg masses per root system (Taylor and Sasser, 1978). Eggs were then extracted with 1% NaOCl as described previously. Final number of eggs (Pf) for each plant was calculated and the reproductive factor (Rf = Pf/Pi) determined. Host suitability was designated as follows Rf ≥ 1, good host; (0.1 Rf < 1.0) poor host; Rf ≤ 0.1, non-host (Sasser *et al.*, 1984). This experiment was then replicated following the exact methods to validate the results. The original fourteen species of plants were again tested with the addition of one new species, okra (*Abelmoschus esculentus* 'Clemson Spineless').

Data Analysis

Data were subjected to analysis of variance (ANOVA) and mean separation ($P \leq 0.05$) for root gall and egg mass indices was accomplished using Duncan's multiple range test. The two tests were analyzed separately due to variability observed between them.

RESULTS AND DISCUSSION

Significant differences were observed among the genotypes evaluated in terms of root galling and egg mass indices (Tables 1 and 2). Galls and egg masses were evident on all good hosts. The higher reproductive factor values found in experiment 1 compared to those in experiment 2 are attributed to the higher temperatures in the greenhouse during experiment 1.

Eleven (78%) of the fourteen selected plant genotypes evaluated against *M. mayaguensis* from Florida were good hosts (Rf ≥ 1.0). Good hosts for *M. mayaguensis* were broccoli 'Waltham', cabbage 'Early Jersey', cowpea 'Iron Clay', eggplant 'Black Beauty', horse bean, mustard 'Florida Broad Leaf', okra 'Clemson Spineless', sweet basil, watermelon 'Crimson Sweet', yellow squash 'Crook Neck' and zucchini squash. The tomato ('Rutgers') control in both tests allowed high gall and egg mass indices along with a high nematode reproduction factor, confirming its susceptibility to nematode infection (Tables 1 and 2). Watermelon, a good host in test 1, was not evaluated in test 2 due to the pruning process that lead to the death of all plants.

Carrot 'Royal Chantenay' and 'Imperator' supported very little or no reproduction of *M. mayaguesis*, thus they were classified as poor hosts in test 1 and non-hosts in test 2 (Tables 1 and 2). Likewise, collard was a non-host in test 1 whereas in test 2 it sustained slightly higher produc-

Table 1. Host response of fourteen plant genotypes to *Meloidogyne mayaguensis* as measured by root galling, egg mass and reproduction factor in the greenhouse, experiment 1.

Plant species and cultivar	Common name	Family	Root galling[y]	Egg mass[y]	RF	Host status[z]
Brassica oleracea var. botrytis 'Waltham'	Broccoli	Brassicaceae	3.3 c	4.2 abc	5.80 gh	Good host
Brassica oleracea 'Florida Broad Leaf'	Mustard	Brassicaceae	4.3 ab	3.7 c	12.10 fg	Good host
Brassica oleracea var. Acephala	Collard	Brassicaceae	1.0 e	2.3 d	0.07 h	Non-host
Brassica oleracea var. Esculenta	Cabbage	Brassicaceae	3.3 c	4.0 bc	6.53 fgh	Good host
Canavalia ensiformis	Horse bean	Fabaceae	5.0 a	4.5 ab	34.47 d	Good host
Citrullus lanatus 'Crimson Sweet'	Watermelon	Curcubitaceae	4.2 b	5.0 a	17.24 ef	Good host
Cucurbita pepo 'Yellow Crook Neck'	Yellow squash	Curcubitaceae	4.5 ab	4.2 abc	9.19 fgh	Good host
Curcurbita pepo	Zucchini	Curcubitaceae	4.8 a	5.0 a	26.07 de	Good host
Daucus carota 'Royal Chantenay'	Carrot	Apiaceae	1.8 d	2.2 d	0.79 h	Poor host
Daucus carota 'Imperator'	Carrot	Apiaceae	1.7 de	2.0 d	0.84 h	Poor host
Ocimum basilicum	Sweet basil	Lamiaceae	5.0 a	4.7 ab	31.40 d	Good host
Solanum melongena 'Black Beauty'	Eggplant	Solanaceae	5.0 a	5.0 a	57.27 b	Good host
Vigna unguiculata 'Iron Clay'	Cowpea	Leguminosae	4.8 ab	4.2 abc	45.90 c	Good host
Lycopersicon esculentum 'Rutgers'	Tomato	Solanaceae	5.0 a	5.0 a	79.11 a	Good host

[y]Gall and egg mass indices: 0-5 scale; where 0 = no galls or egg masses, 1 = 1-2 galls or egg masses, 2 = 3-10 galls or egg masses, 3 = 11-30 galls or egg masses; 4 = 31- 100 galls or egg masses, and 5 = >100 galls or egg masses per root system (Taylor and Sasser, 1978).

[z]Host suitability was designated as follows: Rf ≥ 1, good host; 0.1 < Rf < 1.0, poor host; Rf ≤ 0.1, non-host (Sasser *et al.*, 1984).

Data means of six replications. Means within each column with same letter are not different according to Duncan's multiple range test ($P = 0.05$).

tion of egg masses. However, these egg masses contained a very low number of eggs (Tables 1 and 2).

