RELATIVE EFFICACY OF SELECTED NEMATICIDES FOR MANAGEMENT OF *ROTYLENCHULUS RENIFORMIS* IN COTTON

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ABSTRACT

Koenning, S. R., D. E. Morrison, and K. L. Edmisten. 2007. Relative Efficacy of Selected Nematicides for Management of *Rotylenchulus reniformis* in Cotton. Nematropica 37:227-235.

The effectiveness of selected fumigant and non-fumigant nematicides for management of the reniform nematode, *Rotylenchulus reniformis*, on cotton was evaluated in field experiments in relatively high and low yield environments. Fumigant nematicides 1,3 dichloropropene (1,3-D) or metam sodium provided significant yield increases on cotton, whereas non-fumigant nematicides aldicarb, aldicarb plus oxamyl, or fenamiphos provided variable results. Metam sodium and 1,3-D were equally effective in limiting population densities of *R. reniformis* at mid-season but final population levels at cotton harvest were unaffected by any treatment. Cotton lint yield was positively related to the application rate of metam sodium or 1,3-D. Cotton profitability was improved by low rates of 1,3-D in a low yield environment, but all rates of fumigants were effective in improving cotton profitability in a high yield environment.

Key words: 1,3-dichloropropene, aldicarb, cotton, crop loss, fenamiphos, *Gossypium hirsutum*, host-plant tolerance, management, metam sodium, nematicides, nematode, oxamyl, reniform nematode, *Rotylenchulus reniformis*.

RESUMEN

Koenning, S. R., D. E. Morrison, and K. L. Edmisten. 2007. Eficacia relativa de algunos nematicidas para el manejo de *Rotylenchulus reniformis* en algodón. Nematropica 37:227-235.

Se evaluó la efectividad de algunos nematicidas fumigantes y no fumigantes para el manejo del nematodo reniforme, *Rotylenchulus reniformis*, en algodón en experimentos de campo en ambientes de productividad relativamente alta y baja. Los nematicidas fumigantes 1,3 dicloropropeno (1,3-D) y metam sodio aumentaron significativamente la producción de algodón, mientras que los nematicidas no fumigantes aldicarb, aldicarb más oxamil, o fenamifós mostraron resultados variables. Metam sodio y 1,3-D fueron igualmente efectivos en reducir poblaciones de *R. reniformis* en la mitad de la temporada, pero las poblaciones al tiempo de cosecha no se vieron afectadas por ninguno de los tratamientos. La producción de algodón se relacionó positivamente con las tasas de aplicación de metam sodio ó 1,3-D. La rentabilidad del algodón se aumentó con tasas bajas de 1,3-D en ambientes de baja productividad, pero todas las tasas fueron efectivas en mejorar la rentabilidad del algodón en ambientes de alta productividad.

Palabras clave: 1,3-dicloropropeno, aldicarb, algodón, fenamifós, *Gossypium hirsutum*, manejo, metam sodio, nematicidas, nematodo, nematodo reniforme, oxamil, pérdidas de cultivo, *Rotylenchulus reniformis*, tolerancia de planta hospedante.

INTRODUCTION

The reniform nematode, *Rotylenchulus reniformis* Linford and Oliveira, is wide spread in the Southeastern United States cotton production region (Koenning *et al.*, 2004). This pathogen can parasitize cotton *Gossypium hirsutum* L., soybean *Glycine max*

L., and numerous vegetable crops (Koenning *et al.*, 2004; Robinson *et al.*, 1997).

