Population Dynamics of Belonolaimus longicaudatus and Criconemella ornata and Growth Response of Bermudagrass and Overseeded Grasses on Golf Greens Following Treatment with Nematicides[1]

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Abstract: Portions of a 'Tifgreen' bermudagrass golf green with poor turf and large numbers of *Belonolaimus longicaudatus* and *Criconemella ornata* were treated with selected nematicides in the summers of 1977 and 1978. Improvements in turf quality were observed within 4 wk after treatment with phenamiphos and fensulfothion. Treatment with phenamiphos resulted in lower numbers of *B. longicaudatus* 4 and 14 wk after treatment in the 1977 experiment and up to 1 yr after treatment in the 1978 experiment. Treatment with fensulfothion reduced the number of *B. longicaudatus* for only 1 month after treatment and significantly increased the numbers of this nematode in September and March in the 1978 experiment. Negative correlations were obtained between numbers of *B. longicaudatus* and turf quality up to 1 yr. Numbers of *C. ornata* were reduced only in January and June following treatment with phenamiphos and not at any time with fensulfothion. Treatment with fensulfothion resulted in higher numbers of this nematode than in check plots in November and March. The percent area covered by prostrate spurge the following year was reduced following treatment with phenamiphos, but not with fensulfothion. *Key words:* phenamiphos, fensulfothion, DBCP, sting nematodes, ring nematodes.

Journal of Nematology 14(3):358-363. 1982.

Belonolaimus longicaudatus Rau has been associated with severe damage on bermudagrass (*Cynodon dactylon* [L.] Pers.) in sandy soils of the southeastern United States (1,2,3,4,9,10,11,13), and nematicides are often needed to grow good quality turf when this nematode is present. Since DBCP (1,2-dibromo-3-chloropropane) was recently eliminated from the market, the use of other available nematicides has increased on turfgrasses. Relatively little information is available on the efficacy, susceptibility of different nematode species, and length of control of these nematicides on turfgrasses. A nematicide capable of controlling nematodes for long periods of time following application would be most useful on a perennial crop such as turf. Control of *B. longicaudatus* for up to 12 months has been reported with fensulfothion (0,0-diethyl-0-[4-(methylsulfinyl) phenyl] phosphorathioate) (1,13). Improved turf greenness and sod density and less spurge (*Euphorbia maculata* [L.]) were obtained 2 months after treatment with fensulfothion in Georgia (8). Treatment with phenamiphos (ethyl 3-methyl-4-[methylthio] phenyl [1-methylethyl] phosphoramidate) improved bermudagrass turf on a golf green in Florida but did not control nematodes as well as DBCP (12).

Criconemella ornata (syn. *Macroposthonia ornata* [Raski] de Grisse & Loof) Luc & Raski often occurs in bermudagrass turf in North Carolina (11), but little information is available on the control of this nematode and the damage it causes on bermudagrass. A reduction in numbers of *C. ornata* and other nematodes on centipedegrass (*Eremochloa ophiuroides*) (Munro) Hack was obtained with phenamiphos and fensulfothion 5 months after treatment, but clipping weights were not different from the nontreated plots (6). The growth of 'Tifgreen' bermudagrass and other warm season grasses was not affected 7–9 months

Received for publication 12 November 1981.

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The technical assistance of M. R. Newnam and the staff of the Nematode Assay Laboratory is gratefully acknowledged.

