REACTION OF SELECTED *NICOTIANA* SPP. × *N. TABACUM* CROSSES GROWN IN MICROPLOTS TO THREE *MELOIDOGYNE* SPP.[1,2]

E. L. Davis, J. R. Rich, and G. R. Gwynn

Graduate Research Assistant, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611, U.S.A.; Professor, University of Florida, IFAS Agricultural Research and Education Center, Live Oak, FL 32060, U.S.A.; Research Agronomist, USDA-Agricultural Research Service, Tobacco Research Lab., Box 1555, Oxford, NC 27565, U.S.A. Present address of senior author: USDA-Agricultural Research Service, 2120 Camden Road, Orlando, FL 32803, U.S.A.

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ABSTRACT

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Germplasm from *Nicotiana repanda, N. longiflora* × *N. tabacum* crosses (Group 1) and *N. repanda* × *N. tabacum* selections (Group 2) were evaluated during 1984–1985 for resistance to *Meloidogyne* spp. in microplots. In 1984, several Group 1 breeding lines had less root galling and lower soil juvenile populations upon exposure to *M. incognita* than the susceptible *N. tabacum* cultivar NC 2326. In both the 1984 and 1985 tests, several Group 1 breeding lines had sigificantly lower juvenile numbers or gall ratings than *N. tabacum* cvs. NC 2326 and Speight G-28 when inoculated with *M. arenaria* and *M. javanica*. Group 2 breeding lines were highly susceptible to infection by *M. javanica* and *M. arenaria*. A "resistant" *N. repanda* line had the lowest gall rating and soil juvenile populations of the germplasm tested. Yields of most breeding lines were comparable to or higher than the *N. tabacum* standards in all treatments.

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

RESUMEN

Davis, E. L., J. R. Rich, y G. R. Gwynn. 1988. Reacción de cruces de *Nicotiana* spp. × *N. tabacum* a tres especies de *Meloidogyne* en microparcelas. Nematrópica 18: 109–115.

Germoplasma proveniente de cruces de *Nicotiana repanda, N. longiflora* × *N. tabacum* (Grupo 1) y selecciones de *N. repanda* × *N. tabacum* (Grupo 2) fueron evaluados para su resistencia a *Meloidogyne* spp. en microparcelas durante 1984–1985. En 1984, varias líneas del Grupo 1 mostraron un menor número de agallas radicales y tuvieron poblaciones más bajas de juveniles en el suelo cuando fueron expuestas a *M. incognita* que el cultivar susceptible, *N. tabacum* NC 2326. En la prueba da 1984, como la de 1985, varias líneas del Grupo 1 mostraron numeros sigificativamente más bajos de juveniles o de agallas que *N. tabacum* cvs. NC 2326 y Speight G-28 cuando fueron inoculadas con *M. arenaria* y *M. javanica*. Las líneas del Grupo 2 fueron altamente susceptibles a infección por *M. javanica* y *M. arenaria*. Del germoplasma evaluado, una línea "resistente" de *N. repanda* presentó el índice más bajo de agallas y el menor población de juveniles en el suelo. Los rendimientos de la mayoría de las líneas fueron iguales o mayores que los de *N. tabacum* en todos los tratamientos.

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

INTRODUCTION

Several reports indicate that resistance to *Meloidogyne arenaria* (Neal) Chitwood and *M. javanica* (Treub) Chitwood may exist within the genus *Nicotiana* (2,5–7). Resistance to *M. javanica* has been demonstrated in accessions of *N. longiflora* Cav., and *N. repanda* Willd. (5,6). Although some reduction in nematode reproduction occurs, resistance is expressed mainly as relatively high crop yield in the presence of root-knot nematode infection (tolerance). Additionally, this resistance is decreased upon repeated backcrosses with *N. tabacum.*

Sources of resistance to *M. arenaria, M. javanica,* or both have been found in selections of several *Nicotiana* spp. and breeding lines in greenhouse tests (2). These included lines from *N. repanda* - *N. longiflora* × *N. tabacum* crosses, as well as selections of *N. glauca, N. longiflora, N. nudicaulis, N. plumbaginiflora, N. repanda,* and *N. velutina.* The performance of these lines under field conditions, however, has not been determined. The present study was conducted to further determine relative resistance or tolerance of selected *N. repanda* - *N. longiflora* × *N. tabacum* breeding lines to *M. arenaria, M. incognita* (Kofoid & White) Chitwood, and *M. javanica* in field microplot tests.

