# GREENHOUSE EVALUATION OF *NICOTIANA* SPP. FOR RESISTANCE TO ROOT-KNOT NEMATODES[1,2]

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ABSTRACT

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Germplasm from *Nicotiana repanda* - *N. longiflora* × *N. tabacum* (Group 1), *N. repanda* × *N. tabacum* (Group 2), and various species of *Nicotiana* (Group 3) were evaluated for resistance to *Meloidogyne* spp. in greenhouse tests. Egg mass production by nematodes was used as a measure of relative resistance of the germplasm. In Group I, numbers of *M. incognita* and *M. javanica* egg masses were reduced ($P \leq 0.05$) in most breeding lines when compared to the susceptible *N. tabacum* control cultivar NC 2326. Fewer differences in egg mass numbers were found in breeding lines inoculated with *M. arenaria*. Numbers of egg masses of either *M. arenaria* or *M. javanica* on Group 2 breeding lines were not reduced significantly when compared to *N. tabacum* standards. In Group 3, lines of *N. knightiana*, *N. sanderae*, and *N. velutina* showed significantly reduced egg mass production when inoculated with *M. arenaria*. *Nicotiana megalosiphon* exhibited reduced egg mass production when inculated with *M. javanica*. *Nicotiana glauca*, *N. longiflora*, *N. nudicaulis*, *N. plumbaginifolia*, and *N. repanda* exhibited low egg mass production when inoculated with either *M. arenaria* or *M. javanica*. Several selections of *N. longiflora* and *N. repanda* '46-G' had the lowest egg mass production when inoculated with either *M. arenaria* or *M. javanica*.

*Key words: Meloidogyne* spp., *Nicotiana* spp., resistance, root-knot nematode, tobacco.

RESUMEN

Davis, E. L., J. R. Rich, G. R. Gwynn, y V. Sisson. 1988. Evaluación en invernadero de *Nicotiana* spp. para resistencia a los nematodos noduladores. Nematrópica 18: 99–107.

En pruebas de invernadero, se evaluó germoplasma de *Nicotiana repanda* - *N. longiflora* × *N. tabacum* (Grupo 1), *N. repanda* × *N. tabacum* (Grupo 2) y varias especies de *Nicotiana* (Grupo 3) para determinar su resistencia a *Meloidogyne* spp. Se consideró la producción de masas de huevos por los nematodos como índice de la resistencia relativa del germoplasma. En la mayoría de las lineas del Grupo 1, hubo menor número de masas de huevos ($P \leq 0.05$) de *M. incognita* y *M. javanica* en comparación al número obtenido en el cultivar susceptible, *N. tabacum* NC 2326, que fue usado como testigo. En las lineas inoculadas con *M. arenaria* se encontraron menos diferencias en el número de masas de huevos. Las masas de huevos de *M. arenaria* o de *M. javanica*, en lineas del Grupo 2, no fueron reducidas en comparación a las producidas en *N. tabacum.* En el Grupo 3, se encontró una reducción significativa en la producción de huevos de *M. arenaria* en lineas de *N. knightiana, N. sanderae* y *N. velutina. Nicotiana megalosiphon* redujo la producción de huevos de *M. javanica. Nicotiana glauca, N. longiflora, N. nudicaulis, N. plumbaginifolia* y *N. repanda* mostraron poca producción de masas de huevos cuando fueron inoculadas con *M. arenaria* o *M. javanica.* Varias selecciones de *N. longiflora* y *N. repanda* '46-G' tuvieron la producción más baja de huevos en inoculaciones con *M. arenaria* o *M. javanica.*

*Palabras claves: Meloidogyne* spp., nematodo nodulador, *Nicotiana* spp., resistencia, tabaco.

