Supplement to Journal of Nematology 23(4S):712–716. 1991.


# Effects of Nematicides and Cultivars on *Rotylenchulus reniformis* and Flue-cured Tobacco Yield[1]

T. A. Melton and N. T. Powell[2]

*Abstract:* Main plots of tobacco cultivars were split into subplots treated or not treated with 1,3-D + chloropicrin. Some differences ($P = 0.05$) occurred for tobacco yield, value, and *R. reniformis* populations among the 12 cultivars tested. Treatment increased yields an average of 8.5%, but a significant cultivar × fumigation interaction did not occur. In a nematicide test, six of nine non-fumigant and fumigant nematicides significantly increased the value of tobacco cv. Coker 371-Gold by an average of $1,475/ha and decreased populations of *Rotylenchulus reniformis.* Similar results were not obtained using the cv. K 326 in another year. Nematode population levels often declined from the first sampling to the second, especially when initial numbers were relatively high. These are the first reported field studies involving management of *R. reniformis* on tobacco in the United States.

*Key words:* control, cultivar, fumigation, host range, management, nematode, *Nicotiana tabacum,* reniform nematode, resistance, *Rotylenchulus reniformis,* tobacco.

Tobacco (*Nicotiana tabacum* L.) is a host for the reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira) as reported in India (6), Pakistan (9), China (11), Jamaica (4), Trinidad (10), and Colombia (2). Data on the sensitivity and susceptibility of tobacco to reniform nematode are limited. Heald and Meredith (3) showed that three cultivars of flue-cured tobacco were good hosts for three populations of *R. reniformis* (3) and that tobacco dry weights were reduced for each combination, except for cv. Hicks infected by a population from Baton Rouge, Louisiana. In three tobacco fields assayed in Mysore, India, *R. reniformis* was the predominant nematode parasite with an average population density of 407 juveniles per 500 $cm^3$ of soil (5). Patel et al. (6) reported tobacco cv. Anand-119 supported equal or higher soil and root populations than did cotton cv. Deviraj.

In 1982, *R. reniformis* was discovered in North Carolina in a Scotland County cotton field, and later in other counties where fields were usually rotated with flue-cured tobacco (J. L. Imbriani, pers. comm.). These studies were established to determine the effects of the reniform nematode on tobacco yields when nematicides are applied or where various cultivars were used for nematode management. Two nematicide tests and one cultivar test were conducted. These are the first reported field studies involving management of *R. reniformis* on flue-cured tobacco in the United States.

## Materials and Methods

For these experiments, two adjacent fields in Johnston County, North Carolina, were used, one in 1988 and one in 1989. Both fields were Norfolk loamy sands (80% sand, 16% silt, 4% clay) in the middle coastal plain, and both were planted to cotton (*Gossypium hirsutum* L.) 1 year previous and tobacco 2 years previous to the establishment of the study. Root-knot (*Meloidogyne* spp.) populations were very low in both fields.

*Nematicide Test, 1988:* The field used in 1988 had an average reniform nematode population of 3,690/500 $cm^3$ soil in March 1988. The test was designed as randomized complete blocks with 12 treatments and 8 replicates. Tobacco cv. Coker 371-Gold (susceptible to *Meloidogyne incognita* races 1 and 3) was transplanted on 5 May 1988, in four-row plots, 1.1 m apart and 14.93 m long. Fumigants were applied after bed-

Received for publication 4 March 1991.

[1] The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, nor criticism of similar ones not mentioned.

[2] Assistant Professor and Professor Emeritus, respectively, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-8604.

The author thanks Marsha Gompertz for statistical consultation and David Porter, Keith Wood, Pat Wickham, and Dr. K. R. Barker and his staff for technical assistance.

ding through a single point injector approximately 36 cm below the top of the bed on 6 April 1988 and were sealed with soil. Methyl bromide was injected at two points with one-third of the material applied 25 cm deep and the other two-thirds applied 50 cm deep. Liquid nonfumigants were applied broadcast, and aldicarb was applied in a 35.6-cm band on 2 May 1988. Liquid nonfumigants were disked into the soil and then further incorporated the same day when beds were formed. Soil and root samples for nematode analysis were collected on 6 July and 15 September.

*Nematicide test, 1989:* The field used in 1989 had an average *R. reniformis* population of 2,304/500 $cm^3$ soil in February 1989. This test had a randomized complete block design with 12 treatments and 7 replicates. A major difference from the 1988 test was the use of a different cultivar, K 326 (resistant to *Meloidogyne incognita* races 1 and 3). Soil fumigants were applied on 25 April, nonfumigants were applied on 19 May, and plots were planted on 7 June with 12-week-old transplants. Nematicide application, plot sizes, and cultural practices were identical to those of the 1988 test. Soil samples for nematode analysis were collected on 25 April and 16 August.