Tactics for management of the reniform nematode in cotton in the southeastern U.S. are limited. Peanut and corn can be effective in rotation with host crops where *R. reniformis* is present, but the hectarage of these crops is limited in areas of intensive cotton production (Davis *et al.*, 2003; Lawrence and McLean, 2002b). Resistance to *R. reniformis* in *G. hirsutum* has not been found (Robinson and Bridges, 1998; Robinson and Percival, 1997; Robinson *et al.*, 1999) but recently progress in introgressing resistance from other *Gossypium* species has been made (Robinson *et al.* 2006). Tolerance to reniform nematode has not been positively identified in commercially grown cotton cultivars (Koenning *et al.*, 2000; Robinson and Bridges, 1998; Robinson *et al.*, 1999; Robinson and Percival, 1997; Usery *et al.*, 2005). Management of this nematode also is complicated by the fact that it has the potential to colonize a wide range of soil types and the soil profile to depths of over a meter or more, and survival in the absence of a host tends to be high (Davis *et al.*, 2003; Koenning *et al.* 1996; Robinson *et al.*, 2005).

Nematode management in cotton is largely dependent on nematicides, but research on chemical management in current production systems is limited (Koenning *et al.*, 2004; Lawrence and McLean, 2000; Lawrence and McLean, 2002; Lawrence *et al.*, 1990; Starr, 1988). Management is further complicated by enhanced degradation of aldicarb, a frequently used nematicide in cotton production, in some fields (McLean and Lawrence, 2003). Suitable alternatives to aldicarb have been lacking until the recent introduction of seed treatments for nematode control (Faske and Starr, 2006; Monfort *et al.*, 2006).

Field research focused on the effects of nematicides for the management of reniform nematode in cotton was conducted from 2002 through 2005. Specific objectives of this research were to evaluate the impact of fumigant and non-fumigant nematicides on population densities of *R. reniformis*, on cotton lint yield in the presence of this nematode, and to evaluate the economic potential of nematicides to improve cotton profitability in relatively high or low yield environments.

MATERIALS AND METHODS

Two series of nematicide experiments were conducted from 2001 through 2005 in fields infested with high levels of *R. reniformis* (2000 + per pint (473 cm^3) of soil based on samples taken in the fall is considered a high level [Anonymous 2007]). All experiments were conducted using standard cultural practices for cotton in North Carolina (Anonymous 2007).

The first experiments (series 1) were established in 2001and 2002 in Hoke and Scotland Counties with the cotton cultivar Deltapine 458BR. The soil type at the Hoke County site was a Blaney loamy sand (77% sand, 14% silt, 9% clay, <1% organic matter) with pre-fumigation initial population density (Pi) of 6,616, SD 4,089 vermiform reniform nematodes/500 cm^3 soil. The soil type at the Scotland County site was a Coxville loam (57% sand, 25% silt, 18% clay, <1% organic matter) with a Pi of 6,828, SD 6,685 vermiform reniform nematodes/500 cm^3 soil, respectively. The fumigant 1,3-dichloropropene (1,3-D) was injected 12 inches deep 3 weeks prior to planting in selected plots in all experiments. Plots receiving 1,3-D were injected with the fumigant at rates of 17.0, 34.0, 51.0 and 68.0 kg (a.i.)/ha. Controls included seed treated with thiamethoxam at 2.5 mg (a.i.)/kg of seed, in-furrow treatment with acephate at 1.12 kg (a.i.)/ha, and aldicarb at 0.50 kg (a.i.)/ha at planting for control of early season insects. Fumigant treatments also received aldicarb in-furrow at the insecticidal rate of 0.50 kg (a.i.)/ha for insect control. Additional treatments included aldicarb at 0.84, and 1.18 kg (a.i.)/ha applied in-furrow at planting, aldicarb applied at 2.35 kg/ha in a 15-cm band incorporated immediately before planting with rolling tines, aldicarb at 0.5 and 0.84 kg (a.i.)/ha plus oxamyl applied at 0.55 kg (a.i.)/ha as a banded spray over the cotton at the 5 true leaf stage, fenamiphos at 1.0, 1.34, 1.65 kg (a.i.)/ha in furrow at planting and at 2.35 kg/ha in a 15-cm band as with aldicarb. Seed for all treatments, with the exception of the thiamethoxam treated controls, were treated only with fungicides to improve stands. Plots were four rows wide by 7.62 m long with 3 m alleys between replicates.

