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EFFECTS OF NEMATICIDES ON *ROTYLENCHULUS RENIFORMIS* IN COTTON[1]

by
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Summary. Three field trials were conducted at two locations in Georgia, U.S.A., over three years to compare the efficacy of aldicarb, fenamiphos, 1,3-dichloroproprene (1,3-D), and oxamyl at various rates and combinations on the growth of cotton and population densities of the reniform nematode, *Rotylenchulus reniformis.* The 1,3-D was injected 30-cm-deep with a single in-row chisel and bedded prior to planting. Aldicarb and fenamiphos were applied in-furrow during planting, and oxamyl was applied as a foliar spray at the first pinhead-square stage of cotton growth. Cotton lint yields varied by location and year but were improved with the aldicarb (0.59 kg a.i./ha) + oxamyl (0.28 kg a.i./ha) and the 1,3-D (28.1 kg a.i./ha) + aldicarb (0.59 kg a.i./ha) treatments. Lint yields in the fenamiphos treatment did not differ from the controls in four of five tests. Plant stand, height and reniform nematode populations generally did not differ among treatments. Based on data from this investigation, selected chemicals and rates can be recommended to cotton producers to manage damaging levels of the reniform nematode.

The reniform nematode, *Rotylenchulus reniformis* was first detected on cotton in the continental United States in Georgia (Smith, 1940). Forty years later, it was found in every state in the southeastern United States (Heald and Robinson, 1990) and in Georgia it was found in over one-third of the counties surveyed (Baird *et al.*, 1996a). As production expanded over the past decade, the reniform nematode has become the most serious nematode threat to cotton production in the U.S.A. (Gazaway, 1993). During unfavorable growing conditions, yield losses can be 40-60% in continuously planted cotton fields (Birchfield and Jones, 1961). The reproductive potential and the ability to survive in drought conditions for extended periods enables *R. reniformis* to become the dominant nematode species in the fields; it has been reported to displace *Meloidogyne incognita* in Alabama cotton fields (Gazaway, 1993) and a similar trend has occurred in Georgia (Baird, unpub. data).

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Currently, crop rotation with peanut, corn or sorghum (Gazaway, 1993) is an option available for control of reniform nematodes. Peanut is a nonhost crop of *R. reniformis* and an economically beneficial rotational crop for reducing reniform nematode population densities (Baird *et al.*, 1996b). In the principal areas where this nematode is present, however, growers have traditionally not grown peanut. Corn and sorghum are planted throughout Georgia, but the area grown is low in comparison to cotton. With limited rotation options and the nonavailability of resistance, nematicides are the best method for controlling nematodes in fields where cotton follows cotton. The objective of this study was to determine the efficacy of currently available nematicides for reniform nematode management on cotton.

Materials and methods

In 1995, 1996, and 1997, field trials were established at two locations with previous histories of reniform nematode damage on cotton. One location was in southwestern Georgia U.S.A. at Hattaway Farm with a loamy sand soil (fine-loamy, siliceous thermic Plinthic Kandiudults; pH 6.3). The second site was in southeastern Georgia at Webster Farm with a loamy sand soil (fine-loamy, siliceous, thermic Plinthic Kandiudults; pH 6.0). The average *Rotylenchulus reniformis* Linford *et* Oliveira infestation level at the Hattaway Farm was 2,312 juveniles/100 cm^3 of soil at planting in 1995; the level was 228 and 130 in 1996 and 1997, respectively. Initial infestation levels at Webster Farm were 782/100 cm^3 soil in 1995, 203 in 1996, and 214 in 1997. Cotton (*Gossypium hirsutum* L.) seed bed preparation was by conventional tillage which included discing followed by in-row subsoiling and bedding of the rows. All fertilization rates and weed control practices followed standard recommendations for cotton production in Georgia (Crawford *et al.*, 1995).

Treatments in all experiments were placed in a randomized complete block design with four replicates. Plots were 12-rows wide and rows were on 91 cm centers. At Hattaway Farm, plot lengths were 317 m in 1995, 76 m in 1996, and 83 m in 1997. At Webster Farm, plot lengths were 259 m in 1995 and 1996, and 283 m in 1997. The fumigant 1,3-dichloropropene (1,3-D) was injected into the soil using a single in-row chisel at 30 cm below the final planting depth 10 days prior to planting, and the chisel opening was sealed with a press wheel. Seed of cv. Delta and Pine Land 90 and cv. Hyperformer 46 were planted in May of each year at both locations. Chemical treatments varied by year and location as indicated in Tables I and II. Granules of aldicarb, oxamyl and fenamiphos were applied in-furrow using a planter mounted applicator just before or at planting at the rates indicated in Tables I and II. Disulfoton was applied for management of thrips (*Frankinella* spp.) in the control plots since the other nematicdes have activity against this cotton pest.

