HOST STATUS OF SELECTED CULTIVATED PLANTS TO MELOIDOGYNE MAYAGUENSIS IN FLORIDA

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ABSTRACT


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


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

*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).

*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).
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.

### ACKNOWLEDGMENTS

This project was supported by a TSTAR grant, USDA-CSREES 2005-34135-15895.

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**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.**

<table>
<thead>
<tr>
<th>Plant species and cultivar</th>
<th>Common name</th>
<th>Family</th>
<th>Root galling(^\text{1})</th>
<th>Egg mass(^\text{1})</th>
<th>RF</th>
<th>Host status(^\text{1})</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Brassica oleracea</em> var. Botrytis ‘Waltham’</td>
<td>Broccoli</td>
<td>Brassicaceae</td>
<td>2.8 d</td>
<td>3.5 cde</td>
<td>3.20 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Brassica oleracea</em> ‘Florida Broad Leaf’</td>
<td>Mustard</td>
<td>Brassicaceae</td>
<td>4.4 a</td>
<td>4.2 abc</td>
<td>5.48 cd</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Brassica oleracea</em> var.acephala</td>
<td>Collard</td>
<td>Brassicaceae</td>
<td>3.0 d</td>
<td>2.8 e</td>
<td>0.89 de</td>
<td>Poor host</td>
</tr>
<tr>
<td><em>Brassica oleracea</em> var.esculenta</td>
<td>Cabbage</td>
<td>Brassicaceae</td>
<td>3.7 c</td>
<td>3.3 de</td>
<td>4.84 cd</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Canavalia ensiformis</em></td>
<td>Horse bean</td>
<td>Fabaceae</td>
<td>4.0 bc</td>
<td>4.7 a</td>
<td>12.83 b</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Cucurbita pepo</em> ‘Yellow Crookneck’</td>
<td>Yellow squash</td>
<td>Curcubitaceae</td>
<td>4.0 bc</td>
<td>4.5 ab</td>
<td>3.65 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Curcurbita pepo</em></td>
<td>Zucchini</td>
<td>Curcubitaceae</td>
<td>4.5 a</td>
<td>4.5 ab</td>
<td>3.99 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Daucus carota</em> ‘Royal Chantenay’</td>
<td>Carrot</td>
<td>Apiaceae</td>
<td>0.7</td>
<td>0.2 f</td>
<td>0.01 e</td>
<td>Non-host</td>
</tr>
<tr>
<td><em>Daucus carota</em> ‘Imperator’</td>
<td>Carrot</td>
<td>Apiaceae</td>
<td>0.2</td>
<td>0.0 f</td>
<td>0.00 e</td>
<td>Non-host</td>
</tr>
<tr>
<td><em>Ocimum basilicum</em></td>
<td>Sweet basil</td>
<td>Lamiaceae</td>
<td>3.8 bc</td>
<td>4.0 abcd</td>
<td>3.27 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Solanum melongena</em> ‘Black Beauty’</td>
<td>Eggplant</td>
<td>Solanaceae</td>
<td>4.8 a</td>
<td>4.7 a</td>
<td>8.63 c</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Vigna unguiculata</em> ‘Iron Clay’</td>
<td>Cowpea</td>
<td>Leguminosae</td>
<td>4.8 a</td>
<td>3.7 bcd</td>
<td>3.45 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Abelmoschus esculentus</em> ‘Clemson Spineless’</td>
<td>Okra</td>
<td>Malvaceae</td>
<td>4.8 a</td>
<td>4.0 abcd</td>
<td>2.67 de</td>
<td>Good host</td>
</tr>
<tr>
<td><em>Lycopersicon esculentum</em> ‘Rutgers’</td>
<td>Tomato</td>
<td>Solanaceae</td>
<td>5.0 a</td>
<td>4.3 ab</td>
<td>22.53 a</td>
<td>Good host</td>
</tr>
</tbody>
</table>

\(^\text{1}\)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).

\(^\text{1}\)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 (\(P = 0.05\)).
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Received: 31/X/2006
Accepted for publication: 31/1/2007

Recibido: 
Aceptado para publicación: