ECONOMIC IMPORTANCE OF 1,3-DICHLOROPROPENE OR FENAMIPHOS TO MANAGE *MELOIDOGYNE JAVANICA* IN FLORIDA TOBACCO[†]

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ABSTRACT

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Twelve tobacco (*Nicotiana tabacum* L.) nematicide field trials were conducted over ten years in north-central Florida, U. S. A., on sites containing fine sandy soil. In each of these trials, 1,3-dichloropropene (1,3-D), fenamiphos 3 SC and a control were utilized. The 1,3-D treatments were applied with a single chisel in the row at rates between 68 and 102 kg a.i./ha. Fenamiphos was applied broadcast at 6.7 kg a.i. in 185 L water/ha and double disc-incorporated. Plots were two rows wide (1.12 m wide/row) and 6.1 m long. Tests were arranged in a randomized complete block design with six replicates. Tobacco leaves were harvested 3-4 times upon maturity and cured weights recorded. Root-gall index ratings were made at or near final harvest from four plants in each plot and rated on a 0-4 scale where 0 = 0 and 4 > 76% of the root system galled. Compared to untreated controls, 1,3-D treatments increased yield of cured tobacco by 943 kg/ha providing added gross average value of $3134 (U.S.)/ha at average prices paid to Florida growers in 1995. Average cured yield increase of tobacco in the fenamiphos treatments was 646 kg/ha, providing an enhanced value of $1983/ha. Root-gall index ratings averaged 3.2 for the control and 1.0 and 1.1 for the 1,3-D and fenamiphos treatments, respectively. Fenamiphos and 1,3-D have performed consistently over the years in the deep sands where tobacco is grown in Florida, with 1,3-D providing greater yield and economic benefits.

Key words: 1,3-dichloropropene, fenamiphos, *Meloidogyne javanica*, nematode management, *Nicotiana tabacum*, root-knot nematode, tobacco.

RESUMEN

Rich, J. R. y D. J. Zimet. 1996. Importancia económica de 1,3-dicloropropano o fenamiphos para el manejo de *Meloidogyne javanica* en tabaco en Florida. Nematrópica 26:135-141.

Doce ensayos de campo de nematodos en tabaco (*Nicotiana tabacum* L.) fueron conducidos a lo largo de diez años en la parte centro-norte de Florida, EEUU, en lugares que contienen suelo fino arsenoso. En cada uno de estos ensayos, 1,3-dicloropropano (1,3-D), fenamiphos 3 SC y un control fueron utilizados. Los tratamientos de 1,3-D fueron aplicados con un inyector en la hilera a una dosis entre 68 y 102 kg i.a./ha. Fenamiphos fue aplicado por esparción a 6.7 kg i.a. en 185 L de agua/ha e incorporado con un disco doble. Los terrenos fueron de dos hileras de ancho (1.12 m de ancho/hilera) y 6.1 m de largo. Los tratamientos fueron organizados en un diseño de bloques completamente al azar con seis repeticiones. Hojas de tabacó fueron cosechadas 3-4 veces a la madurez y los pesos curados fueron registrados. Una clasificación de indices de agallas de la raíz fue realizada en o cerca de la cosecha final de cuatro plantas en cada parcela y clasificada en una escala de 0-4 donde 0 = 0 y 4 > 76% del sistema radical agallado. Comparado con los controles no tratados, los tratamientos de 1,3-D incrementaron el rendimiento de tabaco curado en 943 kg/ha resultando en un incremento en el valor promedio bruto de $3134 (U.S.)/ha al precio promedio pagado a agricultores de Florida

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en 1995. El incremento del rendimiento promedio de tabaco curado en los tratamientos de fenamiphos fue 646 kg/ha, resultando en un incremento en valor de $1983/ha. La clasificación de indices de agallas de la raíz promedió en 3.2 para el control y 1.0 y 1.1 para los tratamientos con 1,3-D y fenamiphos, respectivamente. Fenamiphos y 1,3-D han funcionado consistentemente a través de los años en las arenas profundas donde el tabaco es sembrado en Florida, con 1,3-D resultando en un mayor rendimiento y beneficio económico.