*Cultivar test:* The cultivar test was designed as a randomized complete block with 12 treatments (cultivars) and three replicates. Plots were the same size as in the nematicide test, but they were split with two rows nontreated and two rows treated with 111.8 kg a.i./ha of 1,3-dichloropropene + chloropicrin fumigant, which was applied as described above. Fumigation and soil sampling dates were the same as for the 1989 nematicide test.

In all three tests, the crop was transplanted, fertilized, and produced according to normal and recommended practices. Plots were harvested three times, and leaves were cured in a bulk curing barn. U. S. government grades were assigned to each harvest of each plot, and a price per 100 kg was assigned based on the average price paid during the year for that grade. On all sampling dates, nematodes were extracted from soil with a semiautomatic elutriator and from roots with a mist chamber (1). Soil nematode populations in 1988 were transformed ($\log_{10}$) prior to separation of means to normalize residuals and reduce variance. All data were subjected to analysis of variance (ANOVA), and means were separated using the Waller-Duncan k-ratio *t*-test (k-ratio = 100). Correlations and regression analyses were used to related yields and crop values to nematode numbers.

## Results and Discussion

*Nematicide test, 1988:* Fenamiphos, aldicarb, chlorpyrifos, 1,3-D, 50% chloropicrin, and 1,3-D + chloropicrin increased yield and crop value compared to the nontreated control (Table 1). Of those treatments, fenamiphos, aldicarb, 1,3-D, and 1,3-D + chloropicrin also had lower nematode populations than the controls on 6 July. Orthogonal contrasts between treated and nontreated were significant ($P = 0.05$) for yield and value. These results agreed with Prasad's (7), who showed that several nonfumigants, including fenamiphos, reduced populations of reniform nematode. He also demonstrated enhanced yields, but *M. incognita* was also present. In our study, yield (and value) was correlated with the reniform populations on 6 July ($r = -0.47$, $P = 0.01$) and 15 September ($r = -0.30$, $P = 0.01$). For the control plots, the equation

$$\text{yield} = 3{,}020 - 0.3275a,$$

where a = the soil and root reniform population on 6 July, was significant ($P = 0.01$, $r^2 = 0.71$). If a nematicide costs \$250/ha, this equation predicts that the damage at 210 nematodes/500 $cm^3$ soil would equal the cost of treatment. Tobacco price, which was not affected significantly by treatments, averaged \$3.60/kg. In our test, yield responses of up to 18% and net crop value increases up to \$1,825/ha were obtained with reniform populations of 1,718/500 $cm^3$ of soil and roots 55 days after transplanting. These responses are not as great as those reported by Patel et al. (6), who showed a 37.6% increase in shoot weight

TABLE 1. Effects of nematicides on *Rotylenchulus reniformis* populations, yield, and value of flue-cured tobacco cv. Coker 371-Gold in 1988.

| Treatment | Rate (kg a.i./ha) | Yield (kg/ha) | Value ($/ha) | *R. reniformis*/500 cm³ soil and roots | |
|---|---|---|---|---|---|
| | | | | 6 July | 15 Sept. |
| Fenamiphos | 6.72 | 3,246 a | 11,717 a | 367 def | 170 de |
| Aldicarb | 3.36 | 3,216 a | 11,571 a | 423 f | 379 cd |
| Chlorpyrifos | 5.88 | 3,178 a | 11,432 a | 1,534 ab | 1,319 a |
| 1,3-D | 63.8 | 3,116 ab | 11,238 a | 284 ef | 200 d |
| Chloropicrin, 50% | 41.5 | 3,107 ab | 11,184 ab | 764 b–e | 860 ab |
| 1,3-D + chloropicrin | 91.4 + 20.4 | 3,069 ab | 11,058 ab | 115 g | 70 e |
| Chloropicrin, 100% | 41.5 | 2,924 bc | 10,538 ab | 826 a–d | 769 abc |
| Carbofuran | 6.72 | 2,906 bc | 10,484 ab | 541 c–e | 396 bc |
| Ethoprop | 8.96 | 2,806 cd | 10,119 c | 1,002 abc | 1,399 a |
| Control | — | 2,752 c | 9,892 c | 1,718 a | 1,203 abc |
| CV | | 7.1 | 7.2 | 18.9 | 18.2 |

Data are means of eight replications. Means followed by the same letter within a column are not significantly different (k ratio = 100) according to the Waller-Duncan test. Data for *R. reniformis* were $\log_{10}$ (x + 1) transformed prior to ANOVA, CV calculations, and the Waller-Duncan test; nontransformed means are presented.

over a noninoculated control when populations of reniform nematode reached 468/500 cm³ soil 45 days after inoculation.

