EFFICACY OF SELECTED NEMATICIDES FOR MANAGEMENT OF *HOPLOLAIMUS COLUMBUS* IN COTTON

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ABSTRACT

Koenning, S. R., D. E. Morrison, K. L. Edmisten, and R. N. Taylor. 2004. Efficacy of Selected Nematicides for Management of *Hoplolaimus columbus* in cotton. Nematropica 34:211-218.

The effectiveness of selected nematicides for management of the Columbia lance nematode, *Hoplolaimus columbus*, on cotton was evaluated in field experiments. Aldicarb at rates of 0.84 to 1.18 kg (a.i.)/ha was effective in increasing cotton lint yield in several experiments with cultivars that were moderately tolerant to this nematode, whereas fumigant nematicides were required to provide significant yield increases on intolerant cultivars. Metam sodium and 1, 3-dichloropropene (1, 3-D) were effective in limiting population densities of *H. columbus* at two locations at both mid-season and at cotton harvest compared to controls or to the non-fumigant nematicide aldicarb. Cotton lint yield of an intolerant cultivar was positively related to the application rate of metam sodium or 1, 3-D at one location with a high initial population density (Pi) of this nematode, but not at a second location with lower (Pi) and lower sand content. Treatment of soil with relatively high rates of fumigant may alleviate the need for treatment in the subsequent year.

Key words: 1, 3-dichloropropene, aldicarb, Columbia lance nematode, cotton, crop loss, *Gossypium hirsutum*, *Hoplolaimus columbus*, host-plant tolerance, management, metam sodium, nematicides, nematode, oxamyl.

RESUMEN

Koenning, S. R., D. E. Morrison, K. L. Edmisten, y R. N. Taylor. 2004. Eficacia de nematicidas seleccionados para el manejo de *Hoplolaimus columbus* en algodón. Nematropica 34:211-218.

Se evaluó la efectividad de nematicidas seleccionados para el manejo del nemátodo de lanceta de Colombia, *Hoplolaimus columbus*, en algodón en ensayos de campo. Aldicarb era efectivo en el incremento de la cosecha de algodón a tasas de 0.84 a 1.18 kg (i.a.)/ha en experimentos con cultivares que eran moderadamente tolerantes a este nemátodo, mientras que nematicidas fumigantes eran requeridos para proveer incrementos significantes de cosecha en cultivares intolerantes. Sodio de metam y 1, 3-dichloropropano (1, 3-D) eran efectivos en la limitación de las densidades de *H. columbus* en dos localidades en el medio de la temporada y al tiempo de la cosecha comparados a controles o al nematicida no-fumigante aldicarb. La cosecha de algodón de un cultivar intolerante era positivamente relacionada con la tasa de aplicación de sodio de metam o 1, 3-D en una localidad con alta densidad inicial (Pi) de este nemátodo, pero no en otra localidad con una Pi y un contenido de arena más bajos. Tratamiento del suelo con tasas relativamente altas de fumigantes podrían aliviar la necesidad de tratamiento en el año siguiente.

Palabras clave: 1, 3-dichloropropano, aldicarb, algodón, *Gossypium hirsutum*, *Hoplolaimus columbus*, manejo, nematicidas, nemátodo, nemátodo de lanceta de Colombia, oxamyl, pérdida de cosecha, sodio de metam, tolerancia de huésped.

INTRODUCTION

The Columbia lance nematode, *Hoplolaimus columbus* Sher, is limited in distribution to Georgia, North Carolina, South Carolina, and Alabama in the United States (Koenning *et al.*, 2004). This pathogen can parasitize cotton, *Gossypium hirsutum* L., corn, *Zea mays* L., and soybean, *Glycine max* L., especially in sandy soils (Koenning *et al.*, 2003; Noe, 1993; Schmitt and Bailey, 1990).