The second series of experiments was established in Scotland Co. (series 2) in different areas of the same field used in 2002 with cotton cultivar FM 960BR in 2004 and 2005. The mean Pi in 2004 was 5,509, SD 4,477 and in 2005 was 8,193, SD 3,954 reniform nematode vermiforms/500 cm^3 soil. Controls included imidacloprid at 2.5 mg (a.i.)/kg of seed and in furrow treatment with disulfoton at 1.12 kg (a.i.)/ha, or 0.50 kg (a.i.)/ha aldicarb in furrow at planting for early season insect control. Fumigant nematicide treatments were 1,3-D at rates of 17.0, 34.0, 51.0 and 68.0 kg (a.i.)/ha and metam sodium at 14.3, 28.6, 42.9 and 57.3 kg (a.i.)/ha. Fumigant treatments all received 0.50 kg (a.i.)/ha aldicarb in furrow at planting for early season insect control. Non-fumigant treatments included aldicarb at 0.5, 0.84 and 1.18 kg (a.i.)/ha applied in furrow, imidacloprid on seed at planting plus aldicarb at 0.84 kg (a.i.)/ha in furrow at planting, imidacloprid on seed at planting plus an aldicarb side-dress application at 0.84 kg(a.i.)/ha six weeks after planting, 1.18 kg (a.i.)/ha aldicarb in-furrow at planting, and 0.84, kg (a.i.)/ha aldicarb applied in-furrow and then as a side-dress 6 weeks later. Seed for all treatments, with the exception of the imidacloprid treated controls, were treated only with fungicides to improve stands. Plots were two rows wide by 7.6 m long with 3 m alleys between replicates.

Cotton-lint yield was determined after harvest with a modified commercial cotton picker. Samples for nematode assays for each plot were collected prior to fumigation (Pi), at mid-season (Pm), and at cotton harvest. Each soil sample consisted of 8 to 10 soil cores (2.5-cm-diam.) taken to a depth of 15 cm from the center two rows of each plot and composited. A 500-cm^3 subsample was processed by elutriation and centrifugation to extract vermiform nematodes from soil (Barker *et al.*, 1986).

Data analysis consisted of analysis of variance (ANOVA) for a randomized complete block design with six replicates each year (SAS Institute, Cary, NC). The Waller Duncan k-ratio *t* test was used for mean separation and orthogonal contrasts were used to evaluate groups of treatments and rate effects. Years or locations for the field tests were considered to be random effects for combined analysis over years. Nematode numbers were transformed ($\log_{10}[x + 1]$) to normalize variances. Untransformed data are presented in figures for clarity. Regression analysis (PROC GLM) was used to compare the efficacy of selected nematicidal treatments as well as the heterogeneity of slopes test.

The profitability of fumigant nematicides for improving cotton lint yield was evaluated graphically by calculating the value of the cotton crop in response to the various rates of fumigant nematicide used. The value of cotton was calculated assuming a sale price of US $1.32/kg, and the cost of the fumigant 1,3-D as US $2.79/kg, and metam sodium as US $2.32/kg. Thus, profit was the increase in cotton lint yield over the control less the cost of fumigant.

RESULTS

Series One

The data for the 2 years, 2001 and 2002, were pooled because there was no year by nematicide interaction and the two years did not differ with regard to nematicide efficacy.

The yield of cotton cultivar Deltapine 458BR was low both years due to drought at the test locations (Fig. 1). Cotton lint yield was not increased ($P \leq 0.10$) in either 2001 or 2002 according to ANOVA, but yield of fumigant treatments were greater (P = 0.0009) than the three controls (acephate, thiamethoxam seed treatment, acephate 1.12 kg (a.i.)/ha at planting, or 0.50 kg (a.i.)/ha aldicarb in furrow at planting for early season insect control) according to orthogonal contrasts. The comparison of the controls with fenamiphos revealed yield increases (P = 0.0251) using contrasts, but aldicarb treatments were not greater than the controls (P = 0.2351). Treatments that included a foliar application of oxamyl at the five leaf stage following application of aldicarb did not differ from aldicarb alone treatments. The midseason population density (Pm) of *R. reniformis* was affected by only a few nematicide treatments according to the Waller Duncan k-ratio *t* test (Fig. 2). The four treatments of 1,3-D were lower (P = 0.0829) than the controls with orthogonal contrasts and the numbers of reniform pm were negatively related to the rate of fumigant applied (P = 0.0009, R^2 = 0.15). The reniform nematode pm with the 1.65 kg/ha rate of fenamiphos was as low as that of the fumigant treatments, but other treatments with fenamiphos, aldicarb, or aldicarb plus oxamyl did not differ from the control. Final population densities of *R. reniformis* were unaffected by nematicide treatment in either experiment.