*Nematicide test, 1989:* No significant differences occurred among the 1989 nematicide treatments for yield, value, or nematode populations on 25 April (Table 2). Although none of the treatments resulted in lower ($P = 0.05$) nematode populations than the control, the chitin + urea treatment resulted in a greater ($P = 0.05$) population compared to most other treatments, including the control. However, the chitin + urea treatment produced the greatest yield and value (although not significant), which may have been the result of adding extra nitrogen in a year with very high precipitation. For the nontreated plots, yield was related to *R. reniformis* density by the equations

$$\text{yield} = 2{,}851 - 0.7417a,$$

where a is the 16 August reniform population level (soil only; $P = 0.03$, $r^2 = 0.68$),

TABLE 2. Effects of nematicides on *Rotylenchulus reniformis* populations, yield, and value of flue-cured tobacco cv. K 326 in 1989.

| Treatment | Rate (kg a.i./ha) | Application method | Yield (kg/ha) | Value ($/ha) | *R. reniformis*/500 cm³ soil | |
|---|---|---|---|---|---|---|
| | | | | | 25 April | 16 August |
| Chitin + urea | 500 + 100 | Band | 3,075 a | 11,304 a | 1,105 a | 1,186 a |
| Chloropicrin 100 | 41.5 | Band | 3,072 a | 11,229 a | 990 a | 266 c |
| Aldicarb | 3.36 | Band | 2,920 a | 10,706 a | 476 a | 141 c |
| Chloropicrin 70 | 41.5 | Band | 2,915 a | 10,642 a | 1,451 a | 394 bc |
| 1,3-D + chloropicrin | 91.4 + 20.4 | Band | 2,856 a | 10,390 a | 560 a | 49 c |
| Chlorpyrifos | 5.88 | Broadcast | 2,847 a | 10,449 a | 1,073 a | 487 bc |
| 1,3-D | 63.8 | Band | 2,820 a | 10,234 a | 1,180 a | 363 bc |
| Control | — | — | 2,816 a | 10,329 a | 744 a | 453 bc |
| Methyl bromide | 65.9 | Band | 2,683 a | 9,760 a | 560 a | 909 ab |
| Fenamiphos + ethoprop | 3.36 + 6.72 | Broadcast | 2,622 a | 9,465 a | 851 a | 86 c |
| Ethoprop | 8.96 | Broadcast | 2,573 a | 9.429 a | 517 a | 141 c |
| Fenamiphos | 6.72 | Broadcast | 2,520 a | 9.230 a | 1,137 a | 39 c |
| CV | | | 20 | 20 | 85 | 133 |

Data are means of seven replications. Means followed by the same letter within a column are not significantly different (k ratio = 100) according to the Waller-Duncan test.

TABLE 3. Effects of tobacco cultivars on *Rotylenchulus reniformis* densities and on tobacco yield and value, 1989.

| Cultivar | MI response† | Yield (kg/ha) | | Value ($/ha) | | *R. reniformis*/500 cm³ soil | |
|---|---|---|---|---|---|---|---|
| | | NT‡ | T | NT | T | 25 April | 16 August§ |
| K 326 | R | 2,979 a | 3,160 a | 11,013 a | 11,687 a | 187 a | 767 b |
| NC 37NF | S | 2,890 ab | 2,847 ab | 10,840 ab | 10,640 ab | 143 a | 833 b |
| K 358 | R | 2,643 a–c | 2,755 ab | 9,917 a–c | 10,315 ab | 1,660 a | 1,277 ab |
| K 149 | R | 2,594 a–d | 2,654 ab | 9,632 a–d | 9,840 ab | 273 a | 740 b |
| McNair 944 | S | 2,554 a–d | 2,713 ab | 9,422 a–d | 10,054 ab | 270 a | 707 b |
| K 394 | S | 2,455 a–d | 2,444 ab | 8,942 a–d | 8.930 b | 168 a | 623 b |
| Coker 371-Gold | S | 2,433 a–d | 2,522 ab | 8,887 a–d | 9.066 b | 843 a | 907 b |
| K 346 | R | 2,361 b–d | 2,343 b | 8,666 b–d | 8.790 b | 483 a | 753 b |
| Coker 176 | R | 2,303 b–d | 2,338 b | 8,449 cd | 8.567 b | 1,290 a | 670 b |
| Coker 319 | S | 2,186 cd | 2,314 b | 8,019 cd | 8,507 b | 830 a | 1,293 ab |
| Speight G-28 | R | 2,155 cd | 2,339 b | 7,680 cd | 8,426 b | 243 a | 1,012 b |
| Reams 134 | S | 2,303 d | 2,361 b | 7,431 d | 8,727 b | 970 a | 2,407 a |
| $\bar{x}$ | | 2,462* | 2,668 | 9,075* | 9,850 | 613.3 | 999.1 |
| CV | | 12 | 14 | 13 | 15 | 136 | 54 |

Data are means of three replicates. Means followed by the same letter within columns are not significantly different according to Waller-Duncan *t* test, k ratio = 100.

