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Responses of Cotton Yield and *Meloidogyne incognita* Soil Populations to Soil Applications of Aldicarb and 1,3-D in Florida[1]

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Abstract: In four tests conducted in loamy-sand soils in northern Florida, cotton lint yield increased and post-harvest soil populations of *Meloidogyne incognita* were more effectively suppressed by 1,3-dichloropropene (1,3-D) than aldicarb when both nematicides were evaluated over a range of recommended rates. Significant positive relationships existed between lint yield and rates of 1,3-D in three tests, whereas only one significant positive relationship occurred between lint yield and aldicarb rates. Yield increases ranged from 16% to 124%, depending on rate of 1,3-D, and 35% in one aldicarb-treated test. Only a weak negative relationship between post-harvest soil densities of second-stage juveniles (J2) and aldicarb rates was determined by combining data from the four tests. Aldicarb failed to suppress post-harvest J2 soil population densities in any test. All rates of 1,3-D significantly reduced post-harvest *M. incognita* J2 soil population densities in two tests and provided a stronger negative correlation between nematode soil densities and rates than aldicarb when all test data were combined for each nematicide.

Key words: 1,3-D, aldicarb, cotton, *Gossypium hirsutum*, *Meloidogyne incognita*, nematicide, nematode, southern root-knot nematode.

As in much of the southeastern United States, cotton (*Gossypium hirsutum*) has become the major agronomic crop in the northern tier of counties in Florida. Replacing mostly soybean (*Glycine max*) hectarage, cotton plantings in Florida have increased from 12,000 to 40,000 ha from 1987 to 1997. Much of this hectarage has been planted in soils infested with *Meloidogyne incognita*. Surveys have shown that this nematode occurs in more than 60% of cotton fields in Florida, and the average post-harvest mid-winter soil infestation level is more than 100 second-stage juveniles (J2)/100 cm^3 soil in these fields (Kinloch and Sprenkel, 1994). Some growers have adopted rotation practices with peanut to manage *M. incognita* in cotton. However, planting of peanut is limited due to marketing and allotment restraints. A crop of cotton following peanut largely escapes damage but enhances soil population densities of *M. incognita* such that a subsequent cotton crop can be at risk. Rotating cotton with peanut is not an option for most growers, and, taking advantage of favorable current market conditions for cotton, most growers are monoculturing cotton. Currently, the only alternative nematode management strategy is the use of nematicides. Nematicide recommendations for nematode management in Florida cotton include 10- to 15-cm banded applications of aldicarb at rates varying from 0.59 to 1.68 kg a.i./ha or single-chisel row applications of 1,3-dichloropropene (1,3-D) at rates varying from 34 to 128 kg a.i./ha, both based on 91-cm row spacing (Dunn and Noling, 1997).

The objective of this study was to determine the response of cotton yield and *M. incognita* J2 post-harvest soil population densities to aldicarb and 1,3-D applied over a range of their recommended rates.

MATERIALS AND METHODS

Studies were conducted in *M. incognita*-infested field soils at the Gardner Farm, Jackson County (loamy sand: 85% sand, 6% split, 9% clay), and at the Godwin Farm, Santa Rosa County (loamy sand: 82% sand, 10% silt, 8% clay), in 1995, and at two different sites on the Davis Brothers Farm, Santa Rosa County, 1996 and 1997 (both loamy sands: 82% sand, 10% silt, 8% clay). Prior to soil chemical treatment, assigned plots were assayed for *M. incognita* J2 by re-

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moving six cores (2.54-cm diam. × 22-cm deep) from each plot. Cores from individual plots were thoroughly mixed, and a 100-cm^3 subsample was removed for nematode extraction with centrifugal flotation (Jenkins, 1964).

Nematicide treatments were applied to randomized plots consisting of two rows, 7.6 m long and 91 cm apart. Treatments were replicated five times in the Jackson County test and six times in all other tests. The tests included replicated control plots, and all experimental sites were bordered by untreated cotton. The fumigant 1,3-D was applied to a depth of 30 cm via a single chisel beneath the row at 16, 32, 48, and 64 kg a.i./ha, 14 to 17 days before planting in all tests. Granular aldicarb was applied on a 10-cm-wide band and incorporated at planting at 0.50, 1.01, 1.51, and 2.02 kg a.i./ha in both tests conducted in 1995 and at rates of 0.50, 0.84, 1.18, and 1.51 kg a.i./ha in tests in 1996 and 1997. Since soil treatment with aldicarb is recommended to manage thrips, control plots and plots treated with 1,3-D received an at-planting phorate treatment at 1.13 kg a.i./ha. Planting and harvesting dates of Chembrand 407 cotton were 25 April and 20 November at the Jackson County site in 1995, and 15 May and 14 November at the Santa Rosa County site in 1995, respectively. Planting and harvesting dates of Delta pine 5415 cotton were 6 June and 14 November at the Santa Rosa County site in 1996, and 6 May and 20 November at the Santa Rosa County site in 1997, respectively. Soil fertility, weed control, and insect management at all sites were as recommended for the area (Sprenkel, 1996). Seed cotton was harvested from entire plots and converted to lint yield by multiplying by 0.40. Within 1 week following harvest, all plots were sampled for *M. incognita* J2 as described above. Data were analyzed with ANOVA and CORR programs in MSTAT-C software (Michigan State University, East Lansing, MI).

