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Management of Root-knot and Reniform Nematodes in Ultra-Narrow Row Cotton with 1,3-Dichloropropene[1]

R. A. Kinloch and J. R. Rich[2]

Abstract: Ultra-narrow row cotton studies were conducted during 1999 at two field sites in northern Florida. One site was naturally infested with *Meloidogyne incognita* Race 3 and the other with *Rotylenchulus reniformis.* The fumigant 1,3-dichloropropene (1,3-D) was applied broadcast at rates of 0, 16, 32, 48, 64, 80, and 96 kg ai./ha in replicated plots before planting Delta Pine 655 BRR cotton in 25-cm-wide rows. Post-harvest soil population densities at the root-knot nematode site had a significant ($P \leq 0.01$) negative linear relationship to 1,3-D dosage level. Cotton lint yields at this site had a significant ($P \leq 0.01$) positive linear relationship to 1,3-D dosage level. At the reniform nematode site, there was no relationship between post-harvest soil population densities of reniform nematodes and 1,3-D dosage level. However, significant ($P \leq 0.01$) positive curvilinear relationships were found between both plant heights and lint yield to 1,3-D dosage levels.

Key words: 1,3-dichloropropene, cotton, *Gossypium hirsutum, Meloidogyne incognita,* nematicide, reniform nematode, root-knot nematode, *Rotylenchulus reniformis.*

Upland cotton (*Gossypium hirsutum*) is an important agronomic crop in northern Florida and was grown on more than 40,000 ha in 2000 (Anonymous, 2001). Typical production practices include planting on 0.91-m-wide centers at a rate of approximately 9 seed/m row (Sprenkel, 1995). This row spacing has allowed mechanical access for traditional weed and insect management. With the advent of transgenic herbicide-resistant cotton cultivars, less reliance has been placed on cultivation for weed control. Similarly, reduced insect pressures have resulted from the success of the boll weevil eradication program in Florida and from use of transgenic cotton cultivars that contain a toxic protein from *Bacillus thuringiensis.* These developments led to use of higher cotton seeding rates in nonconventional row widths to improve crop yield. Recently, several reports have shown increased cotton yields and profitabilty using ultra-narrow rows (Cawley et al., 1999; Gerik et al., 2000; Husman et al., 2000; Wilson, 1999). Ultra-narrow row cotton, grown mainly on 25-cm-wide centers at approximately 310,000 seed/ha, is currently being produced on several farms in northern Florida (Wright et al., 2001).

Plant-parasitic nematodes, especially the southern root-knot nematode, *Meloidogyne incognita* Race 3, and the reniform nematode, *Rotylenchulus reniformis,* cause widespread yield losses of cotton in the United States. In Florida cotton fields, the frequency of occurrence of root-knot and reniform nematodes among fields is approximately 60% and 16%, respectively (Kinloch and Sprenkel, 1994). Because resistant cotton cultivars are not available, nematodes are managed by crop rotation and nematicides (Kinloch and Rich, 2000). However, due to the profitability of cotton compared to other row crops such as maize and soybean, many growers monoculture cotton. This has led to an increasing use of nematicides. The nematicides 1,3-dichloropropene (1,3-D) and aldicarb have been studied extensively in Florida and Georgia (Baird et al., 2000; Kinloch and Rich, 1998; Rich and Kinloch, 2000). Generally, appropriate rates have been defined, with 1,3-D producing the greatest cotton yield improvements. In Florida, recommended rates of 1,3-D in conventionally planted cotton range between 32 and 64 kg a.i./ha, with the lower rates effective in reniform nematode-infested fields and the higher rates needed in fields heavily infested with root-knot nematodes (Kinloch and Rich, 2000). The efficacy of 1,3-D in ultra-narrow row cotton has not been evaluated. The present tests were conducted to determine the influence of 1,3-D application on root-knot and reniform nematode soil population densities and cotton yield responses in ultra narrow-row production.