## INTRODUCTION

Root-knot nematodes, primarily *Meloidogyne incognita* (Kofoid & White) Chitwood, *M. javanica* (Treub) Chitwood, and *M. arenaria* (Neal) Chitwood reduce yield of flue-cured tobacco *(Nicotiana tabacum* L.) in the southeastern United States and throughout the world (8). These pests are managed with nematicides, crop rotation, and plant resistance. Resistance in flue-cured tobacco to *M. incognita* has been a key component in managing this nematode for over two decades (10).

The use of flue-cured tobacco with resistance to *M. incognita,* however, may have resulted in further selection of biotypes of *M. incognita* (7,13). Other damaging root-knot nematode species, including *M. arenaria* and *M. javanica,* are present in the southeastern United States and have been increasing in prevalence over the past decade (2). In South Carolina, *M. arenaria* was identified in 67% of the samples collected from flue-cured tobacco fields with root-knot nematode problems (3). In Florida, over 55% of all flue-cured tobacco fields surveyed contained *M. javanica* (11,12). As a result of the accumulation of resistance-breaking pouplations of *M. incognita* and the increased prevalence of other *Meloidogyne* spp., the need for additional genetic resistance has become evident.

Members of the genus *Nicotiana* have long been recognized as sources of resistance to diseases of cultivated tobacco (1). The source of *M. incognita* resistance in flue-cured tobacco was recently hypothesized to be *N. tomentosa* Ruiz and Pavon, or a closely related species (17). Resistance to *N. tomentosa* has been shown to be controlled by a single pair of dominant genes as in *N. tabacum* resistance to *M. incognita* (16). Although resistance to *M. incognita* is well established, sources of resistance to *M. javanica* and *M. arenaria* are lacking (15). *Nicotiana longiflora* Cav. and *N. repanda* Willd. have shown resistance to *M. javanica* (9,14). This resistance is not expressed as strongly as *M. incognita* resistance and is reduced upon repeated backcrosses with *N. tabacum.* Few data are available on resistance of *Nicotiana* spp. to *M. arenaria.* The present study was conducted to evaluate germplasm and accessions of *Nicotiana* spp. for resistance to *M. incognita, M. javanica,* and *M. arenaria.*

## MATERIALS AND METHODS

Three groups of tobacco (*Nicotiana* spp.) germplasm were evaluated for resistance to *M. arenaria* (Race 1), *M. incognita* (Race 3), and *M. javanica*. The first group (Group 1) of tobacco germplasm (numbers 2667–2678) contained breeding lines (*N. repanda* - *N. longiflora* × *N. tabacum*) obtained from Zimbabwe. Additionally, a segmented substitution line of *N. repanda* into *N. tabacum*, V-642, from Zimbabwe was tested. Tobacco germplasm in Group 2 (numbers 4870 through 4931, and C319 and M-1-1) consisted of breeding lines from crosses between *N. repanda* and *N. tabacum* (4). The final group (Group 3) contained selection of germplasm of over 60 different species of *Nicotiana*. *Nicotiana tabacum* standards 'NC 2326' (susceptible to *M. incognita*) and 'Speight G-28' and/or 'NC 89' (resistant to *M. incognita*) were included as controls. In each test, five replications were arranged in a completely randomized design on a greenhouse bench. All data were analyzed using the analysis of variance procedure and means were separated using the Waller-Duncan $k$-ratio $t$-test with $k = 100$ ($P \leq 0.05$).

Seed of each tobacco line were planted into 150 $cm^3$ Conetainers® (Leach Nursery, Canby, Oregon) containing steam-sterilized sandy loam soil. Plants were thinned to one per Conetainer when approximately 5 cm high and were inoculated by injecting aqeuous suspensions of 2 000 eggs of either *M. incognita, M. arenaria*, or *M. javanica* into the soil. Eggs used for inoculum were extracted from 'Rutgers' tomato *(Lycopersicon esculentum* Mill.) roots with 0.53% sodium hypochlorite for 30 sec (6). Each tobacco line was inoculated with the appropriate *Meloidogyne* species. Plants were removed from Conetainers 55 days after inoculation and their root systems were washed and then stained with Phloxine B (15 g/L) for 10 min to enhance egg mass visibility (5). The number of egg masses per root system was counted and rated on a scale of 0–5 (5). Group 1 breeding lines were evaluated for host suitability with *M. incognita, M. arenaria*, and *M. javanica* and this test was repeated once. Group 2 and Group 3 lines were evaluated for host suitability to *M. arenaria* and *M. javanica*. All Group 2 germplasm was evaluated twice. All Group 3 accessions were evaluated in the first test, but only those with an egg mass rating of 3.0 or less that emerged properly were subjected to a second test.