Tactics for management of the Columbia lance nematode in cotton in the Southeast U.S. are limited. Crop rotation is not generally an option in fields infested with *H. columbus* due to its wide host range (Koenning *et al.*, 2003a,b). Peanut and tobacco can be effective in rotation with host crops, but the hectarage of these crops is limited. Winter wheat or rye cover crops had no impact on population densities of *H. columbus* (Davis *et al.*, 2000). Planting date had little impact on cotton yield in fields infested with *H. columbus* (Koenning *et al.*, 2003a). Although the incorporation of poultry litter suppressed mid-season *H. columbus* numbers and increased cotton lint yield, the amount of this material required for nematode management may exceed environmental regulations for land application (Koenning *et al.*, 2003b). Subsoiling where a hardpan exists has increased both cotton and soybean yield when *H. columbus* was present, but many farmers now use reduced tillage practices that may preclude the practice of subsoiling (Hussey, 1977; Schmitt and Bailey, 1990). Resistance to *H. columbus* in cotton has not been found, but some cultivars are relatively tolerant to this nematode (Bowman and Schmitt, 1994; Koenning and Bowman, 2003).

Although some transgenic cotton cultivars are highly tolerant to *H. columbus,* others have recently been identified as being intolerant and suffer considerable yield loss from this nematode (Koenning and Bowman, 2003). The rapid expansion in the number of cotton cultivars that are available because of the deployment of transgenic insect- and herbicide-resistant traits has resulted in the use of cultivars with limited field data on nematode tolerance and (or) resistance. New cultivars with additional value-added traits are currently being released with little or no information available about tolerance to plant-parasitic nematodes.

Nematode management in cotton is largely dependent on nematicides, but research on chemical management in current production systems is limited (Koenning *et al.*, 2004; Mueller and Sullivan, 1988; Noe, 1990; Schmitt and Bailey, 1990). Field research focused on the effects of nematicides for the management of Columbia lance nematode was conducted from 1997 through 2003. Specific objectives of this research were to evaluate the impact of fumigant and non-fumigant nematicides on population densities of *H. columbus* and on cotton lint yield.

MATERIALS AND METHODS

Three series of nematicide experiments were conducted from 1997 through 2003 in fields infested with moderate to high levels of *H. columbus.* Each experiment was conducted at two locations using standard cultural practices for cotton in North Carolina (Anonymous, 2004).

The first experiments (series 1) were established in 1997 and 1998 in Scotland County in two different fields with the cotton cultivar Deltapine 50 which is moderately tolerant to Columbia lance nematode. The soil types were a Wagram sand (88% sand, 10% silt, and 2% clay <1% organic matter) and a Goldsboro sandy loam (67% sand, 27% silt, 6% clay, <1% organic matter) with pre-fumigation initial population density (Pi) of 447 ± 45 and 221 ± 20 Columbia lance nematode, respectively. Fumigants were 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 14.0, 28.0, and 42.0 l/ha. Controls included seed treated with imidacloprid 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. Plots were four rows wide by 7.62 m long with 3 m alleys between replicates.

Two experiments were also established in Scotland Co. (series 2) with the moderately tolerant cultivar Deltapine 555 BG/RR in 2003. The soil types at the two locations (fields) were a Marlborough sandy loam 70% sand, 25% silt, 5% clay, <1% organic matter) and a Wagram sand (90% sand, 7% silt, and 3% clay <1% organic matter) with Pi of 776 ± 122 and 428 ± 73, respectively. 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. Nematicidal treatments were 1, 3-D at rates of 14.0 and 28.0 l/ha with imidacloprid treated seed, imidacloprid treated seed with 0.84 kg (a.i.)/ha aldicarb in-furrow at planting, imidacloprid treated seed with 0.84 kg (a.i.)/ha aldicarb applied as a side-dress 6 weeks after planting, 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 6 weeks later. Plots were two rows wide by 7.6 m long with 2 m alleys between replicates.

Two experiments located in Robeson and Hoke Co.s (series 3) were planted with the Columbia lance nematode-intolerant cultivar Suregrow 501BR in 2003. The soil type at the Robeson Co. location was a Marlborough sandy loam 67% sand, 25% silt, 8% clay, <1% organic matter) and soil type at the Hoke Co. location was a Wagram sand (88% sand, 10% silt, and 2% clay <1% organic matter) with Pi of 386 ± 29 and 506 ± 36, respectively. Controls included an in-furrow treatment with disulfoton at 1.12 kg (a.i.)/ha and aldicarb at 0.50 kg (a.i.)/ha. Fumigant treatments included metam sodium at 14.3, 28.6, 42.9, and 57.3 kg (a.i.)/ha, and 1, 3-D at 14.0, 28.0, 42.0 and 58.0 l/ha with aldicarb applied in-furrow at planting for insect control at 0.50 kg (a.i.)/ha. In-furrow nematicidal treatments at planting were aldicarb in-furrow at rates of 0.84 and 1.18 kg (a.i.)/ha and an additional treatment included aldicarb at 0.50 kg (a.i.)/ha in-furrow at planting followed by a foliar application of oxamyl at 0.23 kg (a.i.)/ha applied with a back pack sprayer in 57 l/ha water six weeks after planting. Plots were four rows by 12.2 m long with 4 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 sub-sample was processed by elutriation and centrifugation to extract adults and juveniles from soil. Roots were collected from a sieve on the elutriator and placed in a mist extractor for 5 days to collect vermiform stages (Barker *et al.*, 1986).

Data analysis consisted of analysis of variance (ANOVA) for a randomized complete block design (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. 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.

RESULTS AND DISCUSSION

The data for the 2 years, 1997 and 1998, was pooled because there was no year by nematicide interaction and the two years did not differ in their response to nematicides. The yield of cotton cultivar Deltapine 50 was increased ($P \leq 0.023$) in both 1997 and 1998 according to orthogonal contrasts comparing the low rate of aldicarb, acephate, and imidacloprid to nematicidal rates of aldicarb and the fumigant 1, 3-D (Fig. 1). Mean separation tests were not effective in discriminating between rates of aldicarb or 1, 3-D, although there was a trend toward increased yield with increasing rates of these nematicides. This cultivar is moderately tolerant to *H. columbus* (Koenning *et al.* 2003a) and the increase in lint yield was marginal. Data for both locations for series 2 experiments was pooled since there was not a location by nematicide interaction. The yield of Deltapine 555 BG/RR was lower for the imidacloprid seed treatment alone than for all other treatments according to the Waller Duncan k-ratio *t* test (k-ratio = 50), suggesting that early season insects may have impacted yield (Fig. 2). Fumigant treatments, which were planted with imidacloprid treated seed, yielded significantly more than with imidacloprid-treated seed alone. There was a linear increase ($P \leq 0.05$) in lint yield with increasing rates of

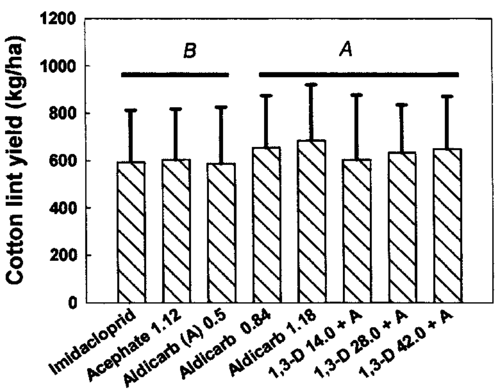

Fig. 1. Impact of nematicides on the mean and standard deviation of cotton lint yield for cultivar Deltapine 50 in two fields (series 1) infested with *Hoplolaimus columbus* in 1997 and 1998. Controls: Imidacloprid at 2.5 mg (a.i.)/kg of seed, infurrow treatments with acephate at 1.12 kg (a.i.)/ha, A = aldicarb at 0.50 kg (a.i.)/ha at planting. Nematicidal treatments: aldicarb infurrow at 0.84 and 1.18 kg (a.i.)/ha at planting, and 1, 3-D injected two weeks prior to planting at rates of 14.0, 28.0, and 42.0 l/ha. Horizontal bars indicate nematicidal treatments are greater than controls ($P \leq 0.023$) according to orthogonal contrasts.