Palabras clave: 1,3-dicloropropano, fenamiphos, manejo de nematodos, *Meloidogyne javanica*, nematodo agallador de la raíz, *Nicotiana tabacum*, tabaco.

INTRODUCTION

Root-knot nematodes (*Meloidogyne* spp.) are a major problem on flue-cured tobacco (*Nicotiana tobacum* L.) in the southeastern U.S.A., and species of importance are *M. hapla* Chitwood, *M. incognita* (Kofoid & White) Chitwood, *M. javanica* (Trueb) Chitwood and *M. arenaria* (Neal) Chitwood (Johnson, 1989). The latter three species can cause yield loss in Florida tobacco, and *Meloidogyne javanica* is the most widespread and damaging (Rich and Garcia, 1985). No varietal resistance to *M. javanica* is available in commercial tobacco cultivars grown in the U.S.A. Practical management methods used widely in Florida tobacco include rotation, sanitation and nematicides (Dunn and Rich, 1995). Due to the predominance of deep sandy soils, *M. javanica*, and mild winters (Rich and Garcia, 1985; Rich *et al.*, 1994), nematode problems in Florida tobacco are somewhat different than in some southeastern states. Soil-applied chemicals readily leach in the deep sands (Rahi *et al.*, 1992). Additionally, even with a temporary zone of protection, *Meloidogyne* species can migrate from below the zone of nematicide protection to tobacco roots (Dickson and Hewlett, 1988). Mild winters also may allow increased survival of nematode populations since the soil seldom freezes. Lastly, *M. javanica* has been shown to be more damaging than *M. incognita* (Arens and Rich, 1981; Barker *et al.*, 1981). These factors have limited the effectiveness of most nematicides tested on Florida tobacco over the past 20 years and only two, 1,3-dichloropropene (1,3-D) and fenamiphos, are currently recommended (Dunn and Rich, 1995). The experiments reported here were conducted to determine efficacy and economic effectiveness of these chemicals for managing *M. javanica* in Florida flue-cured tobacco.

MATERIALS AND METHODS

Twelve tobacco field trials were conducted between 1980 and 1992 to evaluate various nematicides and experimental products. In all of the trials, 1,3-dichloropropene and fenamiphos were compared to an untreated control. The test sites contained fine sandy soil (93% sand, 4% clay, 3% silt, < 1.0% m.) and were infested with *M. javanica*. Prior to chemical application, plots were moldboard plowed to 25-cm-deep and disc-harrowed. Application of 1,3-D was made 10-14 days prior to planting in late March to early April of each year. The 1,3-D was applied to 30-cm-deep with a single chisel in the row using a gravity flow applicator, at rates between 68 and 102 kg a.i./ha. In all tests, fenamiphos 3SC was applied broadcast at 6.7 kg a.i. in 185 L water/ha and double-disc incorporated to a 10-cm-depth immediately prior to transplanting. All plots were bedded after chemical application.

One tobacco cultivar was used each year (NK 326, Speight G28, NC 79, or Hicks), and seedlings were transplanted 51-cm-apart in 1.12-m-wide rows. Plots were 6.1 m in length × two rows wide. The experimental design was a randomized complete block containing six replications. Standard cultural practices including irrigation were utilized to promote good tobacco growth. Tobacco leaves were harvested three or four times from each test as they matured and cured weights recorded. Root-gall indices were rated between 70 and 125 days after transplanting. Ratings were made on a 0-4 scale where 0 equaled no visible root galling and 4 represented 76%-100% of the root system galled. From previous experience, timing of gall ratings was determined when galling of root systems on untreated border rows exceeded a rating of three, or if less, they were taken after final harvest. Data was analyzed using standard analysis of variance procedures, and means were separated by Duncan's multiple range test (Little and Hills, 1972). Paired t-tests were used to compare yield, root galling and value differences between the two nematicides using years for pairing.

