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Evaluation of Fosthiazate for Management of *Meloidogyne javanica* in Florida Flue-cured Tobacco[1]

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Abstract: One grower trial and two experiment station tests were conducted to evaluate a new nematicide, fosthiazate, for management of *Meloidogyne javanica* in Florida flue-cured tobacco. Fosthiazate was applied broadcast and incorporated at rates ranging from 21 to 84 g/100 m^2 and compared with 1,3-dichloropropene at 240 and 460 ml/100 m^2 and fenamiphos at 67 g/100 m^2. All fosthiazate treatments increased tobacco yields and reduced root galling. Application of 1,3-D provided the highest tobacco yields and greatest reductions in root galling. The fenamiphos treatment outperformed all fosthiazate treatments in tobacco yield and root gall reduction. Fosthiazate may therefore have limited utility compared with 1,3-D and fenamiphos as a nematicide for tobacco in peninsular Florida.

Key words: fenamiphos, fosthiazate, 1,3-D, *Meloidogyne arenaria, Meloidogyne javanica,* nematicides, nematode, nematode management, *Nicotiana tabacum,* root-knot nematode, tobacco.

In the southeastern United States, nematicides are used extensively in flue-cured tobacco production to manage the most important nematode pests, *Meloidogyne* spp. (11). The percentage of flue-cured tobacco treated with nematicides varies by state, and estimates range from 60 to 95 percent. Tobacco grown in Florida has the highest treatment percentage among states because of the prevalence of deep sandy soils and widespread presence of *M. javanica* (10).

Nematicides used by tobacco growers in the southeastern United States include ethoprop, carbofuran, fenamiphos, aldicarb, oxamyl, 1,3-dichloropropene (1,3-D), and metham-sodium (6). Nematicides recommended in Florida include only fenamiphos and those containing 1,3-D (3). Florida tobacco growers need more choices of effective nematicides. The purpose of these tests was to evaluate a new nematicide, fosthiazate, for managing *Meloidogyne javanica* in Florida tobacco.

Materials and Methods

Experiment station tests: Two field trials, one each in 1991 and 1992, were conducted on a fine sand soil (93% sand, 4% silt, 3% clay, 5.7 pH) in a field infested with *M. javanica.* In each field, soybean had been planted previously to maintain nematode population densities. In early March of each year, the soil was moldboard plowed 25 cm deep and double-disked 12 cm deep. The fumigant, 1,3-D, was injected 25 cm deep in-row with a single chisel on 26 March 1991 and 24 March 1992 (see Tables 1 and 2 for chemical rates). Treated plots were bedded to a height of 20 cm. Liquid formulations of fenamiphos (Nemacur 3 SC, Miles Corporation) and fosthiazate 900 EC (ISK Biotech) were applied broadcast on 2 April in both years immediately before transplanting tobacco. They were applied in 850 ml of water/100 m^2 with a tractor-mounted CO_2 sprayer containing Teejet 8004 nozzles (R. F. Johnson and Associates). After application, the nonfumigant treatments were double-disked 12 cm deep and plots were bedded. Tobacco 'NK 326' was transplanted 46 cm apart in rows 1.12 m wide, and plots were two rows wide and 7.62 m long. Treatments in each trial were arranged in a randomized complete-block

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TABLE 1. Effect of nematicides on yield and root-gall indices of 'NK 326' tobacco in a field infested with *Meloidogyne javanica,* 1991.

Treatment†	Rate a. i./100 m²	Cured yield kg/ha	Root galling‡
1,3-D	240 ml	2,153 a§	0.92 d
Fenamiphos	67 g	1,786 b	1.00 d
Fosthiazate	84 g	1,558 cd	1.42 cd
Fosthiazate	63 g	1,464 cd	1.83 bc
Fosthiazate	42 g	1,655 bc	1.50 cd
Fosthiazate	21 g	1,402 d	2.33 b
Control	—	1,048 e	3.25 a

† 1,3-D was injected 25 cm deep in-row with a single chisel and sealed by bedding; the fosthiazate and fenamiphos were broadcast and double-disk incorporated.

‡ Root gall index ratings were based on a 0–4 scale, with 0 = no galling and 4 = 76% or greater of the root system galled.

§ Means were derived from six replicates per treatment. Means within the same column, followed by the same letter, are not different ($P \leq 0.05$) according to the Waller-Duncan k-ratio *t* test.

design with six replicates. The crop was maintained under irrigation during the growing season.

Plants were observed for phytotoxicity at weekly intervals for 6 weeks after planting. Root gall indices were recorded from two arbitrarily selected plants in each plot 98 days after transplanting in 1991 and 121 days in 1992. The root-gall index scoring system was 0–4 with 0 = 0 root galling and 4 ≥ 76% of the root system galled (7). Mature tobacco leaves were harvested three times in 1991 and four times in 1992. Green leaf weights were recorded and converted to cured weight by multiplying by a factor of 0.155.