## RESULTS AND DISCUSSION

Seven Group 1 breeding lines showed egg mass ratings of 2.0 or less when inoculated with *M. incognita* in the two greenhouse tests (Table 1). When inoculated with *M. arenaria*, none of the Group 1 germplasm in the first test showed significant differences in egg mass ratings among the lines or with the 'NC 2326' control. In the second test, two lines

Table 1. Egg mass rating of Group 1 breeding lines and *Nicotiana tabacum* cvs. NC 89, NC 2326, and Speight G-28 exposed to *Meloidogyne incognita, M. arenaria* or *M. javanica* in two greenhouse tests.

| | Egg mass rating[y] | | | | | |
|---|---|---|---|---|---|---|
| | *M. incognita* | | *M. arenaria* | | *M. javanica* | |
| *Nicotiana* accession | Test no. 1 | Test no. 2 | Test no. 1 | Test no. 2 | Test no. 1 | Test no. 2 |
| 2676 | 0.8 d[z] | 1.2 cd | 5.0 a | 2.6 gh | 3.0 e | 2.4 c |
| 2670 | 4.0 c | 4.0 b | 4.6 ab | 4.8 a | 5.0 a | 4.8 a |
| 2674 | 0.0 e | 1.0 de | 4.8 ab | 3.2 e-g | 2.6 e | 2.4 c |
| 2675 | 0.0 e | 1.6 c | 4.8 ab | 2.6 gh | 2.6 e | 1.6 d |
| 2673 | 0.2 e | 1.2 cd | 4.8 ab | 2.0 h | 4.2 c | 2.6 c |
| 2678 | 0.0 e | 0.8 de | 4.4 ab | 3.8 c-e | 4.8 ab | 3.8 b |
| 2677 | 0.4 de | 0.6 e | 4.2 ab | 3.2 e-g | 3.6 d | 2.4 c |
| 2667 | 4.6 ab | 4.0 b | 4.6 ab | 3.4 d-f | 5.0 a | 4.6 a |
| 2672 | 0.0 e | 0.8 de | 4.6 ab | 0.2 i | 3.6 d | 3.4 b |
| V-642 | 4.2 bc | 4.6 a | 5.0 a | 4.4 ac | 4.4 bc | 3.6 b |
| NC 89 | 0.0 e | 0.0 f | 4.0 b | 4.6 ab | 5.0 a | 5.0 a |
| NC 2326 | 5.0 a | 5.0 a | 5.0 a | 5.0 a | 5.0 a | 5.0 a |
| Speight G-28 | 0.0 e | 0.0 f | 4.4 ab | 4.8 a | 5.0 a | 5.0 a |

[y]Scale of 0–5 where: 0 = 0; 1 = 1–2; 2 = 3–10; 3 = 11–30; 4 = 31–100; 5 = >100 egg masses/root system.
[z]Mean of five replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test (*k* = 100).

showed egg mass ratings of 2.0 or less compared to the controls with line 2672 showing fewest *M. arenaria* egg masses. Seven of the lines inoculated with *M. javanica* showed significantly lower egg mass production in both greenhouse evaluations, but only line 2675 had an egg mass rating of less than 2.0. Data from these tests indicate variability in genotypes within the *N. repanda* - *N. longiflora* × *N. tabacum* crosses. Selections of the most promising types in this group should be backcrossed and undergo additional selection for resistance to these *Meloidogyne* spp.