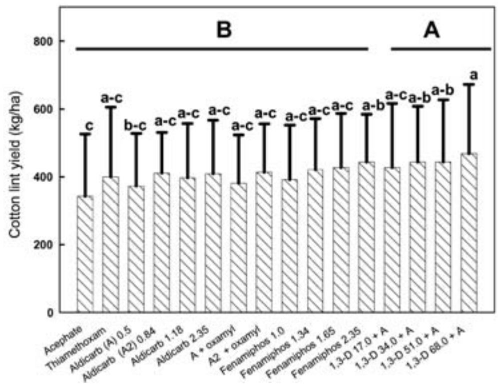

Fig. 1. Impact of nematicides on the mean and standard deviation of cotton lint yield for cultivar Deltapine 458BR in two fields infested with *Rotylenchulus reniformis* in 2001 and 2002. Controls: thiamethoxam at 2.5 mg (a.i.)/kg of seed, in furrow treatments with acephate at planting at 1.12 kg (a.i.)/ha, or (A) = aldicarb at 0.50 kg (a.i.)/ha. Nematicidal treatments: (A2) = aldicarb at 0.84 kg (a.i.)/ha aldicarb in furrow, aldicarb at 1.18 kg (a.i.)/ha in furrow at planting, aldicarb at 2.35 kg (a.i.)/ha in a 15 cm band incorporated at planting, fenamiphos at 1.0 kg (a.i.)/ha in furrow, fenamiphos at 1.34 kg (a.i.)/ha in furrow at planting, fenamiphos at 1.34 kg (a.i.)/ha in furrow at planting, fenamiphos at 2.35 kg (a.i.)/ha in a 15 cm band incorporated at planting, and 1,3-dichloropropene (1,3-D) was injected two weeks prior to planting at rates of 17.0, 34.0, 51.0, and 68 kg/ha plus 0.5 kg (a.i.)/ha aldicarb in furrow at planting. Means with the same lower case letters do not differ according to Waller Duncan k-ratio *t* test (k-ratio = 50). Horizontal bars indicate treatments with 1,3-D are greater (P = 0.023) than all other nematicidal treatments according to orthogonal contrasts.

Series Two

Data for the years 2004 and 2005 were pooled because there was not a year by nematicide interaction. The lint yield of Fiber Max 960BR was much greater in this series of experiments (2004-2005) than for