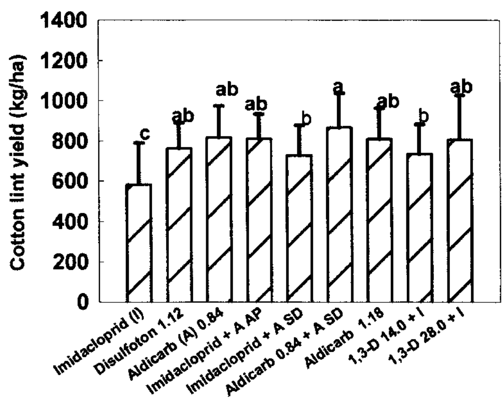

Fig. 2. Mean and standard deviation of cotton cultivar Deltapine 555 BG/RR lint yield as affected by nematicides in two fields infested with *Hoplolaimus columbus* in 2003. Controls included: treatment with imidacloprid (I) at 2.5 mg (a.i.)/kg of seed and infurrow treatment with disulfoton at 1.12 kg (a.i.)/ha. Nematicidal treatments were imidacloprid treated seed with 0.84 kg (a.i.)/ha aldicarb in furrow at planting (AP), imidacloprid treated seed with 0.84 kg (a.i.)/ha aldicarb applied as a side-dress 6 (SD), 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 (SD); and 1, 3-D at rates of 14.0 and 28.0 l/ha with imidacloprid treated seed (I). Means followed by the same letter do not differ according to Waller Duncan k-ratio *t* test (k-ratio = 50).

1, 3-D for treatments with imidacloprid treated seed, and for increasing rates of aldicarb when using disulfoton as the control according to orthogonal polynomial contrasts. Typically, imidacloprid provides several weeks less protection from insects than do aldicarb or disulfoton (J. Bacheler, pers. comm.). The 0.84 kg (a.i.)/ha aldicarb treatment with an additional sidedress application of 0.84 kg (a.i.)/ha aldicarb yielded more than either the imidacloprid treated seed with a sidedress of aldicarb or the lowest rate of 1, 3-D.

Yield data were not pooled for experimental series 3 because of a significant nematicide by location interaction (P = 0.05). In general, the fumigants 1, 3-D and metam sodium increased ($P \leq 0.01$) the yield of the *H. columbus* intolerant cultivar Suregrow 501 BR compared to the use of non-fumigant nematicides according to orthogonal comparisons at both locations (Fig. 3). Both metam sodium and 1, 3-D resulted in yield increases at the Robeson Co. site, and this response was not related to the amount of material applied (Fig. 3A). In contrast, there was a linear increase ($P \leq 0.07$) associated with the amount of fumigant used at the Hoke Co. location, although it was more pronounced for 1, 3-D (Fig. 3B). The lack of rate response to fumigants at the Robeson Co. compared to the Hoke Co. location can likely be attributed to the lower Pi and finer soil texture at the Robeson Co. location. The yield of non-fumigant nematicide-treated plots did not differ from that of the disulfoton treated control at either location according to the Waller Duncan k-ratio t test (k-ratio = 50). The failure of non-fumigant nematicides to improve lint yield at these locations can probably be attributed to very high rainfall in 2003 that may have leached these materials from the root zone. Lint yield of the aldicarb plus oxamyl-treated plots was not more than the disulfoton control plots. Aldicarb plus oxamyl has been recommended in Mississippi for management of *Rotylenchulus reniformis* on cotton (Lawrence and Mclean, 2000), but has not performed well in other experiments with *H. columbus* in North Carolina (S. R. Koenning, unpublished data).