All group 2 *Nicotiana* spp. lines including 4870–4931, C319, and M-1-1 produced egg mass ratings of 5.0 when exposed with either *M. arenaria* or *M. javanica* in two greenhouse tests. These data are not presented in tables but agree with earlier tests which showed little resistance to *M. javanica* in the M-1 lines (4).

Several of the Group 3 *Nicotiana* species exhibited low egg mass ratings when inoculated with either *M. arenaria* or *M. javanica* (Table 2). In the first test, *N. glauca, N. knightiana, N. longiflora, N. megalsiphon, N. paniculata, N. plumbaginifolia,* and *N. velutina* produced egg mass ratings of less than 2.0 when inoculated with *M. arenaria*. Similarly, *M. javanica* reproduced poorly on *N. glauca, N. longiflora, N. megalosiphon, N. nocti-*

Table 2. Egg mass ratings of *Nicotiana* spp. (Group 3) 55 days after exposure to either *Meloidogyne arenaria* or *M. javanica* under greenhouse conditions.

| | Egg mass rating[y] | | | |
|---|---|---|---|---|
| *Nicotiana* sp. and line | *M. arenaria* | | *M. javanica* | |
| *N. acaulis* 1-G | — | | 5.0 | a |
| *N. acuminata* 2-G | 5.0 | a[z] | 5.0 | a |
| *N. acuminata* 2A-G | 5.0 | a | 5.0 | a |
| *N. africana* 71-G | 4.6 | a-c | 2.6 | f-h |
| *N. alata* 3-G | 3.6 | d | 3.6 | de |
| *N. alata* 4-G 4n | 4.0 | cd | 4.2 | b-d |
| *N. amplexicaulis* 65-G | 5.0 | a | 5.0 | a |
| *N. amplexicaulis* 65A-G | 5.0 | a | 5.0 | a |
| *N. angustifolia* 5-G | 5.0 | a | 5.0 | a |
| *N. arentsii* 6-G | 2.2 | ef | 4.6 | a-c |
| *N. attenuata* 7-G | 5.0 | a | 5.0 | a |
| *N. benavidesii* 8-G | 4.6 | a-c | 4.4 | a-c |
| *N. benthumiana* 9-G | 5.0 | a | 5.0 | a |
| *N. benthumiana* 9A-G | 5.0 | a | 4.6 | a-c |
| *N. bigelovii* 10-G | 4.6 | a-c | 5.0 | a |
| *N. bigelovii* 12-G | 4.8 | ab | 4.8 | ab |
| *N. bigelovii* 13-G | 4.8 | ab | 5.0 | a |
| *N. bonariensis* 11-G | 5.0 | a | 5.0 | a |
| *N. cavicola* 68-G | 5.0 | a | 4.8 | ab |
| *N. clevelandii* 14-G | 5.0 | a | 5.0 | a |
| *N. cordifolia* 15-G | 5.0 | a | 5.0 | a |
| *N. cordifolia* 15A-G | 4.8 | ab | 4.8 | ab |
| *N. corymbosa* 16-G | 5.0 | a | 5.0 | a |
| *N. debneyi* 17-G | 5.0 | a | 5.0 | a |
| *N. eastii* 18-G | 4.8 | ab | 2.4 | f-h |
| *N. excelsior* 19-G | 4.2 | b-d | 3.0 | ef |
| *N. excelsior* 19A-G | 5.0 | a | 5.0 | a |
| *N. exigua* 20-G | 4.4 | a-c | 4.6 | a-c |
| *N. exigua* 20A-G | 5.0 | a | 4.6 | a-c |
| *N. forgetiana* 21A-G | 5.0 | a | 5.0 | a |
| *N. forgetiana* 21B-G | 5.0 | a | 5.0 | a |
| *N. fragans* 22-G | 5.0 | a | 4.4 | a-c |
| *N. glauca* 23-G | 4.8 | ab | 5.0 | a |
| *N. glauca* 23A-G | 4.8 | ab | 1.4 | j-l |
| *N. glauca* 23B-G | 1.2 | gh | 0.6 | mn |
| *N. glauca* 23C-G | 3.6 | d | 0.8 | lm |
| *N. glauca* 23D-G | 0.8 | h-j | 2.2 | g-i |
| *N. glutinosa* 24-G | 5.0 | a | 5.0 | a |
| *N. glutinosa* 24A-G | 5.0 | a | 5.0 | a |
| *N. glutinosa* 24B-G | 5.0 | a | 4.6 | a-c |
| *N. goodspeedii* 25-G | 4.6 | a-c | 4.8 | ab |
| *N. gossei* 26-G | 4.6 | a-c | 5.0 | a |
| *N. heperis* 67-G | 4.8 | ab | 3.0 | ef |
| *N. hesperis* 67A-G | 5.0 | a | 5.0 | a |
| *N. ingulba* 64-G | 5.0 | a | 4.6 | a-c |
| *N. kawakamii* 72-G | 5.0 | a | 4.6 | a-c |