Farm test: An on-farm test was conducted in 1992 in a north Florida grower's field that was infested with *M. javanica* and *M. arenaria.* The soil was a fine sand (93% sand, 4% silt, 3% clay, 5.9 pH). The 1,3-D treatment was injected through chisels spaced 30-cm apart and 30-cm deep on 15 February 1992 and immediately disked afterwards to seal the soil (Table 3). Fosthiazate and fenamiphos treatments were applied on 19 March 1992 and incorporated to 12 cm by shallow disking. Seedlings of tobacco 'Speight G-28' were transplanted 46 cm apart in rows 1.12 m wide. Plots were two rows wide and 13.8 m long, and treatments were replicated two times. The tobacco was irrigated as needed over the season.

Tobacco was monitored for phytotoxicity at weekly intervals for 6 weeks, and data on percentage flowering were taken 84 days after transplanting. Root gall indices were recorded on four plants in each replicate after final harvest, 140 days after transplanting. Mature leaves were harvested four times in coordination with the grower's schedule. Cured weights were estimated from fresh leaf weights by application of a series of conversion factors weighted to account for accumulation of increased levels of dry matter later in the growing season (12). Only significant ($P \leq 0.05$) data from these tests will be discussed unless otherwise stated.

RESULTS

In the 1991 test, leaf yield was significantly higher due to all treatments compared with the control (Table 1). Leaf yield was higher in plots treated with 1,3-D than the other treatments. Among the fosthiazate treatments, the 42 g/100 m² rate gave the largest numerical yield. Root galling indices were reduced by all treatments

TABLE 2. Influence of nematicides on 'NK 326' tobacco yield and root gall indices in a field infested with *Meloidogyne javanica,* 1992.

Treatment†	Rate a. i./100 m²	Cured yield kg/ha	Root-gall index‡
1,3-D	240 ml	2,843 a§	1.00 bc
Fenamiphos	67 g	2,746 a	0.42 c
Fosthiazate	63 g	2,514 ab	1.09 bc
Fosthiazate	42 g	2,526 ab	0.92 bc
Fosthiazate	32 g	2,254 ab	1.92 abc
Fosthiazate	21 g	2,176 ab	2.25 ab
Control	—	1,769 b	3.25 a

† 1,3-D was injected 25 cm deep in-row with a single chisel and sealed by bedding; fosthiazate and fenamiphos were broadcast and double-disk incorporated.

‡ Root gall index ratings were based on a 0–4 scale, with 0 = no galling and 4 = 76% or greater of the root system galled.

§ Means were derived from six replicates per treatment. Means within the same column, followed by the same letter, are not different ($P \leq 0.05$) according to the Waller-Duncan k-ratio *t* test.

TABLE 3. Effect of four nematicide treatments on yield, flowering, and root-gall indices of 'Speight G-28' tobacco in a grower field infested with *Meloidogyne arenaria* and *M. javanica,* 1992.

Treatment†	Rate a. i./100 m^2	Cured yield kg/ha	Percentage flowering‡	Root-gall indices§
1,3-D	460 ml	3,958	94	0.92
Fenamiphos	67 g	3,460	60	2.83
Fosthiazate	42 g	3,425	54	3.33
Fosthiazate	21 g	3,392	51	3.58
Control	—	3,356	43	4.00

† The 1,3-D was injected through chisels-spaced 30 cm apart; the fenamiphos and fosthiazate treatments were applied broadcast and disk-incorporated; treatments were replicated two times.

‡ Percentages of plants flowering were recorded on 11 June, 84 days after transplanting.

§ Root gall index ratings based on a 0–4 scale, with 0 = no galling and 4 ≥ 76% of the root system galled.

compared with that of the control, with greatest reduction due to 1,3-D, fenamiphos, and the 84 g/100 m^2 fosthiazate treatments. No phytotoxicity was observed in any of the treatments.

In the 1992 experiment station test, 1,3-D and fenamiphos increased tobacco yields compared with the control (Table 2). No increases in yield were found with fosthiazate treatments compared with the control treatment. As fosthiazate rates increased from 21 to 42 g/100 m^2, tobacco yield numerically increased among these treatments. Root-gall indices were reduced by the two highest rates of fosthiazate and the 1,3-D and fenamiphos treatments. Root-gall indices decreased numerically as rates of fosthiazate increased. No phytotoxicity was observed in any of the treatments.

In the farm test, tobacco yields increased modestly in response to 1,3-D (17.5% more than the control) but little to fosthiazate (1–2%) or fenamiphos (3%) (Table 3). The 1,3-D produced earlier and more uniform flower initiation than the other treatments. Eighty-four days after transplanting, fewer than half of the untreated plants were flowering, between 50 and 60% of plants in fenamiphos- and fosthiazate-treated plots were in flower, and 94% of the 1,3-D treated plants were flowering. Root-gall indices were slightly reduced by both rates of fosthiazate (21 and 42 g/100 m^2) and by fenamiphos; only 1,3-D substantially reduced galling relative to the control plants.