Materials And Methods

Studies were conducted during 1999 at two field sites in northern Florida. One site was in root-knot nematode-infested sandy loam soil (82% sand, 10% silt, and 8% clay) in Santa Rosa County (N30.47.642; W87.02.064), and the other was in reniform nematode-infested sandy loam soil (80% sand, 8% silt, and 12% clay) in Gadsden County (N30.32.059; W84.35.017). Both sites had been planted to cotton in 1998, and each was double-disced and fertilized with 5-10-15 NPK at 560 kg/ha for the 1999 crop season. The root-knot nematode site was demarcated to accommodate 48 plots, 2.74 m wide and 15.2 m long, arranged in six tiers separated by 7.6-m-wide alleys. These plots were sampled for nematodes on 28 April 1999 by taking six cores, 2.54 cm wide and 20 cm deep, from across each plot. The cores were mixed and a 100-cm^3 soil sub-sample from each plot was processed by centrifugal flotation (Jenkins, 1964). Second-stage infective juveniles (J2) averaged 25/100 cm^3 soil across all plots. The reniform nematode site was demarcated to accommodate 42 plots with dimensions as described

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[1] University of Florida, Agricultural Experiment Station Journal Series No. R-08067.
[2] University of Florida, Institute of Food and Agricultural Sciences, West Florida Research and Education center, 4253 Experiment Drive, Highway 182, Jay, FL 32565, and North Florida Research and Education Center, 30 Research Road, Quincy, FL 32353, respectively.
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E-mail: rakh@gnv.ifas.ufl.edu
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and arranged in six tiers separated by 4.3-m-wide alleys. At the latter site, reniform nematode soil population densities, sampled and processed as described above, averaged 389 all stages/100 cm^3 soil across non-treated plots on 1 June.

Treatments at both sites included applications of 1,3-D at 16, 32, 48, 80, and 96 kg a.i./ha. These were applied through chisels set 41 cm apart and injected 30 cm deep on 11 May at the reniform nematode site and on 18 May at the root-knot nematode site. Both sites included untreated check plots that were chiseled as described. The root-knot nematode site had an additional six untreated plots that were not chiseled. Cotton seed, Delta Pine 655 BRR, were planted with a grain drill in rows set 25 cm apart on 14 May at the reniform nematode site and on 28 May at the root-knot nematode site. Plant counts averaged 9/m row at the root-knot nematode site on 9 June and 6/m row at the reniform nematode site on 19 July. Plant heights at the reniform nematode site were measured on 19 July. Cotton at both sites was managed with herbicides and insecticides according to standard regional practices (Sprenkel, 1995). Neither site received additional irrigation. The entire plots on the reniform nematode site were harvested on 20 October with a mechanical cotton stripper; at the root-knot nematode site, harvesting was on 9 November by mechanically picking bolls from two 72-cm-wide swaths through each plot. Seed cotton weights were converted to lint cotton weights by multiplying by 0.4. Post-harvest nematode soil population densities were determined on 1 November at the reniform nematode site and on 15 November at the root-knot nematode site using sampling and extraction procedures as described above.

Results

At the root-knot nematode-infested site, plots assigned to each treatment were uniformly infested with J2 (Table 1). Increases in J2 soil population densities over the course of the crop season occurred in untreated plots, both chiseled and unchiseled, and in plots treated with 16 kg 1,3-D a.i./ha. Chiseling alone significantly ($P \leq 0.05$) reduced post-harvest soil infestation levels below that of the unchiseled check. Treatments of 32 kg 1,3-D a.i./ha and higher were sufficient to maintain post-harvest J2 soil population densities at the same level as found prior to treatment. Among the chiseled plots at the root-knot site, there was a significant negative relationship between post-harvest soil infestation levels of J2/100 cm^3 soil and 1,3-D a.i./ha. Cotton lint yields from the unchiseled and chiseled checks were not significantly ($P \leq 0.05$) different from each other (Table 1), and a significant yield increase over the chiseled check required a 1,3-D treatment of 48 kg a.i./ha. Among the chiseled treatments at this site, there was a significant positive relationship between lint yield/ha and 1,3-D a.i./ha (Fig. 1).

