Effects of Fumigant and Nonfumigant Nematicides on *Belonolaimus longicaudatus* and *Hoplolaimus galeatus* Populations and Subsequent Yield of Cabbage

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ABSTRACT

Rhoades, H. L. 1986. Effects of fumigant and nonfumigant nematicides on *Belonolaimus longicaudatus* and *Hoplolaimus galeatus* populations and subsequent yield of cabbage. Plant Disease 70:581-582.

Two experiments were conducted on Myakka fine sand in which soil fumigant nematicides (dichloropropene and metam-sodium) and nonfumigant nematicides (aldoxycarb, carbofuran, ethoprop, fenamiphos, oxamyl, and terbufos) were tested for their efficacy in reducing population levels of *Belonolaimus longicaudatus* and *Hoplolaimus galeatus* and increasing yields of cabbage (*Brassica oleracea* var. *capitata*). Both soil fumigants reduced populations of *B. longicaudatus* and *H. galeatus* and resulted in increased yields of cabbage. All nonfumigants significantly reduced *B. longicaudatus* populations and increased yields in one or both experiments but were not effective against *H. galeatus*. *B. longicaudatus* caused severe plant and root injury symptoms in untreated plots, but there was no evidence of injury from *H. galeatus*.

The sting nematode (*Belonolaimus longicaudatus* Rau) causes extensive injury to many vegetable crops produced on fine sandy soils in Florida (1). Cabbage (*Brassica oleracea* var. *capitata* L.), a major crop produced on these soils, is one of those susceptible to the attack of this nematode that often causes serious yield losses (3–6). Another plant-parasitic nematode associated with many vegetable crops, including cabbage, in these fine sandy soils of Florida, is the lance nematode (*Hoplolaimus galeatus* (Cobb) Sher); however, the extent of injury from this nematode to cabbage has not been reported. When coincident populations of these nematodes were found in moderate to high numbers in fields available for experimentation, nematicide efficacy trials were planned.

Both fumigant and nonfumigant nematicides have been used successfully for controlling plant nematodes on cabbage (3,4,6). However, greater use of the granular nonfumigant nematicides on cabbage is occurring because of the recent ban of several fumigants by the U.S. Environmental Protection Agency. Nevertheless, many growers prefer soil fumigants and have shown an increased interest in using those remaining on the market. One of these, metam-sodium, a multipurpose soil fumigant usually used in seedbed operations and on high-profit crops to control nematodes, weeds, insects, and diseases, is now being reexamined for possibly more extensive use in field operations. Experiments were designed to compare the efficacy of two soil fumigants and six nonfumigants for reducing populations of *B. longicaudatus* and *H. galeatus* and increasing yields of cabbage in the fine sandy soils of central Florida.

Journal Series No. 6827 of the University of Florida, Institute of Food and Agricultural Sciences, Florida Agricultural Experiment Station, Gainesville 32611.

Accepted for publication 26 December 1985.

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MATERIALS AND METHODS

Two experiments were conducted during 1984–1985 (fall and spring, respectively) at the Central Florida Research and Education Center, Sanford, on Myakka fine sand (92.2% sand, 5.7% silt, and 2.1% clay) naturally infested with high populations of the sting nematode (*B. longicaudatus*) and the lance nematode (*H. galeatus*). Other plant nematodes present in low and variable numbers were the stubby-root nematode (*Paratrichodorus christiei* (Allen) Siddiqi) and a root-knot nematode (*Meloidogyne incognita* (Kofoid & White) Chitwood);

Table 1. Effects of fumigant and nonfumigant nematicides on nematode populations and yield of cabbage[y]

Treatment	Application rate	Nematode populations[z] BL	HG	Yield (kg/ha)
		Fall 1984		
Control	...	221 a	55 a	28,245 c
Dichloropropene	56 L/ha	49 bcd	14 a	43,651 ab
Metam-sodium	140 L/ha	7 d	2 a	45,705 ab
	280 L/ha	3 d	2 a	41,597 ab
	420 L/ha	2 d	0 a	45,705 ab
Fenamiphos	2.24 kg a.i./ha	4 d	89 a	39,543 ab
	3.36 kg a.i./ha	18 cd	92 a	47,246 a
Carbofuran	2.24 kg a.i./ha	108 bc	33 a	40,570 ab
	3.36 kg a.i./ha	137 ab	10 a	46,732 a
Ethoprop	2.24 kg a.i./ha	34 cd	75 a	44,678 ab
	3.36 kg a.i./ha	25 cd	84 a	43,137 ab
Oxamyl	2.24 kg a.i./ha	95 bcd	78 a	34,407 bc
Terbufos	2.24 kg a.i./ha	27 cd	68 a	46,732 a
Aldoxycarb	2.24 kg a.i./ha	98 bcd	34 a	44,164 ab
		Spring 1985		
Control	...	122 a	102 a	30,299 c
Dichloropropene	56 L/ha	3 d	2 c	42,110 ab
Metam-sodium	140 L/ha	4 d	17 bc	41,597 ab
	280 L/ha	8 cd	21 bc	48,786 a
Fenamiphos	2.24 kg a.i./ha	32 bcd	94 a	45,192 ab
	3.36 kg a.i./ha	16 bcd	59 ab	45,705 ab
Carbofuran	2.24 kg a.i./ha	42 bc	89 a	38,002 abc
	3.36 kg a.i./ha	43 bc	95 a	43,651 ab
Ethoprop	2.24 kg a.i./ha	36 bcd	74 a	36,975 abc
	3.36 kg a.i./ha	33 bcd	93 a	35,434 bc
Oxamyl	2.24 kg a.i./ha	53 b	104 a	41,597 ab
	3.36 kg a.i./ha	28 bcd	97 a	47,759 a
Terbufos	2.24 kg a.i./ha	25 bcd	96 a	43,137 ab
	3.36 kg a.i./ha	32 bcd	87 a	46,732 ab
Aldoxycarb	2.24 kg a.i./ha	48 bc	109 a	42,110 ab
	3.36 kg a.i./ha	43 bc	101 a	42,624 ab