Table 2. (continued)

| *Nicotiana* sp. and line | Egg mass rating[y] *M. arenaria* | | *M. javanica* | |
|---|---|---|---|---|
| *N. knightiana* 27-G | 0.4 | i-k | 3.6 | de |
| *N. langsdorffii* 28A-G | 5.0 | a | 5.0 | a |
| *N. langsdorffii* 28B-G | 5.0 | a | 5.0 | a |
| *N. linearis* | — | | 5.0 | a |
| *N. longiflora* 30-G | — | | 0.6 | mn |
| *N. longiflora* 30A-G | 0.8 | h-j | 0.0 | n |
| *N. longiflora* 30B-G | 0.2 | jk | 0.0 | n |
| *N. longiflora* 30C-G | 4.4 | a-c | 4.6 | a-c |
| *N. maritima* 31-G | 4.8 | ab | 4.6 | a-c |
| *N. megalosiphon* 32-G | 1.0 | g-i | 0.4 | mn |
| *N. megalosiphon* 32A-G | 4.8 | ab | 2.6 | f-h |
| *N. miersii* 33-G | 5.0 | a | 5.0 | a |
| *N. nesophila* 34A-G | 5.0 | a | 5.0 | a |
| *N. noctiflora* 35-G | 3.6 | d | — | |
| *N. noctiflora* 35A-G | 4.2 | b-d | 1.0 | k-m |
| *N. nudicaulis* 36-G | 2.0 | ef | 0.0 | n |
| *N. occidentalis* 37-G | 5.0 | a | 4.2 | b-d |
| *N. occidentalis* 37A-G | 5.0 | a | 4.8 | ab |
| *N. occidentalis* 37B-G | 5.0 | a | 4.8 | ab |
| *N. otophora* 38-G | 4.2 | b-d | 2.6 | f-h |
| *N. otophora* 38A-G | 4.8 | ab | 4.0 | cd |
| *N. otophora* 38B-G | 4.8 | ab | 5.0 | a |
| *N. otophora* 38C-G | 5.0 | a | 5.0 | a |
| *N. palmeri* 39-G | 4.8 | ab | 5.0 | a |
| *N. paniculata* 40-G | 2.2 | ef | 4.8 | ab |
| *N. paniculata* 40A-G | 0.6 | h-k | 2.8 | fg |
| *N. paniculata* 40B-G | 2.6 | e | 4.8 | ab |
| *N. paniculata* 40C-G | 4.8 | ab | 4.6 | a-c |
| *N. pauciflora* 41-G | 5.0 | a | 5.0 | a |
| *N. petunioides* 42-G | 4.8 | ab | 5.0 | a |
| *N. plumbaginifolia* 43A-G | 1.6 | fg | 4.0 | cd |
| *N. plumbaginifolia* 43B-G | 4.8 | ab | 0.4 | mn |
| *N. plumbaginifolia* 43C-G | 4.4 | a-c | 2.0 | h-j |
| *N. raimondii* 45-G | 5.0 | a | — | |
| *N. repanda* 46-G | 0.0 | k | 0.0 | n |
| *N. rosulata* 53-G | 5.0 | a | 5.0 | a |
| *N. rosulata* 53A-G | 5.0 | a | 5.0 | a |
| *N. rotundifolia* 47-G | 5.0 | a | 5.0 | a |
| *N. rotundifolia* 47A-G | 5.0 | a | 5.0 | a |
| *N. rustica* 44-G | 4.8 | ab | 4.8 | ab |
| *N. rustica* 48-G | 5.0 | a | 5.0 | a |
| *N. rustica* 49-G | 4.6 | a-c | 4.8 | ab |
| *N. rustica* 49A-G | 5.0 | a | 5.0 | a |
| *N. rustica* 49B-G | 5.0 | a | 4.6 | a-c |
| *N. sanderae* 50A-G | 3.6 | d | 4.8 | ab |
| *N. sanderae* 50B-G | 2.2 | ef | 3.6 | de |