Results

There were no significant ($P < 0.05$) differences in the average pretreatment numbers of *M. incognita* J2 among plots in any test. Pretreatment J2 densities averaged 23 and 21 juveniles/100 cm^3 soil for the Jackson County and Santa Rosa County sites in 1995, respectively, and 4 and 25 J2/100 cm^3 soil for the sites in 1996 and 1997, respectively.

Cotton lint yield increases with aldicarb over the untreated control were significant ($P < 0.05$) only for the 1.51 kg a.i./ha treatment in the 1997 test (Table 1). Cotton lint yield did not increase from any rate of 1,3-D at the Santa Rosa County test site in 1995 (Table 2). However, significant increases were obtained with 1,3-D at 47.7 and 63.6 kg a.i./ha in the other three tests and by the 15.9 and 31.8 kg a.i./ha treatments in two of the other tests. In three tests there were positive correlations between cotton lint yield and rates of 1,3-D (Table 3). When data were combined from the four tests, the re-

TABLE 1. Cotton lint yield and post-harvest *Meloidogyne incognita* second-stage juvenile (J2) soil population densities following soil applications of aldicarb in four Florida field tests.

	Jackson, 1995		Santa Rosa, 1995		Santa Rosa, 1996		Santa Rosa, 1997	
Aldicarb (kg a.i. per ha)	Lint (kg per ha)	J2 per 100 cm^3 soil	Lint (kg per ha)	J2 per 100 cm^3 soil	Lint (kg per ha)	J2 per 100 cm^3 soil	Lint (kg per ha)	J2 per 100 cm^3 soil
None	361 a	62 a	715 a	613 a	391 a	353 a	460 b	1,125 a
0.50	490 a	71 a	752 a	615 a	599 a	287 a	404 b	1,465 a
0.84	—	—	—	—	521 a	173 a	406 a	1,162 a
1.01	492 a	62 a	748 a	418 a	—	—	—	—
1.18	—	—	—	—	559 a	77 a	495 a	1,015 a
1.51	489 a	34 a	772 a	523 a	464 a	467 a	621 a	750 a
2.02	498 a	84 a	788 a	393 a	—	—	—	—

Data are averages of five replicates at the Jackson County site and six replicates at the Santa Rosa County sites; data followed by similar letters within a column are not different ($P < 0.05$) according to Duncan's multiple-range test.

TABLE 2. Cotton lint yield and post-harvest *Meloidogyne incognita* seond-stage juveniles (J2) soil population densities following soil applications of 1,3-D in four Florida field tests.

1,3-D (kg a.i. per ha)	Jackson, 1995 Lint (kg per ha)	Jackson, 1995 J2 per 100 cm^3 soil	Santa Rosa, 1995 Lint (kg per ha)	Santa Rosa, 1995 J2 per 100 cm^3 soil	Santa Rosa, 1996 Lint (kg per ha)	Santa Rosa, 1996 J2 per 100 cm^3 soil	Santa Rosa, 1997 Lint (kg per ha)	Santa Rosa, 1997 J2 per 100 cm^3 soil
None	361 b	62 a	715 a	613 a	391 c	353 a	460 d	1,125 a
16	531 a	59 a	809 a	302 b	455 bc	285 a	708 c	180 b
32	621 a	117 a	817 a	172 b	507 abc	427 a	742 bc	75 b
48	575 a	44 a	813 a	143 b	578 ab	515 a	1,031 a	90 b
64	640 a	64 a	826 a	147 b	593 a	32 a	918 ab	168 b

Data are averages of five replicates at the Jackson County site and six replicates at the Santa Rosa County sites; data followed by similar letters within a column are not different ($P < 0.05$) according to Duncan's multiple-range test.

lationship between cotton lint yield (Y in kg per ha) and 1,3-D rate (X in kg a.i. per ha) was

$$Y = 529 + 4.1X,\ r = 0.44,\ \mathrm{df} = 113,\ P < 0.001.$$

Only in 1997 was there a positive correlation between cotton lint yield and rates of aldicarb. However, aldicarb increased cotton yield numerically in each test such that when data from the four tests were combined there was a relationship between cotton lint yield (Y in kg per ha) and aldicarb rate (X in kg a.i. per ha) expressed by