† R = resistant to *Meloidogyne incognita* races 1 and 3; S = susceptible.

‡ NT = not treated with 111.8 kg a.i./ha of 1,3-D + chloropicrin; T = treated.

* NT and T are significantly different ($P = 0.01$).

§ Only data from nontreated plots are shown for 16 August.

and

$$\text{yield} = 2{,}818 - 0.407\text{lb},$$

where b is the 25 April population level ($P = 0.01$, $r^2 = 0.77$). Therefore, a preplant population of 95 nematodes/500 cm³ soil would be required to pay for a $250/ha treatment. Tobacco prices were not significantly affected by treatments and averaged $3.66/kg.

*Cultivar test, 1989:* The nontreated and treated plots of cv. K 326 produced a greater yield and value than five other cultivars (Table 3). The nontreated Reams 134 yielded the least, and this cultivar benefitted the most from treatment. Significant treatment × cultivar interactions did not occur for any variables. However, the average yield of the treated plots was 8.5% greater ($P = 0.01$) than the nontreated ones, with a maximum difference of 18%. Reniform populations averaged 999/500 cm³ soil 83 days after transplanting. Yield was correlated with populations on 25 April ($r = -0.24$, $P = 0.05$), but was not correlated ($P = 0.19$) with populations on 16 August. The mean *R. reniformis* populations for *Meloidogyne incognita* resistant and susceptible cultivars were 860 and 1,128 nematodes/500 cm³ soil, respectively. However, when Reams 134 was removed from the mean calculations, the susceptible cultivars averaged only 872 nematodes/500 cm³ soil. Contrasts between the resistant and susceptible cultivars were not significant for yield or value.

Although tobacco value was significantly decreased by the reniform nematode at populations considered moderate or high for soybeans and cotton, our studies would indicate that tobacco is not a good host for high populations of this nematode. In both nematicide tests, it was common for populations to decline from the first sampling to the second, especially when populations were relatively high at the first sampling. Furthermore, populations never were as high as in the February or March samples taken after a cotton crop. However, reproduction of reniform nematode may vary according to the population (3) and soil texture (8).

## LITERATURE CITED

1. Barker, K. R. 1985. Nematode extraction and bioassays. Pp. 19–35 *in* K. R. Barker, C. C. Carter,

and J. N. Sasser, eds. An advanced treatise on *Meloidogyne.* Volume II: Methodology. Raleigh: North Carolina State University Graphics.

2. Barriga, O. R. 1971. Survey of plant parasitic nematodes associated with tobacco in Colombia. Nematrópica 1:1 (Abstr.).

3. Heald, C. M., and J. A. Meredith. 1987. Response of three tobacco cultivars to three *Rotylenchulus reniformis* populations. Nematrópica 17:95–98.

4. Hutton, D. G. 1979. Effect of *Rotylenchulus reniformis* in yield of tobacco. Bulletin, Ministry of Agriculture, Jamaica.

5. Krishna, Murthy G. V. G., and N. A. Elias. 1969. Vertical distribution pattern of plant parasitic nematodes in tobacco fields in Mysore India. Indian Phytopathology 22:252–254.

6. Patel, D. B., D. J. Patel, and H. M. Shah. 1987. Susceptibility of different crop plants to *Rotylenchulus reniformis.* International Nematology Network Newsletter 4:25–27.

7. Prasad, K. S. K. 1987. Suppression of *Meloidogyne incognita* and *Rotylenchulus reniformis* affecting beedi tobacco in Karnataka India. Journal of Soil Biology and Ecology 7:20–26.

8. Robinson, A. F., C. M. Heald, S. L. Flanagan, W. H. Thames, and J. Amador. 1987. Geographical distributions of *Rotylenchulus reniformis, Meloidognye incognita,* and *Tylenchulus semipenetrans* in the lower Rio Grande valley as related to soil texture and land use. Supplement to the Journal of Nematology 19:20–25.

9. Saeed, M., H. A. Khan, S. A. Khan, and F. Qamar. 1986. A survey of nematode problems of tobacco in Pakistan. (A) Nurseries. Pakistan Journal of Scientific and Industrial Research 29:279–283.

10. Singh, N. D. 1974. Preliminary investigations on the parasitic nematodes associated with tobacco in Trinidad. Nematrópica 4:11–16.

11. Ying, K. C. 1985. Morphological character of different stages of *Rotylenchulus reniformis.* Chinese Journal of Zoology 20:29–32.