TABLE 1. Soil population densities of *Meloidogyne incognita* second-stage juveniles (J2) and yield of cotton grown in ultra-narrow rows in response to treatments of 1,3-dichloropropene (1,3-D) applied to sandy loam soil in Florida, 1999.

1,3-D[a] kg a.i./ha 18 May[b]	J2/100 cm^3 soil: Pre-treatment 28 April	J2/100 cm^3 soil: Post-harvest 15 November[c]	J2/100 cm^3 soil: t-significance[d]	Lint kg/ha 9 November
0 not chiseled	28 a	377 a	$P \leq 0.03$	490 d
0 chiseled	30 a	177 b	$P \leq 0.01$	637 cd
16	28 a	92 b	$P \leq 0.05$	739 bc
32	27 a	33 b	nsd	783 bc
48	25 a	31 b	nsd	903 ab
64	25 a	22 b	nsd	913 ab
80	20 a	13 b	nsd	937 ab
96	20 a	11 b	nsd	1,056 a

[a] Applied via chisels set 41-cm-apart and 30-cm-deep.
[b] Applied 10 days before planting.
[c] In chiseled treatments, post-harvest soil infestation levels of J2/100 cm^3 soil (Y) are related to 1,3-D a.i./ha (X) by $Y = 125 - 1.5X$, $r = -0.7$, $df = 40$, $P \leq 0.01$.
[d] Paired comparison between pre-treatment and post-harvest nematode soil densities.

Data are the averages of six observations. Averages followed by a similar letter within a column are not significantly ($P \leq 0.05$) different according to Duncan's multiple-range test.

Application of 1,3-D had an influence on cotton plant height at the reniform nematode-infested site (Table 2), where there was a significant positive relationship between plant height and 1,3-D kg a.i./ha. At least 32 kg a.i. 1,3-D/ha was required to increase cotton lint yields significantly ($P \leq 0.05$) above that from the untreated check. Yields from treatments at this and higher dosages could not be distinguished by mean separation. However, there was a significant positive curvilinear relationship between kg lint/ha and 1,3-D kg a.i./ha (Fig. 1).

There were no significant differences among the average post-harvest soil population densities of all stages of reniform nematodes following untreated and various 1,3-D treatments (Table 2). However, there was a tendency for reduced post-harvest nematode densities/100 cm^3 soil with increasing kg a.i. of 1,3-D/ha.

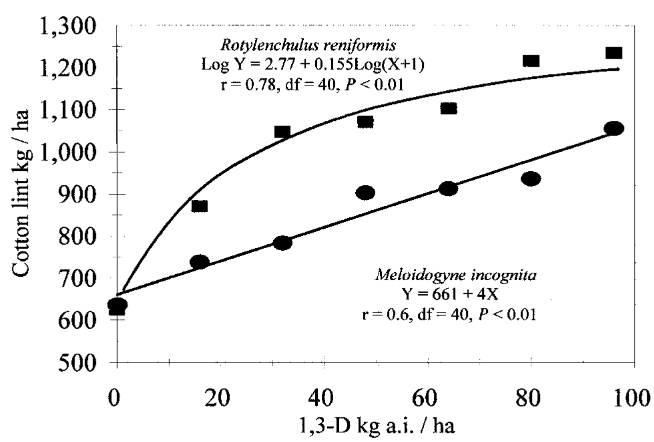

FIG. 1. Relationships between 1,3-D kg a.i./hectare and ultra-narrow row cotton lint yield responses in sandy loam soils separately infested with *Rotylenchulus reniformis* or *Meloidogyne incognita* in Florida. Data points represent averages of six observations.