Mid-season and Pf numbers of *H. columbus* in the 1997-98 experiments were lower ($P \leq 0.01$) in fumigated plots than in non-fumigated plots according to orthogonal contrasts (Fig. 4). There were no differences ($P \leq 0.10$) between non-fumigant treatments and controls, and suppression of *H. columbus* by fumigants was related to the rate at which it was applied. No differences were evident in Columbia lance nematode population densities at any sampling in the series 2 experiments with two levels of 1, 3-D at two locations in Scotland Co. in 2003. However, population densities of *H. columbus* at mid-season and at cotton harvest were suppressed by both fumigant nematicides in the series 3 experiments compared to non-fumigant nematicides and the controls at the Robeson Co. and Hoke Co. locations in 2003.

This research shows that nematicides can enhance cotton yield in the presence of Columbia lance nematode and agrees with other studies conducted in North Carolina, South Carolina, and Georgia (Mueller and Sullivan, 1988; Noe, 1990; Schmitt and Bailey, 1990). The current study, however, more clearly quantifies the impact of the rate of fumigant nematicides on cotton lint yield and suppression of *H. columbus* population densities. This is the first report on the efficacy of metam sodium for suppression of *H. columbus* in cotton. Earlier work with soybean showed that nematicides could be integrated with tolerant cultivars to improve the profitability of soybean (Schmitt and Imbriani, 1987). Our experiments show that fumigant nematicides