Table 2. (continued)

| *Nicotiana* sp. and line | Egg mass rating[y] *M. arenaria* | | *M. javanica* | |
|---|---|---|---|---|
| *N. sanderae* 50C-G | 5.0 | a | 5.0 | a |
| *N. sanderae* 50D-G | 5.0 | a | 4.6 | a-c |
| *N. setchelli* 51-G | 4.4 | a-c | 5.0 | a |
| *N. simulans* 66-G | 5.0 | a | — | |
| *N. solandifolia* 52-G | 5.0 | a | 4.8 | ab |
| *N. spegazzanii* | — | | 5.0 | a |
| *N. stocktoni* 54-G | 5.0 | a | 4.6 | a-c |
| *N. suaveolens* 55-G | 5.0 | a | 5.0 | a |
| *N. suaveolens* 55A-G | 4.4 | a-c | 4.6 | a-c |
| *N. suaveolens* 55B-G | 4.8 | ab | 5.0 | a |
| *N. suaveolens* 55C-G | 4.0 | cd | 4.4 | a-c |
| *N. sylvesteris* 56A-G | 5.0 | a | 5.0 | a |
| *N. tabacum* NC 2326 | 5.0 | a | 5.0 | a |
| *N. tabacum* Speight G-28 | 4.8 | ab | 4.6 | a-c |
| *N. thyrsiflora* 57-G | 4.4 | a-c | 4.8 | ab |
| *N. tomentosa* 58-G | 5.0 | a | 4.8 | ab |
| *N. tomentosa* 58A-G | 5.0 | a | 4.4 | a-c |
| *N. tomentosiformis* 59-G | 5.0 | a | 5.0 | a |
| *N. trigonophylla* 60-G | 4.4 | a-c | 5.0 | a |
| *N. umbratica* 69-G | 4.6 | a-c | 5.0 | a |
| *N. undulata* 61A-G | 5.0 | a | 5.0 | a |
| *N. undulata* 61B-G | 5.0 | a | 5.0 | a |
| *N. undulata* 61C-G | 5.0 | a | 4.8 | ab |
| *N. velutina* 62-G | 4.8 | ab | 0.4 | mn |
| *N. velutina* 62A-G | 0.4 | i-k | 1.6 | i-k |
| *N. velutina* 62B-G | 5.0 | a | 4.2 | bd |
| *N. wigandioides* 63-G | 5.0 | a | 5.0 | a |

[y]Scale of 0–5 where 0 = 0; 1 = 1–2; 2 = 3–10; 3 = 11–30; 4 = 31–100; and 5 = > 100 egg masses/root system.
[z]Mean of five replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test (*k* = 100).