MATERIALS AND METHODS

Selected breeding lines previously studied in greenhouse tests were chosen for evaluation in field microplot studies during the 1984 and 1985 growing seasons (2). The breeding lines consisted of six entries obtained from Zimbabwe derived from *N. repanda* - *N. longiflora* × *N. tabacum* crosses. These were designated 2670, 2672, 2673, 2674, 2675, and 2677. In addition, a segmented substitution line of *N. repanda* into *N. tabacum*, V642, was tested along with *N. tabacum* controls, 'NC 2326' and 'Speight G-28'. The entries were inoculated with *M. incognita* (Race 3), *M. arenaria* (Race 1), *M. javanica,* or no nematodes in field microplots. Microplots were 76 cm in diam × 61 cm deep and contained a Lakeland fine sand (93% sand, 4% silt, and 3% clay). Soil was treated with methyl bromide and 1,3-dichloropropene prior to inoculation for control of weeds, diseases, and nematodes (1).

Eggs of the appropriate *Meloidogyne* species were extracted from *Lycopersicon esculentum* Mill. cv. Rutgers tomato roots with sodium hypochlorite (3) and suspended in water. Two L of the suspension were applied to the soil surface and incorporated into each microplot at the rate of 20 eggs/100 cm^3 of soil calculated to a depth of 23 cm. One tobacco seedling was transplanted into each microplot and treatments were replicated four times in a completely randomized design. Data were analyzed using the analysis of variance procedure and means were separated using the Waller-Duncan k-ratio t-test with $k = 100$ ($P \leq 0.05$).

Standard cultural practices were maintained throughout the growing season. Mature tobacco leaves were harvested three times and green weights determined. Four soil cores (2.5 × 30 cm deep) were collected from each microplot at harvest and *Meloidogyne* second-stage juveniles (J2) in 100 cm^3 of soil were extracted using a modified centrifugal-flotation technique (4). At harvest, roots were rated for galling on a scale of 0–4 where: 0 = no galling and 4 = 76–100% root galling.

In 1985, breeding lines were tested under similar conditions as in 1984. Entries were as in the previous test except line 2676 was substituted for line 2670. Six additional lines (M-1-1, 4917, 4925, 4921, 4922, and *N. repanda* 46-G) were also included from another breeding program (6). 'Coker 319', 'Speight G-28', and 'NC 2326' served as *N. tabacum* controls. Procedures were the same as in 1984 with the following exceptions. Treatment with *M. incognita* was omitted due to a limited number of transplants available of some tobacco lines, and each treatment was replicated three times. No yield data were collected from *N. repanda* '46-G' due to the low, bushy growth habit of this species.

RESULTS AND DISCUSSION

In the 1984 test, four lines inoculated with *M. incognita* had fewer J2 in the soil than the 'NC 2326' control whereas two lines promoted significantly more J2 than 'NC 2326' (Table 1). Root galling was also reduced in five of the lines. Numbers of J2 were not reduced in five of

Table 1. Juvenile numbers and gall ratings of selected *Nicotiana* breeding lines and *N. tabacum* cvs. NC 2326 and Speight G-28 exposed to *Meloidogyne incognita, M. javanica,* or *M. arenaria* in microplots (1984).

	M. incognita		*M. arenaria*		*M. javanica*	
Nicotiana line	Juvenile numbers[x]	Root galling[y]	Juvenile numbers	Root galling	Juvenile numbers	Root galling
2670	2 791 a[z]	4.0 a	757 ab	2.5 ab	1 643 a	3.5 ab
2672	29 c	0.3 c	1 529 ab	2.8 ab	1 744 a	3.3 ab
2673	761 bc	1.5 b	1 291 ab	3.0 ab	1 852 a	3.8 a
2674	14 c	0.3 c	818 ab	1.8 b	805 a	2.5 b
2675	5 c	0.0 c	439 b	1.5 b	1 040 a	2.5 b
2677	4 c	0.3 c	878 ab	2.3 b	1 404 a	3.0 ab
V-642	2 988 a	4.0 a	1 893 a	2.8 ab	1 459 a	3.3 ab
NC 2326	1 592 b	4.0 a	549 b	4.0 a	1 323 a	4.0 a
Speight G-28	0 c	0.0 c	1 405 ab	2.8 ab	2 281 a	4.0 a

[x]Number of second-stage juveniles per 100 cm^3 of soil at end of season.