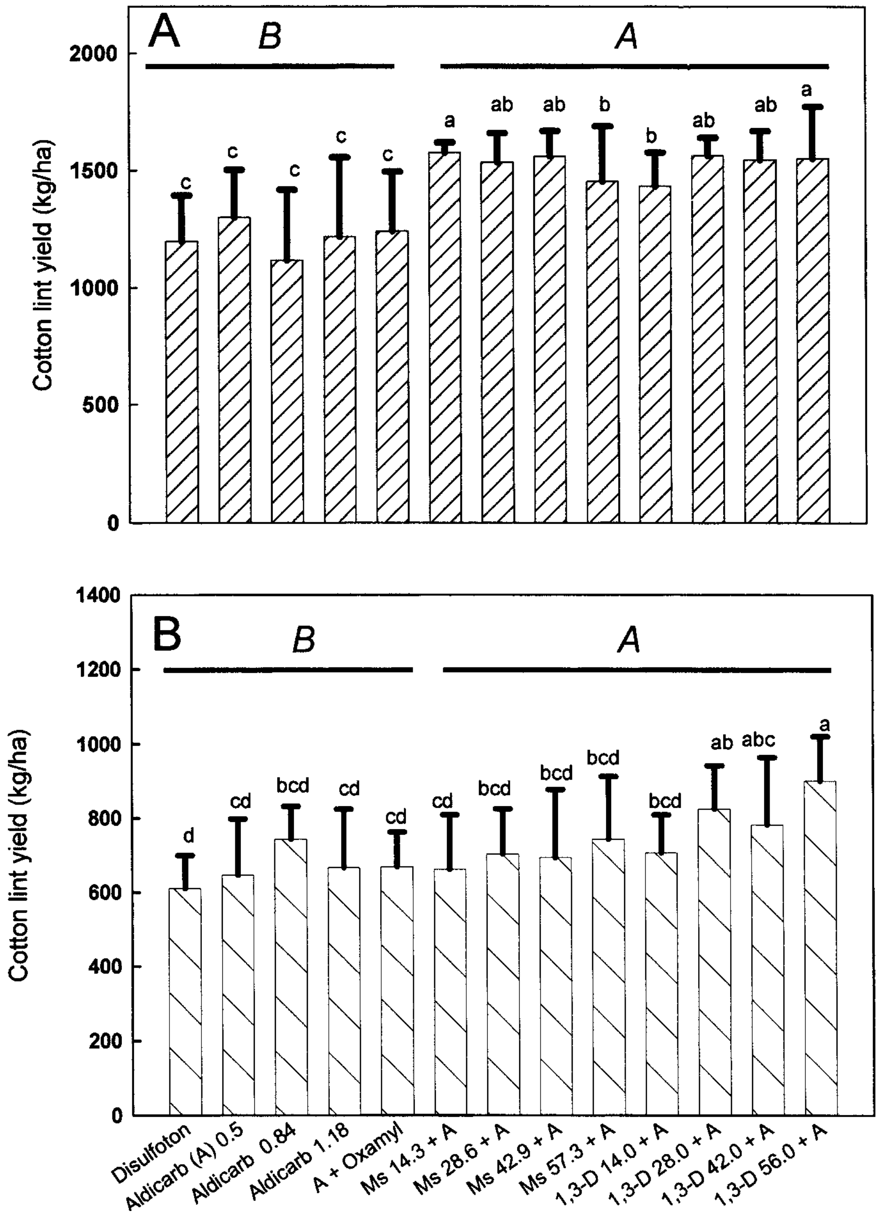

Fig. 3. Influence of nematicides on cotton lint yield of the *Hoplolaimus columbus* intolerant cultivar Suregrow 501 BR at two locations in 2003. Controls: in-furrow treatment at planting with disulfoton at 1.12 kg (a.i.)/ha, and aldicarb in-furrow at rates of 0.50 kg (a.i.)/ha. Non-fumigant nematicide treatments were 0.84 and 1.18 kg (a.i.)/ha aldicarb in-furrow, and aldicarb at 0.50 kg (a.i.)/ha at planting followed by a foliar application of oxamyl at 0.23 kg (a.i.)/ha six weeks after planting (A + Oxamyl). Fumigant treatments included metam sodium at 14.3, 28.6, 42.9, and 57.3 kg (a.i.)/ha, and 1, 3-D at 14.0, 28.0, 42.0, and 58.0 l/ha with aldicarb applied in furrow at planting for insect control at 0.50 kg (a.i.)/ha. A. Robeson County location. B. Hoke Co. location. Means followed by the same lower case letter do not differ according to the Waller Duncan k-ratio *t* test (k-ratio = 50). Horizontal bars indicate orthogonal comparison of non-fumigant versus fumigant nematicides and upper case letters denote significant differences ($P \leq 0.05$).

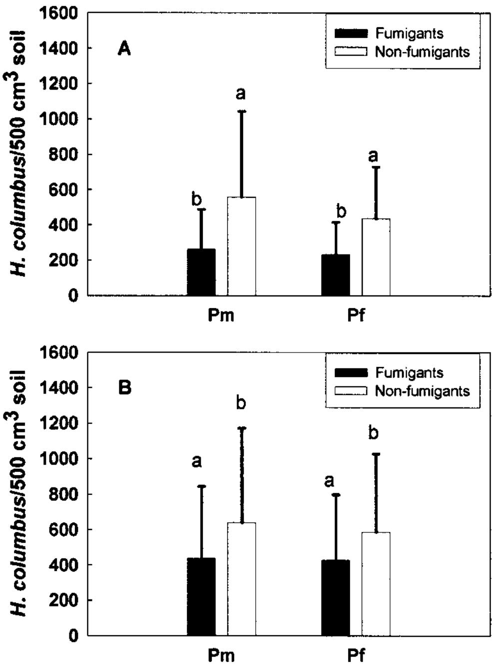

Fig. 4. Impact of fumigant versus non-fumigant nematicides on mid-season (Pm) and final (Pf) population densities of *Hoplolaimus columbus*. A. The Scotland Co. experiments (series 1) conducted in 1997 and 1998. B. The Robeson and Hoke Co. experiments in 2003 (series 3). Means followed by the same letter do not differ according to orthogonal contrasts ($P \leq 0.01$).

may be necessary to maximize yield for intolerant cotton cultivars, while non-fumigant nematicides may be sufficient when cultivars relatively tolerant to this nematode are used.

Options for management of Columbia lance 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 means that growers must rely on nematicides and (or) cultivars with high levels of tolerance. More emphasis on nature of tolerance to *H. columbus* in cotton is needed to alleviate yield suppression by this nematode.

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