The host preference of the Florida isolate of *M. mayaguensis* differed from that of an isolate (P8) from Cuba, which failed to reproduce on 'Premium' cabbage and broccoli (Rodríguez *et al.*, 2003). The differences in host responses observed between these two studies might be due to the plant cultivar or/and nematode isolates used. In this test, the Florida isolate of *M. mayaguensis* heavily infected horse bean as does *M. incognita* race 1; however, this plant was a non-host for *M. arenaria* race 2 and *M. javanica* (Rodríguez-Kábana *et al.*, 1992). Likewise, 'Black Beauty' eggplant was a good host for *M. mayaguensis* in this study, but a poor host for *M. haplanaria* (Bendezu *et al.*, 2004). 'Iron Clay' cowpea sustained high reproduction of the Florida isolate of *M. mayaguensis* and showed extensive root galls and egg masses in this study (Tables 1 and 2); however, this same cultivar was resistant to *M. arenaria* race 1, *M. incognita*, and *M. javanica* in other studies (McSorley, 1999). 'Iron Clay" cowpea possesses the *Rk gene* which confers resistance to *M. incognita*, *M. javanica*, and *M. hapla* (Fery and Dukes, 1980). The results of this test show that this gene does not protect this cultivar from *M. mayaguensis* infection. Therefore, in areas where one or more of these nematode species

Table 2. Host response of fourteen plant genotypes to *Meloidogyne mayaguensis* as measured by root galling, egg mass and reproduction factor in the greenhouse, experiment 2.

Plant species and cultivar	Common name	Family	Root galling[y]	Egg mass[y]	RF	Host status[z]
Brassica oleracea var. Botrytis 'Waltham'	Broccoli	Brassicaceae	2.8 d	3.5 cde	3.20 de	Good host
Brassica oleracea 'Florida Broad Leaf'	Mustard	Brassicaceae	4.4 a	4.2 abc	5.48 cd	Good host
Brassica oleracea var.acephala	Collard	Brassicaceae	3.0 d	2.8 e	0.89 de	Poor host
Brassica oleracea vr. esculenta	Cabbage	Brassicaceae	3.7 c	3.3 de	4.84 cd	Good host
Canavalia ensiformis	Horse bean	Fabaceae	4.0 bc	4.7 a	12.83 b	Good host
Cucurbita pepo 'Yellow Crookneck'	Yellow squash	Curcubitaceae	4.0 bc	4.5 ab	3.65 de	Good host
Curcurbita pepo	Zucchini	Curcubitaceae	4.5 a	4.5 ab	3.99 de	Good host
Daucus carota 'Royal Chantenay'	Carrot	Apiaceae	0.7	0.2 f	0.01 e	Non-host
Daucus carota 'Imperator'	Carrot	Apiaceae	0.2	0.0 f	0.00 e	Non-host
Ocimum basilicum	Sweet basil	Lamiaceae	3.8 bc	4.0 abcd	3.27 de	Good host
Solanum melongena 'Black Beauty'	Eggplant	Solanaceae	4.8 a	4.7 a	8.63 c	Good host
Vigna unguiculata 'Iron Clay'	Cowpea	Leguminosae	4.8 a	3.7 bcd	3.45 de	Good host
Abelmoschus esculentus 'Clemson Spineless'	Okra	Malvaceae	4.8 a	4.0 abcd	2.67 de	Good host
Lycopersicon esculentum 'Rutgers'	Tomato	Solanaceae	5.0 a	4.3 ab	22.53 a	Good host

[y]Gall and egg mass indices: 0-5 scale; where 0 = no galls or egg masses, 1 = 1-2 galls or egg masses, 2 = 3-10 galls or egg masses, 3 = 11-30 galls or egg masses; 4 = 31-100 galls or egg masses, and 5 = >100 galls or egg masses per root system (Taylor and Sasser, 1978).

[z]Host suitability was designated as follows: $Rf \geq 1$, good host; $0.1 < Rf < 1.0$, poor host; $Rf \leq 0.1$, non-host (Sasser *et al.*, 1984).

Data means of six replications. Means within each column with same letter are not different according to Duncan's multiple range test ($P = 0.05$).

occur together with *M. mayaguensis*, the use of 'Iron Clay' cowpea as cover crop to manage root-knot nematodes should be avoided. An isolate of *M. mayaguensis* from Brazil also reproduced (Rf = 38.93) well on another cultivar of cowpea (IPA-206) (Guimarães *et al.*, 2003).

The results obtained from this and other previously published studies show clearly that *M. mayaguensis* has a wide host range. The plant hosts in our test belong to seven botanical families (Brassicaceae, Fabaceae, Curcubitaceae, Lamiaceae, Leguminosae, Malvaceae, and Solanaceae). Similarly, *M. mayaguensis* from Cuba has been reported parasitizing plants from many families including Curcubitaceae, Chenopodiaceae, Fabaceae, Myrtaceae, Solanaceae, and Umbelliferae (Rodriguez *et al.*, 2003). Our findings, combined with the ability of this nematode to parasitize selected crops with resistance to other *Meloidogyne* spp. and the diminishing availability of effective and environmentally-friendly nematicides, demonstrate the potential economic impact of *M. mayaguensis* to the agricultural industry both in Florida and other regions where it is present.

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