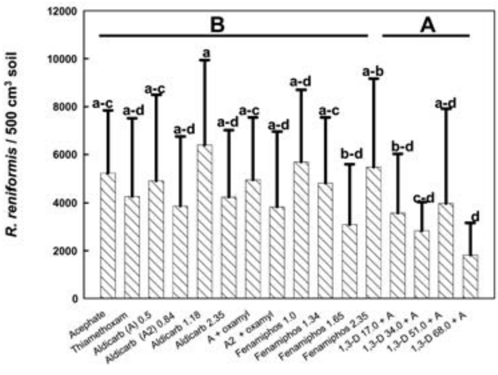

Fig. 2. Impact of nematicides on the mean and standard deviation of mid-season population densities of *Rotylenchulus reniformis* in 2001 and 2002 on cotton cultivar Deltapine 458BR at two locations. Controls: thiamethoxam at 2.5 mg (a.i.)/kg of seed, in furrow treatments with acephate at 1.12 kg (a.i.)/ha at planting, and (A) = aldicarb at 0.50 kg (a.i.)/ha. Nematicidal treatments: (A2) = aldicarb at 0.84 kg (a.i.)/ha aldicarb in furrow at planting, aldicarb at 1.18 kg (a.i.)/ha in furrow at planting, aldicarb at 2.35 kg (a.i.)/ha in a 15 cm band incorporated at planting, fenamiphos at 1.0 kg (a.i.)/ha in furrow, fenamiphos at 1.34 kg (a.i.)/ha in furrow at planting, fenamiphos at 1.34 kg (a.i.)/ha in furrow at planting fenamiphos at 2.35 kg (a.i.)/ha in a 15 cm band incorporated at planting, and 1, 3-dichloropropene (1,3-D) was injected two weeks prior to planting at rates of 17.0, 34.0, 51.0, and 68 kg/ha plus 0.5 kg (a.i.)/ha aldicarb in furrow at planting. Means with the same lower case letters do not differ according to Waller Duncan k-ratio *t* test (k-ratio = 50). Horizontal bars indicate treatments with 1,3-D are lower ($P = 0.093$) than all other treatments according to orthogonal contrasts.

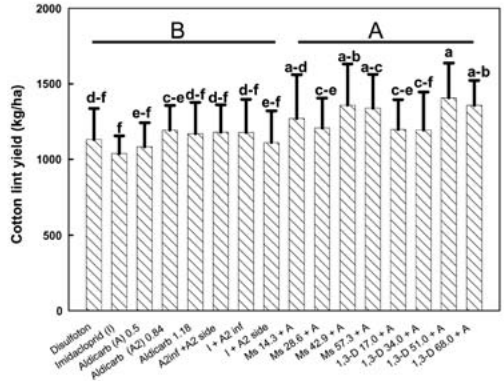

Fig. 3. Mean and standard deviation of cotton cultivar Fibermax 960 BG/RR lint yield as affected by nematicides in 2004 and 2005 in fields infested with *Rotylenchulus reniformis.* Controls included: treatment with imidacloprid (I) at 2.5 mg (a.i.)/kg of seed and in furrow treatment at planting with disulfoton at 1.12 kg (a.i.)/ha or (A) = aldicarb at 0.50 kg (a.i.)/ha. Nematicidal treatments were imidacloprid treated seed with 0.84, kg (a.i.)/ha aldicarb in-furrow at planting (A2 inf), imidacloprid treated seed with 0.84, kg (a.i.)/ha aldicarb applied as a side dress 6 (A2 side), 0.84, and 1.18 kg (a.i.)/ha aldicarb in-furrow at planting, and 0.84, kg (a.i.)/ha aldicarb applied in-furrow and then as a side (A2 side); 1, 3-dichloropropene (1,3-D) injected three weeks prior to planting at rates of 17.0, 34.0, 51.0, and 68 kg/ha plus 0.5 kg (a.i.)/ha aldicarb in furrow at planting, metam sodium 1, 3-D injected three weeks prior to planting at rates of 14.3, 28.6, 42.9, and 57.3 kg/ha plus 0.5 kg (a.i.)/ha aldicarb (A) in-furrow at planting. Means followed by the same lower class letter do not differ according to Waller Duncan k-ratio *t* test (k-ratio = 50). Horizontal bars indicate that cotton lint yield of fumigant treatments are greater ($P = 0.0043$) than controls and all other treatments.

the first series (2001-2002) as a result of relatively high rainfall, with yields more than double that encountered in the first set of experiments (Figs. 1 and 3). Although there was a trend toward higher yields with the nonfumigant nematicide aldicarb compared to the controls (imidacloprid treated seed, 0.50 kg (a.i.)/ha aldicarb, or disulfoton 1.12 kg (a.i.)/ha in furrow at planting for early season insect control), neither in furrow aldicarb treated cotton or aldicarb side dress applications yielded more than the control according to the Waller Duncan k-ratio *t*-test (k-ratio = 50) or orthogonal contrasts ($P \leq 0.10$). Cotton yield of the fumigant treatments, metam sodium and 1,3-D, were greater compared to the controls and nonfumigant nematicides ($P = 0.0043$) according to orthogonal contrasts. The yields of fumigant treated cotton plots increased with increasing rates of fumigant for both metam sodium ($P \leq 0.10$) and 1,3-D ($P = 0.0043$) (Fig. 4). The heterogeneity of slopes test was used to compare slopes, which did not differ ($P \leq 0.10$). Although treatments did not differ with respect to