*flora, N. nudicaulis, N. plumbaginifolia,* and *N. velutina. Nicotiana repanda* allowed only minimal reproduction of both *M. arenaria* and *M. javanica.*

In the second test, low egg mass production of *M. arenaria* was confirmed from *N. glauca, N. longiflora, N. plumbaginifolia, N. repanda,* and *N. velutina* (Table 3). Reproduction of *M. javanica* was low on *N. glauca, N. longiflora, N. nudicaulis,* and *N. repanda.* Low egg mass production by *M. arenaria* and *M. javanica* on some *Nicotiana* spp. selections was not confirmed in a second test due to emergence failure.

Some root systems of *N. glauca* and *N. longiflora* were relatively heavily galled, but the nematodes produced very few egg masses. This may indicate that nematode development was slowed or had ceased after gall

Table 3. Egg mass rating of selected *Nicotiana* spp. (Group 3) 55 days after exposure to either *Meloidogyne arenaria* or *M. javanica* under greenhouse conditions.

| | Egg mass rating[y] | |
|---|---|---|
| *Nicotiana* sp. and line | *M. arenaria* | *M. javanica* |
| *N. arentsii* 6-G | 4.8 a[z] | — |
| *N. eastii* 18-G | — | 5.0 a |
| *N. excelsior* 19-G | — | 4.6 ab |
| *N. glauca* 23A-G | — | 2.0 g |
| *N. glauca* 23B-G | 1.2 d | 1.4 h |
| *N. glauca* 23C-G | — | 1.0 h |
| *N. glauca* 23D-G | 0.4 ef | 3.2 cd |
| *N. hesperis* 67-G | — | 5.0 a |
| *N. knightiana* 27-G | 2.4 bc | — |
| *N. longiflora* 30-G | — | 0.4 i |
| *N. longiflora* 30A-G | 0.8 de | 0.4 i |
| *N. longiflora* 30B-G | 0.4 ef | 0.0 i |
| *N. megalosiphon* 32-G | — | 2.0 g |
| *N. megalosiphon* 32A-G | — | 2.8 de |
| *N. noctiflora* 35A-G | — | 4.4 b |
| *N. nudicaulis* 36-G | 2.6 bd | 0.2 i |
| *N. otophora* 38-G | — | 5.0 a |
| *N. paniculata* 40-G | 2.8 b | — |
| *N. paniculata* 40A-G | 3.0 b | 3.6 c |
| *N. paniculata* 40B-G | 4.8 a | — |
| *N. plumbaginifolia* 43A-G | 0.0 f | — |
| *N. plumbaginifolia* 43B-G | — | 2.6 ef |
| *N. plumbaginifolia* 43C-G | — | 2.2 fg |
| *N. repanda* 46-G | 0.2 ef | 0.0 i |
| *N. sanderae* 50B-G | 2.0 c | — |
| *N. tabacum* NC 2326 | 5.0 a | 5.0 a |
| *N. tabacum* Speight G-28 | 4.4 a | 5.0 a |
| *N. velutina* 62A-G | 0.4 ef | 5.0 a |

[y]Scale of 0–5 where: 0 = 1–2; 2 = 3–10; 3 = 11–30; 4 = 31–100; and 5 = >100 egg masses/root system.
[z]Mean of five replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test (*k* = 100).

formation. *Nicotiana repanda* '46-G' was the most promising species tested, producing almost no galls or egg masses when exposed to root-knot nematodes. Resistance to *M. javanica* in *N. repanda* has been reported elsewhere (9). Some *Nicotiana* species were resistant in one greenhouse test but not in a second test, indicating variability in susceptibility within the germplasm of these lines.

Data presented from these tests indicate sources of resistance to *M. arenaria* and *M. javanica* are present in various *Nicotiana* spp. and *N. repanda* - *N. longiflora* × *N. tabacum* crosses. This resistance should be exploited further in tobacco breeding programs.

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