RESULTS AND DISCUSSION

Root-gall development was suppressed ($P \leq 0.05$) in all but the 1984 trial with application of either 1,3-D or fenamiphos (Table 1). The 1,3-D treatment provided numerically greater root-knot control than

Table 1. Root-galling of tobacco in 12 field trials treated with 1,3-dichloropropene (1,3-D) and fenamiphos 3SC to manage *Meloidogyne javanica*.[w,x]

	Root-gall index[y]		
Year	Control	1,3-D	Fenamiphos
1980	3.5a[z]	1.4b	0.3b
1981	3.4a	0.3c	0.9b
1984	3.0a	1.4a	2.2a
1985	2.9a	0.5b	0.8b
1985	2.8a	0.9b	1.2b
1986	3.1a	0.8c	1.9b
1987	2.1a	0.5b	0.8b
1988	3.9a	1.9b	2.0b
1988	3.5a	1.0b	1.9b
1989	3.8a	1.3b	0.2c
1991	3.3a	0.9b	1.0b
1992	3.3a	1.0b	0.4b
Average	3.2a	1.0b	1.1b

[w]1,3-D was applied in the row 30-cm-deep with a single chisel at rates of 68-102 kg a.i./ha. Fenamiphos was applied broadcast and disc-incorporated to 10-cm-deep at 6.7 kg a.i./ha.

[x]Values for each year are means of 6 replications.

[y]Root-gall index ratings were made on a 0-4 scale where 0 = 0 galling and 4 > 76% of the root system galled.

[z]Horizontal means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

fenamiphos in 9 of the 12 trails, however, significantly greater control with 1,3-D occurred in only 2 trials. Tobacco yield was increased ($P \leq 0.05$) in all 1,3-D treatments as compared to the control (Table 2). Fenamiphos application resulted in increased yield ($P \leq 0.05$) in eight of the 12 trials. In three trials, 1,3-D increased yield over the fenamiphos treatment. A paired t-test comparison of yield over all trials showed a yield increase ($P \leq 0.01$) with 1,3-D compared to fenamiphos treatments. Average tobacco cured yield increase was 43% with 1,3-D and 29% with fenamiphos treatment. Application of 1,3-D increased yield in all tests an average of 943 kg/ha with a range of 472-1505 kg/ha. Based on an average price of $3.52 U.S./kg paid to Florida tobacco growers in 1995, net return for 1,3-D treatment was $3134/ha with a range of $1476-$5113/ha (Table 3). Use of fenamiphos increased yield an average of 646 kg/ha with a range between 311 and 1268 kg/ha. Net value return with fenamiphos treatment was improved by an average of $1983 with a range of $804-$4172. A paired t-test comparison indicated application of 1,3-D ($P \leq 0.01$) improved net value return over treatment with fenamiphos.

Costs of materials and application were not equal for the two chemical treatments.

Table 2. Yield of tobacco in 12 field trials treated with 1,3-dichloropropene (1,3-D) and fenamiphos 3SC to manage *Meloidogyne javanica*.[x]

Year	Cured yield in kg/ha[y]		
	Control	1,3-D	Fenamiphos
1980	2067a[z]	2587b	2387ab
1981	2408a	2880c	2730b
1984	3482a	4391b	3927ab
1985	2876a	3570b	3527b
1985	1929a	2697b	2865b
1986	3273a	4209b	3584a
1987	1584a	3089c	2324b
1988	2572a	3660b	3057ab
1988	2759a	3839b	3318b
1989	790a	1955b	2058b
1991	1048a	2151c	1786b
1992	1769a	2843b	2746b
Average	2213a	3156c	2859b

[x]1,3-D was applied in the row 30-cm-deep with a single chisel at rates of 68 - 102 kg a.i./ha. Fenamiphos was applied broadcast and disc-incorporated to 10-cm-deep at 6.7 kg a.i./ha.
[y]Values for each year are means of 6 replications.
[z]Horizontal means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