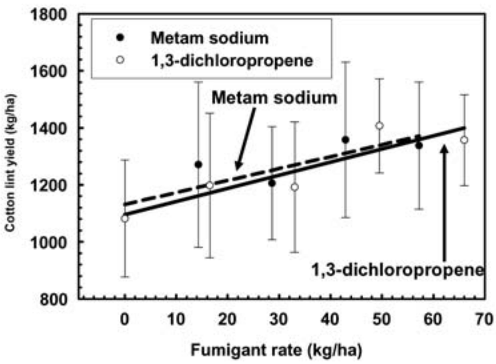

Fig. 4. Relationship of fumigant rate (metam sodium and 1, 3-dichloropropene [1,3-D]) and cotton lint yield of FiberMax 960BR using the mean of controls: imidacloprid (I) at 2.5 mg (a.i.)/kg of seed and in-furrow treatment with disulfoton at 1.12 kg (a.i.)/ha), or aldicarb at 0.50 kg (a.i.)/ha at planting as the 0.0 rate. Regression equations - metam sodium: $Y = 1131 + 4.18 X$ ($r^2 = 0.72$, $P = 0.10$); 1,3-D: $Y = 1095 + 4.60 X$ ($r^2 = 0.82$, $P = 0.0043$).

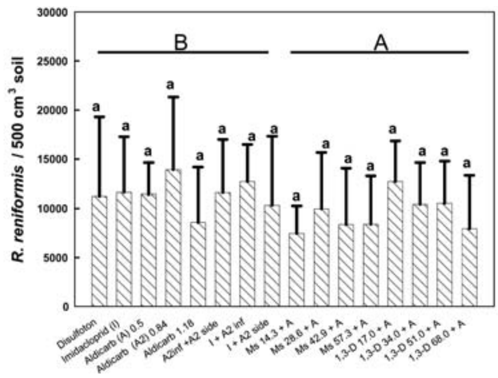

Fig. 5. Mean and standard deviation of *Rotylenchulus reniformis* mid-season population density on cotton cultivar Fibermax 960 BR as affected by nematicides in 2004 and 2005 in fields infested with *Rotylenchulus reniformis.* Controls included: treatment with imidacloprid (I) at 2.5 mg (a.i.)/kg of seed and in furrow treatment at planting with disulfoton at 1.12 kg (a.i.)/ha, or (A) = aldicarb at 0.50 kg (a.i.)/ha. Nematicidal treatments were imidacloprid treated seed with 0.84, kg (a.i.)/ha aldicarb in furrow at planting (A2 inf), imidacloprid treated seed with 0.84, kg (a.i.)/ha aldicarb applied as a side-dress 6 (A2 side), 0.84, and 1.18 kg (a.i.)/ha aldicarb in furrow at planting, and 0.84, kg (a.i.)/ha aldicarb applied in furrow and then as a side-dress (A2 side); 1, 3-dichloropropene (1,3-D) injected three weeks prior to planting at rates of 17.0, 34.0, 51.0, and 68 kg/ha plus 0.5 kg (a.i.)/ha aldicarb in furrow at planting, metam sodium and 1, 3-D injected three weeks prior to planting at rates of 14.3, 28.6, 42.9, and 57.3 kg/ha plus 0.5 kg (a.i.)/ha aldicarb in furrow at planting. Means followed by the same lower class letter do not differ according to Waller Duncan k-ratio *t* test (k-ratio = 50). Horizontal bars indicate *R. reniformis* mid-season population density of fumigant treatments was lower ($P = 0.0043$) than controls and all other treatments according to orthogonal contrasts.