[y]Scale of 0–4 where: 0 = 0%; 1 = 1–25%; 2 = 26–50%; 3 = 51–75%; and 4 = 76–100% of root system galled.

[z]Mean of four replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test (k = 100).

Table 2. Yield of selected *Nicotiana* breeding lines and *N. tabacum* cvs. NC 2326 and Speight G-28 exposed to *Meloidogyne incognita, M. arenaria,* or *M. javanica* in microplots (1984).

	Yield[y]			
Nicotiana line	Control	*M. incognita*	*M. arenaria*	*M. javanica*
2670	345 b[z]	500 ab	364 ab	405 bc
2672	635 a	428 bc	498 ab	258 d
2673	639 a	470 a-c	515 ab	486 a-c
2674	576 a	500 ab	481 ab	534 ab
2675	635 a	499 ab	586 a	525 ab
2677	584 a	520 ab	466 ab	618 a
V-642	375 b	175 d	300 b	352 cd
NC 2326	610 a	111 d	286 b	85 e
Speight G-28	691 a	663 a	512 ab	355 cd

[y]Yield expressed as grams green leaf weight.
[z]Mean of four replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test ($k = 100$).

the lines. Numbers of J2 were not reduced in lines inoculated with *M. arenaria,* whereas root galling was significantly reduced in three of the lines compared to the 'NC 2326' control. No significant reduction in J2 was found in lines inoculated with *M. javanica,* whereas two lines showed a significant reduction in root galling. These data indicated a relatively high degree of resistance of several lines to *M. incognita* but only moderate resistance to *M. arenaria* and even less to *M. javanica.*

Yields of noninoculated lines, except 2670 and V-642, were comparable to that of *N. tabacum* standards (Table 2). Leaves of the breeding lines were large, smooth, and relatively thinner than *N. tabacum* standards. 'Speight G-28,' resistant to *M. incognita,* produced the greatest yield in the presence of this nematode, but the yield of was not significantly higher than five of the lines. The 'NC 2326' standard produced the lowest yield in microplots infested with *M. incognita,* indicating a degree of tolerance or resistance in several of the breeding lines.

Breeding line 2675 produced the highest yield of any tobacco exposed to *M. arenaria,* but little yield differences were found among the lines and controls. Most of the *Nicotiana* spp. lines yielded significantly higher than *N. tabacum* standards upon exposure to *M. javanica,* with 2677 producing the greatest yield. Line 2673 exposed to *M. arenaria* and 2677 exposed to *M. javanica* produced relatively high yields even though both were heavily infected by these nematodes. These data indicated a high degree of tolerance of these two lines to *M. arenaria* and *M. javanica.*

Breeding lines 2672, 2673, 2674, 2675, and 2677 had lower gall ratings when exposed to *M. arenaria* and *M. javanica* in 1985 than in

Table 3. Gall ratings of selected *Nicotiana* breeding lines and *N. tabacum* cvs. NC 2326 and Speight G-28 exposed to either *Meloidogyne javanica* or *M. arenaria* in microplots (1985).

Nicotiana line	Gall rating[x]	
	M. javanica	*M. arenaria*
2672	1.0 b[y]	2.3 cd
2673	0.3 b	1.0 ef
2674	0.3 b	0.7 ef
2675	1.0 b	1.0 ef
2676	1.3 b	1.7 de
2677	0.3 b	2.7 bd
C319	3.7 a	4.0 a
M-1-1	3.7 a	3.3 a-c
4917	3.7 a	4.0 a
4925	4.0 a	4.0 a
4921	3.7 a	3.7 ab
4922	3.0 a	3.0 a-c
46-G[z]	0.3 b	0.3 f
V-642	3.0 a	2.3 cd
NC 2326	4.0 a	4.0 a
Speight G-28	3.7 a	3.7 ab

[x]Scale of 0–4 where: 0 = 0%; 1 = 1–25%; 2 = 26–50%; 3 = 51–75%; and 4 = 76–100% of root system galled.
[y]Mean of three replications. Column means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t*-test ($k = 100$).
[z]An accession of *N. repanda*.

1984 (Table 3). Inoculum viability was considered satisfactory since the *N. tabacum* standards were heavily galled. Galls on *N. repanda* exposed to either *M. arenaria* or *M. javanica* were small and very few in number, and almost no J2 were recovered from soil (Table 4). These data were consistent with earlier greenhouse tests and work of others (2,4). Lines 2674 and 2675 once again demonstrated relatively good resistance to *M. arenaria* and *M. javanica*.