$$Y = 492 + 70X,\ r = 0.25,\ \mathrm{df} = 113,\ P < 0.01.$$

Soil densities of *M. incognita* J2 in untreated plots increased 3-, 29-, 88-, and 45-fold during the cotton growth season at the sites in Jackson County and Santa Rosa in 1995, and in the 1996 and 1997 tests, respectively. Aldicarb had no significant influence on post-harvest J2 densities in any of the tests (Table 4), whereas numbers were significantly reduced by all rates of 1,3-D in the Santa Rosa tests in 1995 and 1997. In both tests, post-harvest J2 densities were negatively correlated with rates of 1,3-D (Table 4). When data were combined from the four tests, the relationship between post-harvest J2 densities (Y per 100 cm^3 soil) and 1,3-D rate (X in kg a.i. per ha) was

$$Y = 444 - 5.8X,\ r = -0.32,\ \mathrm{df} = 113,\ P < 0.01.$$

DISCUSSION

The counties of northern Florida receive 125 to 180 cm of rainfall annually. Primarily as a result of hurricanes Erin and Opal, the test conducted in Santa Rosa County in 1995 suffered from extreme amounts of rainfall (98 cm) from 4 August to near cotton harvest. Despite extensive lodging, plants in untreated plots considerably outyielded those in other tests. Since all rates of 1,3-D significantly reduced nematode densities in this test, weather conditions ameliorated possible detrimental effects caused by nema-

TABLE 3. Relationships between cotton lint yield (Y in kg per ha) and rates of nematicides (X) in Florida field sites infested with *Meloidogyne incognita*, 1995–1997.

Site and year	Nematicide[a]	Relationship
Jackson Co.—1995	Aldicarb	None
	1,3-D	Y = 425 + 3.8X, r = 0.64, df = 23, $P < 0.01$
Santa Rosa Co.—1995	Aldicarb	None
	1,3-D	None
Santa Rosa Co.—1996	Aldicarb	None
	1,3-D	Y = 399 + 3.3X, r = 0.56, df = 28, $P < 0.01$
Santa Rosa Co.—1997	Aldicarb	Y = 394 + 102X, r = 0.40, df = 28, $P < 0.05$
	1,3-D	Y = 524 + 7.8X, r = 0.73, df = 28, $P < 0.01$

[a] Aldicarb was evaluated at 0, 0.50, 1.01, 1.51, and 2.02 kg a.i./ha in 1995, and 0, 0.50, 0.84, 1.18, and 1.51 kg a.i./ha in 1996 and 1997. 1,3-D was evaluated at 0, 16, 32, 48, and 64 kg a.i./ha.

TABLE 4. Relationships between post-harvest populations of *Meloidogyne incognita* J2 per 100 cm^3 soil (Y) and rates of nematicides (X) applied to cotton in Florida field sites, 1995–1997.

Site and year	Nematicide[a]	Relationship
Jackson Co.—1995	Aldicarb	None
	1,3-D	None
Santa Rosa Co.—1995	Aldicarb	None
	1,3-D	$Y = 494 - 6.9X$, $r = -0.76$, df = 23, $P < 0.01$
Santa Rosa Co.—1996	Aldicarb	None
	1,3-D	None
Santa Rosa Co.—1997	Aldicarb	None
	1,3-D	$Y = 728 - 12.6X$, $r = -0.6$, df = 28, $P < 0.01$

[a] Aldicarb was evaluated at 0, 0.50, 1.01, 1.51, and 2.02 kg a.i./ha in 1995, and 0, 0.50, 0.84, 1.18, and 1.51 kg a.i./ha in 1996 and 1997. 1,3-D was evaluated at 0, 16, 32, 48, and 64 kg a.i./ha.

todes and masked any value that may have accrued from the 1,3-D treatments. Consequently, if data from this test were removed, the relationship between cotton lint yield (Y in kg per ha) and rates of 1,3-D (X in kg per a.i. ha) from the remaining tests would be

$$Y = 451 + 5.03X,\ r = 0.52,\ \mathrm{df} = 83,\ P < 0.001.$$

Thus, in average years there was a predicted increase of approximately 5 kg of cotton lint/ha for each kg a.i. of 1,3-D applied per ha. A previous report recorded 4 kg/ha cotton lint for each kg a.i. of 1,3-D applied (Thomas and Smith, 1993). The range of 1,3-D rates evaluated in our tests was not extensive enough to determine phytotoxicity on the cotton crop. Consequently, increasing rates of 1,3-D above those tested may provide further increases in lint yield. Similarly, there was a significant trend of decreasing J2 densities with increasing rates of 1,3-D. The maximum rate of 1,3-D tested was insufficient to reduce J2 enough that a subsequent cotton crop could forego nematicide application. Aldicarb did not consistently improve cotton yields, even at the higher-than-recommended rates used. The failure of aldicarb to reduce *M. incognita* J2 densities has been observed previously (Colyer et al., 1997).

A grower's option for nematicidal management of *M. incognita* on cotton depends on the relationship between nematicide application costs and expected income from increased yield. We believe the data presented here will aid in this decision-making.

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