R. reniformis Pm according to ANOVA or orthogonal contrasts (Fig. 5.), Pm was negatively ($P = 0.0022$) related to the rate of either metam sodium or 1,3-D according to regression analysis and the slopes of the two fumigants did not differ according to the heterogeneity of slopes test (Fig. 6). Final population densities of *R. reniformis* were unaffected by nematicide treatment.

Economic Analysis

Only the lowest rate of 1,3-D (17 kg/ha) was profitable with the low yields encountered in series one experiments (Fig. 7). Higher rates though providing greater yields than the controls or the 17 kg/ha rate were not cost effective in managing *R. reniformis* because of the fumigant cost. In contrast, with the higher yields in the series two experiments all rates of 1,3-D or metam sodium were profitable with optimal returns on the 42.9 kg/ha rate of metam sodium and 51 kg/ha rate of 1,3-D (Fig. 8).

DISCUSSION

This research shows that the fumigant nematicides 1,3-D and metam sodium can enhance cotton yield in the presence of reniform nematode and in large part agrees with other studies conducted in Mississippi (Lawrence *et al.*, 1990; Lawrence and McLean 2002b). Fenamiphos was superior to aldicarb in increasing cotton lint yield in the first set of experiments, and there was also evidence for superior

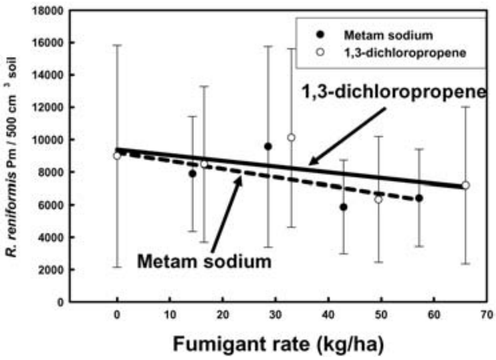

Fig. 6. Regression of the relationship of fumigant rate (metam sodium and 1, 3-dichloropropene [1,3-D]) and *Rotylenchulus reniformis* mid-season population density over two years (2005-2006) in Scotland Co. North Carolina on cultivar FiberMax 960BR using the mean of controls (imidacloprid [I] at 2.5 mg (a.i.)/kg of seed and in furrow treatment with disulfoton at 1.12 kg (a.i.)/ha) as the 0.0 rate. Regression equations - metam sodium: $Y = 9188 - 50.25\ X$ ($r^2 = 0.50$, $P \leq 0.01$); 1,3-D: $Y = 9381 – 34.97\ X$ ($r^2 = 0.37$, $P \leq 0.01$).

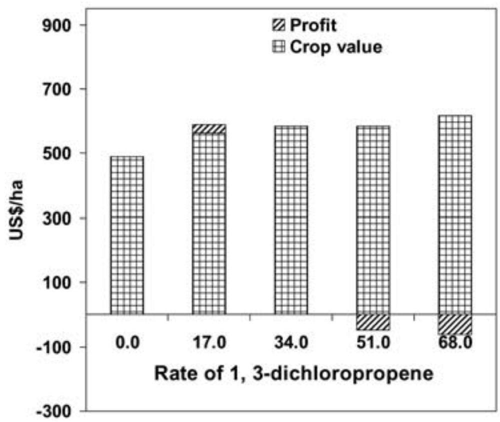

Fig. 7. Influence of rate of 1, 3-dichloropropene (1,3-D) on crop value of cotton lint and profit or loss after subtracting cost of fumigant in the presence of *Rotylenchulus reniformis* in 2001 and 2002 on cultivar Deltapine 458BR at two locations (series 1). Value of cotton lint yield at US$ 1.32/kg and cost of 1,3-D at US$ 2.79/kg.