Twenty soil cores (2.5 cm diam) were taken in each plot to 25-cm-deep, mixed and nematodes were extracted from a 100 cm^3 soil subsample by centrifugation-flotation (Jenkins, 1964) and counted. Plant stand counts were recorded from 6.1 m of row in each plot. Heights were determined from 20 randomly selected plants in each plot. Heights were measured between late June and early September at each location and cotton was harvested mechanically in November at Hattaway Farm and in October at Webster Farm. Cotton was mechanically harvested on 17 November 1995, 16 November 1996, and 10 November 1997 at Hattaway Farm. At Webster Farm, harvesting was conducted on 7 October 1995, 20 October 1996, and 18 October 1997.

Data were analyzed by analysis of variance procedures and differences among means were separated by Waller-Duncan's k-ratio t-test ($P \leq 0.05$).

Results

Nematode population densities from midseason soil samples did not differ ($P \leq 0.05$) among treatments or with the controls (disulfoton) in the six tests (Table I). At planting and at harvest nematode densities similarly showed no differences in these tests and no treatment effects were determined ($P \leq 0.05$ - data not shown). Plant stand densities varied per treatment and among years during this investigation but were not significantly different (data not shown). At the Webster Farm, plant heights were not significantly different among chemical treatment or the controls (data not shown). At the Hattaway Farm in 1995 plots treated with 1,3-D at 28.1 L a.i./ha + aldicarb at 0.59 kg a.i./ha had significantly increased plant heights compared to the control. Plant heights were not different the following two years at this location.

Cotton lint yields at Webster Farm in 1995 and 1996 were similar between treatments and the control, although most chemical treatments were numerically higher (Table II). In 1997, six of the eight chemical treatments significantly improved cotton lint yield over the controls. Aldicarb at 0.59 kg a.i./ha + oxamyl at 0.56 kg a.i./ha produced the greatest yield followed closely by the aldicarb at 0.59 kg a.i./ha. At Hattaway Farm plots treated with 1,3-D at 28.1 L a.i./ha + aldicarb at 0.59 kg a.i./ha had consistently higher yields during the three year investigation. In 1995, fenamiphos at 1.68 kg a.i./ha had greater yield numerically than the other treatments, but aldicarb at 1.17 kg a.i./ha + oxamyl at 0.28 kg a.i./ha and aldicarb at 0.59 kg a.i./ha produced numerically greater yields in 1996. In 1997, 1,3-D at 28.1 L a.i./ha + aldicarb at 0.59 kg a.i./ha and aldicarb alone at 1.17 kg a.i./ha significantly increased yields over the control.

TABLE I - *Effect of nematicide treatments on* Rotylenchulus reniformis *population levels in infested cotton fields in Georgia U.S.A.*

Treatment	Rate a.i./ha	Number of nematodes per 100 cm^3 of soil (midseason)					
		Webster Farm			Hattaway Farm		
		1995	1996	1997	1995	1996	1997
Dichloroproprene + aldicarb	28.1 L 0.59 kg	473 a[a]	263 a	154 a	307 b	76 a	68 a
Aldicarb	0.59 kg	1,493 a	322 a	157 a	341 ab	1,249 a	92 a
Aldicarb	1.17 kg	1,700 a	287 a	164 a	481 ab	1,250 a	150 a
Aldicarb	0.84 kg	1,455 a	110 a	212 a	–	–	–
Aldicarb + oxamyl	1.17 kg 0.28 kg	–	–	–	691 a	1,876 a	100 a
Fenamiphos	1.68 kg	–	310 a	196 a	428 ab	3,167 a	118 a
Disulfoton (control)	1.17 kg	953 a	113 a	505 a	554 ab	895 a	238 a
Aldicarb + oxamyl	0.59 kg 0.56 kg	643 a	235 a	128 a	–	–	–
Aldicarb + oxamyl	0.59 kg 0.28 kg	560 a	210 a	48 a	–	–	83 a

[a]Means within a column with a letter in common are not significantly different ($P \leq 0.05$) according to Waller-Duncan k-ratio t-test.

TABLE II - *Effect of nematicide treatments on yield (lint kg/ha) of cotton in* R. reniformis *infested fields in Georgia U.S.A.*

Treatment	Rate a.i./ha	Webster Farm			Hattaway Farm		
		1995	1996	1997	1995	1996	1997
Dichloroproprene + aldicarb	28.1 L 0.59 kg	881 a[a]	1,198 a	526 a-c	948 a	1,102 a	1,031 a
Aldicarb	0.59 kg	780 a	1,125 a	546 a-c	828 ab	1,107 a	945 b
Aldicarb	1.17 kg	700 a	966 a	485 c-e	780 b	1,077 ab	1,026 a
Aldicarb	0.84 kg	914 a	971 a	545 a-c	–	–	–
Aldicarb + oxamyl	1.17 kg 0.28 kg	–	–	–	833 ab	1,125 a	981 ab
Fenamiphos	1.68 kg	–	1,036 a	515 a-d	973 a	1,067 ab	815 b
Disulfoton (control)	1.17 kg	801 a	973 a	417 e	825 ab	931 b	792 b
Aldicarb + oxamyl	0.59 kg 0.56 kg	960 a	994 a	556 a	–	–	–
Aldicarb + oxamyl	0.59 kg 0.28 kg	928 a	1,141 a	495 c	–	–	980 ab

[a] Means within a column with a letter in common are not significantly different (P≤0.05) according to Waller-Duncan k-ratio t-test.