In the 1985 test, yield of the noninoculated *N. tabacum* standards was significantly greater than all other tobacco tested (Table 5). Lines 4917, 4921, 4922, and 4925 produced leaves similar to those of *N. tabacum*, but yields were variable. Lines 2676 and 4921 produced high yields upon exposure to *M. javanica*, even though 4921 was heavily infected by *M. javanica*. Variability in reaction of line 2676 to *M. arenaria* and *M. javanica* exists between greenhouse and microplot tests (2). Line 4921 also produced relatively high yields in the presence of *M. arenaria* infection, and so did 4917, 4922, 4925, V-642, and Speight G-28. These lines demonstrated little resistance to either *M. arenaria* or *M. javanica* in greenhouse tests (2) but appeared tolerant to infection by these root-knot nematodes in microplot studies.

Table 4. Numbers of *Meloidogyne javanica* and *M. arenaria* second-stage juveniles in microplots containing selected *Nicotiana* breeding lines and *N. tabacum* cvs. NC 2326 and Speight G-28 (1985).

	No. juveniles/100 cm³ of soil			
	M. javanica		*M. arenaria*	
Nicotiana line	Mid-season	Harvest	Mid-season	Harvest
2672	3 c[y]	45 d	4 f	452 c-e
2673	9 c	83 d	13 f	213 de
2674	2 c	111 d	7 f	70 e
2675	7 c	111 d	59 ef	109 e
2676	18 c	174 d	5 f	129 e
2677	4 c	127 d	2 f	335 c-e
C319	132 bc	6 647 ab	325 cd	6 222 a
M-1-1	71 bc	3 819 bd	42 f	5 751 a
4917	230 bc	5 374 a-c	487 b	5 177 ab
4925	209 bc	8 040 ab	413 bc	6 233 a
4921	380 b	3 437 b-d	202 de	6 533 a
4922	44 bc	1 896 cd	113 ef	4 047 a-c
46-G[z]	1 c	2 d	1 f	2 e
V-642	35 c	3 343 bd	13 f	1 695 be
NC 2326	793 a	9 764 a	891 a	4 027 a-d
Speight G-28	377 b	7 393 ab	274 cd	3 453 a-e

[y]Mean of three replications. Column means followed by the same letter are not significantly different according to Waller-Duncan *k*-ratio *t*-test ($k = 100$).
[z]An accession of *N. repanda*.

Data from these tests and earlier greenhouse work (2) indicate that a number of sources of resistance to *M. arenaria* and *M. javanica* are present within the genus *Nicotiana*. In particular, *N. repanda* '46-G' exhibited a high level of resistance to *M. arenaria* and *M. javanica* in both greenhouse and microplot tests. Several other *Nicotiana* species demonstrated resistance to either *M. arenaria* or *M. javanica*, but yield and leaf quality of these various tobacco species were considerably inferior to those of flue-cured tobacco. Tobacco lines with characteristics similar to those of *N. tabacum* were moderately resistant to *M. arenaria* and *M. javanica*, but backcrosses with *N. tabacum* appeared to reduce resistance to these root-knot nematodes (5,6). A detailed study of the nature of inheritance of resistance in some of these *Nicotiana* species may provide avenues for incorporation of this resistance into commercial tobacco cultivars.

Table 5. Yields of selected *Nicotiana* breeding lines and *N. tabacum* cvs. NC 2326 and Speight G-28 exposed to either *Meloidogyne javanica* or *M. arenaria* in microplots (1985).

	Yield[y]		
Nicotiana line	Control	*M. javanica*	*M. arenaria*
2672	411 bc[z]	399 ab	441 a
2673	454 bc	413 ab	429 a
2674	290 cd	335 ab	441 a
2675	420 bc	481 ab	473 a
2676	552 b	589 a	406 a
2677	428 bc	394 ab	336 a
C319	378 b-d	434 ab	398 a
M-1-1	200 d	346 ab	295 a
4917	535 b	296 b	467 a
4925	339 cd	431 ab	461 a
4921	307 cd	585 a	491 a
4922	466 bc	463 ab	470 a
V-642	342 cd	420 ab	412 a
NC 2326	764 a	277 b	342 a
Speight G-28	778 a	394 ab	429 a

[y]Yield in grams green leaf weight.
[z]Mean of three replications. Column means followed by the same letter are not significantly different according to Waller-Duncan *k*-ratio *t*-test ($k = 100$).

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