[y] Values within the same column with a common letter for each year are not statistically different ($P = 0.05$) according to Duncan's multiple range test.

[z] Average number of nematodes extracted from 100 cm^3 of soil before harvest; BL = *Belonolaimus longicaudatus* and HG = *Hoplolaimus galeatus*.

however, their presence appeared to have little or no effect on experimental results. The experimental design was a randomized complete block with five replicates. Each plot consisted of two rows 76 cm apart and 12.2 m long.

Soil fumigants used in the experiments were dichloropropene applied at 56 L/ha and metam-sodium applied at 140–420 L/ha. Nonfumigants were aldoxycarb, carbofuran, ethoprop, fenamiphos, oxamyl, and terbufos. In the first experiment, the soil fumigants were applied on 10 October 1984. Metam-sodium was injected 15 cm deep with two chisels spaced 25 cm apart, and dichloropropene was applied 15 cm deep at 25-cm intervals as a single line of injections in the center of the row with a hand injector. The nonfumigants were applied on 22 October. Granular formulations of carbofuran, ethoprop, fenamiphos, and terbufos were applied as 38-cm-wide bands in-the-row and incorporated 5–8 cm with spiked rotary cultivator wheels. Liquid formulations of aldoxycarb and oxamyl were applied in water as a spray in a 38-cm-wide band, then incorporated in the same manner as the granules. Rio Verde cabbage was transplanted into the plots on 23 October. Normal cultural practices for the area were followed, and the cabbage was harvested three times from 9 January to 13 February 1985. Soil samples were collected for nematode population determination by taking five cores 2.5 × 18 cm at random from the plot rows on 7 January 1985. Processing was done by a centrifugal-flotation technique (2).

In the spring experiment, the nematicides were applied in the same manner as in the fall except both dichloropropene and metam-sodium were injected 20 cm deep with a hand injector. The soil fumigants were applied on 1 March and the nonfumigants on 5 March 1985. Rio Verde cabbage was transplanted on 6 March. Normal cultural practices were followed and the cabbage was harvested twice (16 and 28 May). Soil samples were collected and processed for nematode population determination on 22 April, in the same manner as in the fall experiment. Data were subjected to analysis of variance and means compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Fall experiment. Considerable stunting, uneven growth, and restricted root systems with the typical sting-nematode symptoms of discoloration, lesions, and stubby roots (1) occurred in control plots. All treatments except oxamyl (2.24 kg/ha) significantly ($P = 0.05$) increased yield (Table 1). Only the soil fumigants appeared effective in reducing populations of *H. galeatus.*

Spring experiment. The results in the spring experiment were very similar to those obtained the previous fall. All treatments significantly reduced *B. longicaudatus* populations, with the greatest controls coming from the soil fumigants. Only the soil fumigants were effective in reducing *H. galeatus* populations; however, there was no evidence of injury from this nematode. Significant yield increases were obtained from all treatments but carbofuran (2.24 kg/ha) and ethoprop (2.24 and 3.36 kg/ha).

The results of these experiments demonstrate that all nematicides used were effective in reducing populations of *B. longicaudatus* and increasing yields of cabbage. Best control of *B. longicaudatus* was obtained from the soil fumigants, and it appears that metam-sodium would be a highly effective nematicide when applied in-the-row in the field as well as a multipurpose nematicide used for seedbeds and high-profit crops.

Although many of the nonfumigant nematicides were less effective than the fumigants in reducing populations of *B. longicaudatus*, yields were increased equally in most instances, indicating that sufficient initial control had been provided to allow near-normal plant growth and yield. Only the soil fumigants were effective in controlling *H. galeatus*; however, no symptoms of injury were observed and yields were usually not affected where populations were not reduced. These results indicate that *H. galeatus* probably causes little or no injury to cabbage at the population levels present in these studies.

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