Table 3. Value increase (U.S. dollars) of tobacco in 12 field trials treated with 1,3-dichloropropene (1,3-D) and fenamiphos 3SC to manage *Meloidogyne javanica*.[w]

	Net value increase[x,y]	
Year	1,3-D	Fenamiphos
1980	1645	835
1981	1476	842
1984	3015	1275
1985	2258	2001
1985	2518	3004
1986	3110	804
1987	5113	2314
1988	3645	1416
1988	3617	1677
1989	3916	4172
1991	3698	2306
1992	3595	3148
Average	3134a[z]	1983b

[w]1,3-D was applied 30-cm-deep with a single chisel in the row to 30-cm-deep at rates between 68-102 kg a.i./ha. Fenamiphos was applied at 6.7 kg a.i./ha broadcast and disc-incorporated to 10-cm-deep.
[x]Gross increase was calculated as the average price of $3.52 (U.S./kg) paid to growers in 1995 for tobacco multiplied by the yield increase over control.
[y]Net increase equals gross increase less per ha treatment cost of $185 for 1,3-D and $291 for fenamiphos.
[z]Paired t-test comparisons significant at $P \leq 0.01$.

Application of 1,3-D requires an extra trip over the field while fenamiphos is mixed with herbicides by tobacco growers. The cost benefit analysis reflect these differences. Based on 1995 input prices, the estimated cost of using fenamiphos was $291/ha for the material alone. The estimated cost of using 1,3-D at 68 kg a.i/ha was $185/ha which included a charge for the application equipment of $14/ha, an additional pass over the field at $16/ha, and cost of material of $155/ha. Although fenamiphos was more costly to use, its benefits were less.

Data from this and previous studies (Garcia and Rich, 1983) have shown generally superior efficacy of 1,3-D in Florida compared to nonfumigant nematicides. Because 1,3-D kills nematodes on contact, it's retention around a developing root system is not required (Bunt, 1987). In comparison, nonfumigants must be retained to be effective. Thus, the deep sandy soils in Florida sometimes limit the effectiveness of nonfumigant nematicides during periods of high rainfall. The efficacy of fenamiphos, however, was good in these tests, and it may not leach as much as some other materials (Johnson *et al.*, 1995; Rahi *et al.*, 1993). Yield and economic data indicate 1,3-D as the preferred nematicide over fenamiphos. However, fenamiphos is a valuable tool particularly during cool, wet springs when application and movement of 1,3-D can be problematic. Repeated use of fenamiphos has resulted in reports of enhanced microbial degradation (Ou, 1991). In these tests, however, the efficacy of fenamiphos remained good, possibly due to use of the material on the same site at a minimum of two years apart.

Growers in other regions of the southeastern U.S.A. have access to other nonfumigant nematicides such as ethoprop and aldicarb (Johnson, 1995), but these products have previously been shown to be ineffective in Florida tobacco (Rich, unpubl.; Garcia and Rich, 1983). Multipurpose fumigants such as methyl-isothiocyanate generating compounds and chloropicrin are available for use and have been shown to provide fair to good nematode control (Garcia and Rich, 1983; Melton *et al.*, 1995). These materials have not been widely utilized by Florida tobacco growers due to favorable cost and efficacy of 1,3-D. Because of limited choices, loss of 1,3-D containing products or fenamiphos could be problematic to the Florida tobacco industry since over 95% of the acreage is treated with one of these two products. Other control options such as development of plant resistance to *M. javanica* should be explored to lessen dependence on chemical inputs.

Previous tests have indicated root-gall ratings compared favorably to counting nematodes in soil samples for chemical efficacy determinations (Rich *et al.*, 1984). However, variability of at-planting nematode population densities and environmental conditions can cause problems with timing of root-gall ratings to assess efficacy of chemical treatments. These data suggest that periodically observing root-gall development from nontreated border rows and obtaining all ratings when these are over 3 (0-4 scale) was a reliable method to provide good statistical separation in these tests.

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