DISCUSSION

Fosthiazate treatments provided moderate activity in these tests with some increase in tobacco yields and reductions in root gall indices. The minimum rate to provide this level of management was 42 g/100 m^2. However, lower yields obtained at higher rates of fosthiazate suggested unobserved plant stunting. Present data with 1,3-D and fenamiphos are similar to those obtained in the past and indicate greatest efficacy with 1,3-D (4). Another important consideration in using 1,3-D is uniformity of plant growth and flowering (9), which allows growers to make most effective use of axillary bud (sucker) control chemicals, and improves harvesting and curing uniformity.

Tobacco production and nematode problems in Florida are different than in many other southeastern tobacco-producing states. Four main factors that contribute to those differences include the deep sand soils, mild winters, short rotations, and presence of *M. javanica* (10). The fine sandy soils in the three trials are similar to most tobacco farms in Florida: >90% sand and <1% organic matter. Intensive cropping on most of the tobacco fields (tobacco grown at least every third year, often every other year and sometimes two or more years consecutively) promotes high population levels of *Meloidogyne* spp. Frequent use of cultivars resistant only to *M. incognita* accentuates the development of high proportions of *M. javanica* and in some cases *M. arenaria* in

these fields. Similar results have been reported in Georgia (2,5).

The low soil organic matter content in Florida tobacco soil leaves the sands susceptible to leaching of soluble materials. Because of the lack of cation exchange capacity of these soils, tobacco grown in them has access to few reserves of nutrients or water. The crop therefore is damaged by low levels of root-knot nematodes (1). Moreover, the limited capacity of the soil to store water and the extremely high value of the crop induce farmers to irrigate tobacco frequently. Under these conditions, agricultural chemicals whose efficacy depends on retention in the soil solution for several weeks or months, as do organophosphate nematicides such as fenamiphos and fosthiazate, are at a distinct disadvantage when compared with 1,3-D, which acts quickly and dissipates within a few days before planting.

In tobacco and field crop production areas with heavier soil types, fosthiazate has shown nematicidal efficacy comparable to fenamiphos and should compete well for market share if the cost is not prohibitive (8,13). Our data suggest that fosthiazate may have limited use as a nematicide for tobacco in the sandy soils of peninsular Florida.

Literature Cited

1. Arens, M. L., J. R. Rich, and D. W. Dickson. 1981. Yield response and injury level of *Meloidogyne incognita* and *M. javanica* on the suceptible tobacco cultivar 'McNair 944'. Journal of Nematology 13: 201–205.

2. Csinos, A. S., A. W. Johnson, and A. M. Golden. 1986. Metalaxyl and fenamiphos applied through irrigation water to control black shank/root-knot complex on tobacco. Plant Disease 70:210–213.

3. Dunn, R. A. 1992. Nematode management in tobacco. Florida Cooperative Extension Service, No. NF-NG019, Gainesville, FL.

4. Garcia-M., R., and J. R. Rich. 1983. Efficacy of selected fumigant and nonfumigant nematicides to control *Meloidogyne javanica* in Florida tobacco. Nematropica 13:125–134.

5. Johnson, A. W., A. S. Csinos, A. M. Golden, and N. C. Glaze. 1992. Time and method of pesticide tank mix application for pest management and production of flue-cured tobacco. Tobacco Science 36:36–39.

6. Johns, J. L., C. S. Johnson, P. J. Semtner, T. D. Reed, B. B. Ross, and C. A. Wilkinson. 1993. Flue-cured tobacco production guide. Virginia Cooperative Extension Service Publication No. 436-420, Blacksburg, VA.

7. Krusberg, L. R., and L. W. Nielsen. 1958. Pathogenesis of root-knot nematodes to the Puerto Rico variety of sweet potato. Phytopathology 48:30–39.

8. Minton, N. A., T. B. Brenneman, K. Bondari, and G. W. Harrison. 1993. Activity of fosthiazate against *Meloidogyne arenania, Frankliniella* spp., and *Sclerotium rolfsii* in peanut. Peanut Science 20:66–70.

9. Rich, J. R., and K. R. Barker. 1984. Suppression of flowering of flue-cured tobacco by *Meloidogyne* spp. Journal of Nematology 16:402–403.

10. Rich, J. R., and R. Garcia-M. 1985. Nature of the root-knot disease in Florida tobacco. Plant Disease 69:972–974.

11. Rich, J. R., J. D. Arnett, J. A. Sheperd, and M. C. Watson. 1989. Chemical control of nematodes on flue-cured tobacco in Brazil, Canada, United States, and Zimbabwe. Journal of Nematology 21: 609–611.

12. Stocks, G. R. 1991. Lower leaf harvesting options and leaf position effects on some agronomic, chemical, and mineral characteristics of flue-cured tobacco. Ph.D. Dissertation, University of Florida, Gainesville, FL.

13. Woods, A. C., J. R. French, and M. Ichinohe. 1991. Toxicology and spectrum of nematicidal and insecticidal activity of a new organophosphorus compound. Journal of Nematology 23:556 (Abstr.).