suppression of *R. reniformis* with fenamiphos compared to aldicarb although numerical differences were not statistically significant. The current research indicates that samples to evaluate the response of *R. reniformis* to nematicides should be taken prior to midseason. Lawrence *et al.* (1990) also found fenamiphos superior to aldicarb alone, and superior to low rates of 1,3-D. Unfortunately, fenamiphos is no longer labeled for use in the US (Environmental Protection Agency, 2002). Treatments with aldicarb followed by a foliar application of oxamyl in the first series of experiments did not improve cotton lint yield or suppress *R. reniformis* numbers at mid-season. This result differs from other research (Lawrence and McLean, 2000) in that they reported significant increases in seed cotton yield with oxamyl applications. The drought conditions that limited cotton lint yield in the current research may also have limited the efficacy of oxamyl treatments and restricted oxamyl translocation from leaves to roots. Although aldicarb in furrow followed by oxamyl foliar application provided for little or no cotton yield increases in Arkansas (Lorenz *et al.*, 1996), or in the current research, this treatment has provided significant suppression of *R. reniformis* and yield increases in Alabama and Mississippi (Burmester *et al.*, 1998; Lawrence and McLean, 2000). Even with higher cotton lint yields in the second series of experiments, the current study clearly quantifies the impact of the rate of fumigant required for optimal cotton yield in the presence of damaging levels of reniform nematode. Either 42.9 kg (a.i.)/ha metam sodium or 51 kg (a.i.)/ha 1,3-D resulted in the highest yields and increasing rates did not further enhance yield. Also, similar levels of nematode suppression were encountered with both fumigant nematicides. This is among the first reports of the efficacy of metam sodium for suppression of *R. reniformis* in cotton, and demonstrates that it is approximately equivalent to 1,3-D for this purpose, in agreement with Lawrence *et al.* (2003).

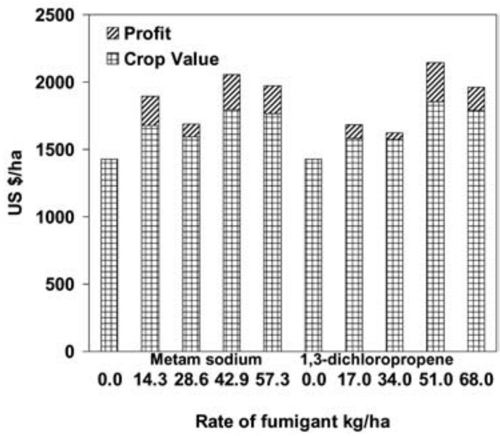

Fig. 8. Influence of rate of 1, 3-dichloropropene (1,3-D) or metam sodium on crop value of cotton lint and profit or loss after subtracting cost of fumigant in the presence of *Rotylenchulus reniformis* in 2005 and 2006 on cultivar Fibermas 960BR for two years in Scotland Co. North Carolina. Value of cotton lint yield at US$ 1.32/kg, cost of 1,3-D at US 2.79/kg, and cost of metam sodium at US$ 2.39/kg.

The economic analysis provides interesting insights into the profitability and the advisability of nematicide usage for cotton. The percentage increase in yield was equivalent in both sets of experiments, but the increase in yield in a low yield environment was insufficient to cover control costs. Zimet *et al.* (2002) reported economic returns only with lower rates of 1,3-D (16 or 32 kg/ha) in Florida fields infested with reniform nematode, similar to our results in a low yield environment. With greater yields, as experienced in series two experiments, any activity that improved management of reniform nematode resulted in a positive economic return. This is problematic for cotton growers that do not have the ability to irrigate, since this is a major constraint on cotton yield. Growers who cannot irrigate must make a decision prior to planting about the use of the relatively expensive fumigant nematicides, when their return is uncertain.

Options for management of Reniform nematode on cotton are limited, especially in areas where cotton production is intensive. The ineffectiveness of cultural practices and the lack of suitable rotation crops for management of this nematode require growers to rely on nematicides for management of this nematode. The need for *R. reniformis* resistant cotton cultivars has become increasingly critical with the continued spread of this nematode in the southeastern U.S.

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