Discussion

Population densities of reniform nematodes were similar between the nematicide treatments at both locations during this investigation. Numerical differences were observed at Webster Farm, but population levels varied among treatments for each year. At Hattaway Farm, population levels were numerically lower than the other treatments during each year in plots treated with 1,3-D at 28.1 l a.i./ha + aldicarb at 0.59 kg a.i./ha. The large plot sizes used in this test, and high reproductive potential of the nematode, probably contributed to the lack of significant differences in population levels among treatments. In other studies comparing different rates of aldicarb, with or without oxamyl, significantly lower population densities of reniform nematodes occurred which also corresponded with increased yields (Burmester *et al.*, 1997; Lawrence *et al.*, 1997; Goodell and Eckert, 1998).

Chemical application had little effect on cotton stand counts among treatments thus indicating little phytotoxicity to germinating seed. Additionally, periodic observations after stand establishment did not reveal abnormal foliar symptoms. Plant height varied among the treatments at both locations in 1995 but were similar among treatments for the remainder of the study.

Treatments containing plants with significantly greater heights (P≤0.05) did not have the greatest yields in 1995.

Yields varied among the treatments at both locations throughout the study. At Webster Farm, yields in the nematicide treatments were similar to the disulfoton control in 1995 and 1996. In 1997, drought was severe and rainfall was absent for 60 days during the critical stages of flowering and boll development, resulting in very low yields. Significant differences in yield, however, were recorded in 1997. At Hattaway farm, 1,3-D at 28.1 l a.i./ha + aldicarb at 0.59 kg a.i./ha produced consistently higher yields; it is uncertain why this treatment did not provide similar yield levels at Webster Farm. At both locations, the 1,3-D + aldicarb treatment produced highest average lint yield (158 kg/ha) over all chemical treatments compared to the control. These data are similar to those of McGriff *et al.* (1997) who found higher cotton yields with the combination of 1,3-D + aldicarb than with aldicarb alone.

In Georgia, the 0.59 kg a.i./ha rate of aldicarb is used primarily for thrips control and is believed to have marginal nematicide activity (Baird *et al.*, 1995). However, the average yield increase at this rate was 99 kg/ha while with the 0.84 and 1.17 kg a.i./ha rates, yields were 80 and 49 kg/ha, respectively. It is suspected that lower yields at the higher rates may have been due to undetected phytotoxity. High in-furrow rates of aldicarb have periodically been found to cause phytotoxity in cotton. In Louisiana, aldicarb applied in-furrow at 0.55-0.59 kg a.i./ha from 1981 through 1996 increased yields over untreated control plots in 27 trials by an average of 328 kg/ha when the reniform nematode was present in cotton fields (Overstreet and McGawley, 1997). In Alabama, aldicarb at 0.84 and 1.17 kg a.i. kg/ha increased yields by 151 kg/ha and 174 kg/ha, respectively, in two separate trials (Burmester *et al.*, 1997). In another investigation, significantly greater yields were noted when 1,3-D was applied, but aldicarb did not show significant increases (Goodell and Eckert, 1998).

Treatments containing aldicarb at 0.59 kg a.i./ha + oxamyl at 0.28 kg a.i./ha increased yields compared with the controls by an average of 140 kg/ha. Similarly in Alabama, when oxamyl was applied in plots treated with aldicarb, yield increases were noted ranging from 73 to 364 kg/ha, but there was a decrease of 196 kg/ha in one of the three trials (Burmester *et al.*, 1998).Yield increases were also noted when using this combination in several trials in Mississippi (Lawrence and McLean, 1994). In a study in Arkansas, the aldicarb + oxamyl treatments, however, did not provide yield benefits (Lorenz *et. al.*, 1998). If oxamyl was applied later than at the pinhead-square stage, beneficial plant-bug populations could have been lowered which adversely affected subsequent yields (Ruberson, unpub. data).

Fenamiphos showed variable results in ability to increase cotton yields, although average yield increase was 93 kg/ha. Lint yields in this treatment, however, did not differ from the controls in four of five tests. It is uncertain why results were inconsistent using fenamiphos during the study. One possibility is that fenamiphos increases soil microflora populations that naturally degrade the nematicide and subsequently reduces the efficacy of this chemical (Ou *et al.*, 1994).

Select nematicide treatments evaluated at both locations improved yield, but efficacy of individual treatments varied each year. Variations in nematode population densities among plots makes it difficult to evaluate the efficacy of nematicides (Noe, 1990). Even though populations densities of reniform nematodes are considered to be more uniform across fields than other cotton nematode species, variations among plots in this study were observed. Even with population density variations, the 1,3-D + aldicarb, aldicarb + oxamyl and aldicarb alone were generally effective, and these nematicides can be recommended for nematode control in Georgia cotton.

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