TABLE 2. Plant heights and yields in ultra-narrow row cotton and post-harvest soil population densities of all stages of *Rotylenchulus reniformis* in response to treatments of 1,3-dichloropropene (1,3-D) applied to sandy loam soil in Florida, 1999.

1,3-D[a] kg a.i./ha 11 May[b]	Plant height cm 19 July[c]	Lint kg/ha 20 October	Nematodes 100 cm^3 soil 1 November[d]
0	60.1 d	626 c	1,500 a
16	72.3 c	871 b	1,088 a
32	78.1 bc	1,048 ab	868 a
48	84.6 ab	1,071 a	1,038 a
64	79.5 bc	1,103 a	669 a
80	89.8 a	1,216 a	825 a
96	87.4 ab	1,236 a	954 a

[a] Applied via chisels set 41 cm apart and 30 cm deep.
[b] Applied 4 days before planting.
[c] Plant height in cm (Y) is related to 1,3-D a.i./ha (X) by Log = 1.77 + 0.0.085Log(X + 1), r = 0.76, df = 40, $P \leq 0.01$.
[d] Post-harvest reniform nematode densities/100 cm^3 soil (Y) is related to 1,3-D/ha by Y = 1244 − 5.3X, r = −0.3, df = 40, $P \leq 0.03$.
Data are the averages of six observations. Averages followed by a similar letter within a column are not significantly ($P \leq 0.05$) different according to Duncan's multiple-range test.

Discussion

Nematodes were sampled in this study from across the plot area so the soil nematode population density data were indicative of the overall soil infestation rather than just from the treated crop row. This is in contrast to the sampling procedure that is normally used in studies involving conventionally planted cotton The significant negative effect that increasing dosage level of 1,3-D had on the post-harvest soil population density of root-knot nematode J2 could be a major factor in decisions to use ultra-narrow row production in *M. incognita*-infested soil and broadcast application of the fumigant for managing this nematode. The dosage/nematode relationship predicts that 96 kg 1,3-D a.i./ha, the highest dosage used in this study, was sufficient to reduce J2 post-harvest soil population densities to nearly undetectable levels. This would have a significant bearing on the choice of nematode management in a subsequent crop. Possibly, if these higher dosages of 1,3-D were used in the first year of a cotton monoculture, a second year of cotton production would not require fumigation. However, this would not be feasible if the soil was infested with *R. reniformis.* Although our data show a significant but slight negative effect of increasing dosage of 1,3-D on post-harvest reniform nematode soil population densities, damaging densities of nematodes remained even with the highest level of 1,3-D used in this study. Extrapolation of the derived dosage/nematode relationship indicated that as much as 235 kg 1,3-D a.i./ha applied broadcast would have been required to bring the reniform nematode populations down to nondetectable levels following harvest.

The relationship between lint yield and 1,3-D dosage in the root-knot nematode site predicts an average increase of 4 kg lint for each kg a.i. of 1,3-D applied. This yield response was equivalent to that found in previous studies using traditional row spacing in *M. incognita*-infested soil (Kinloch and Rich, 1998; Thomas and Smith, 1993). Also, ultra-narrow row cotton yield responses to 1,3-D application in *R. reniformis*-infested soil was similar to that found where cotton was planted in traditional row spacing (Rich and Kinloch, 2000).

We conclude that management of Florida's major nematode problems on ultra-narrow row cotton is feasible by broadcast applications of 1,3-D and that it may be more advantageous to use this production-and-treatment practice than traditional row spaced-fumigation for the long-term management of *M. incognita*. Populations of root-knot nematode are more effectively managed than those of reniform nematode by using this fumigation and cotton cropping practice. In fields infested with *R. reniformis,* the curvilinear relationship between yield and 1,3-D dosage indicates that the profitability of fumigant dosages higher than 30 kg a.i./ha will be greatly dependent on the relative value of fumigant and cotton lint.

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