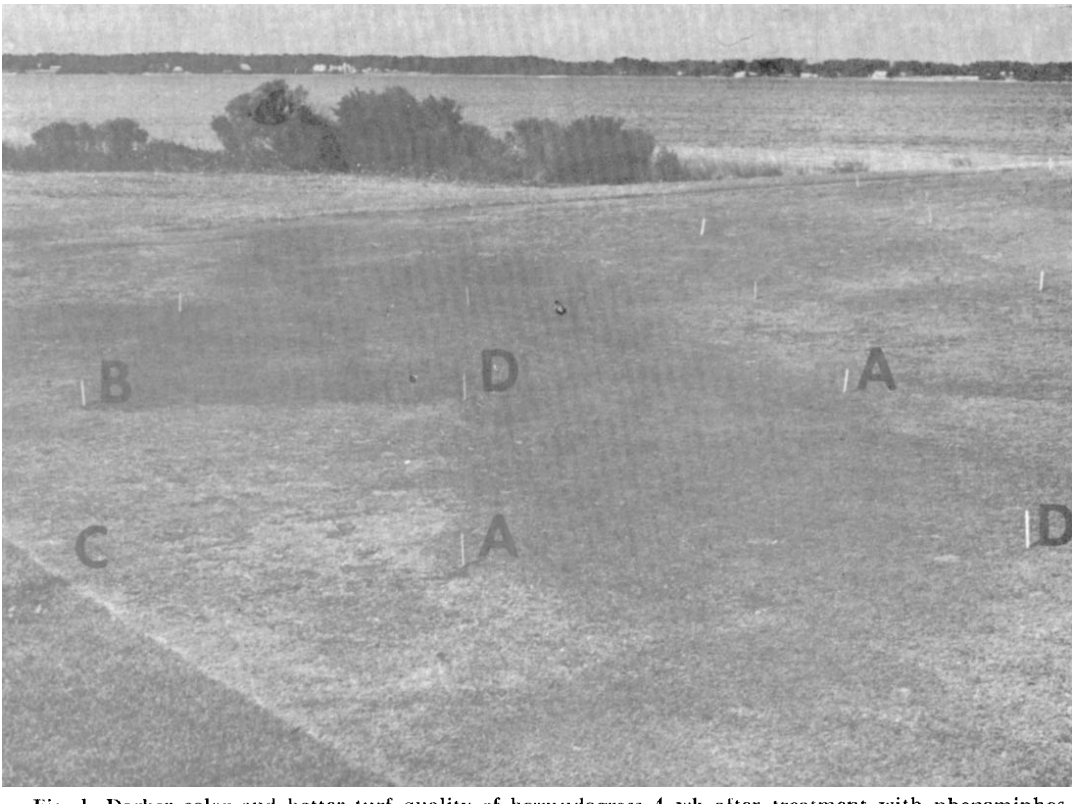

Fig. 1. Darker color and better turf quality of bermudagrass 4 wk after treatment with phenamiphos (A), fensulfothion (B), or DBCP (D), compared to check (C) on golf green infested with *Belonolaimus longicaudatus* and *Criconemella ornata*.

after inoculation with the related species, *Criconemoides lobatum* Raski (7)

A preliminary report on the control of *B. longicaudatus* and improved turf quality in North Carolina was reported earlier (10). This research was conducted in naturally infested soil to determine the responses of bermudagrasses and overseeded grasses to selected nematicides over a 2-yr period.

MATERIALS AND METHODS

Phenamiphos 15G, fensulfothion 15G, and DBCP 10G were applied at rates of 0.2, 0.2, and 0.45 kg a.i. per 93 m^2, respectively, to uniformly poor quality 'Tifgreen' hybrid bermudagrass (*Cynodon dactylon* × *C. transvaalensis* [Burt-Davy]) on a golf green on 7 August 1977. The soil composition was very coarse to coarse (2 to 0.5 mm) sand, 8–9%; medium (0.5 to 0.25 mm) sand, 19–21%; fine (0.25 to 0.1 mm) sand, 53–59%; very fine (0.1 to 0.05 mm) sand, 6–8%; silt 1.6%; and clay 7.8%. The green was overseeded with a mixture of perennial ryegrass (*Lolium perenne* L.), red fescue (*Festuca ruba* L.), and common ryegrass (*Lolium multiforum* Lam.) in October each year. The grass was mowed regularly at 0.6 cm and maintained with normal practices for a golf green. An average of 560 *B. longicaudatus* and 1,313 *C. ornata* per 500 cm^3 of soil were detected at the time of treatment. Nematicides were applied with a 46-cm-wide drop spreader and were washed into the soil immediately after application with 1.3 cm of irrigation water. Plots were 1.8 × 3 m and were arranged in a randomized complete block design with four replications.

Thirty-six soil cores, 1 cm in diameter and 8.5 cm deep, were collected from each plot immediately before treatment and 4, 6, 14, 42, 54, and 96 wk after treatment. Soil cores from each plot were mixed, and nematodes were extracted from 200-cm^3 soil samples from each plot using the centrifugation-flotation-sieving method (5). Nematode counts were converted to numbers per 500

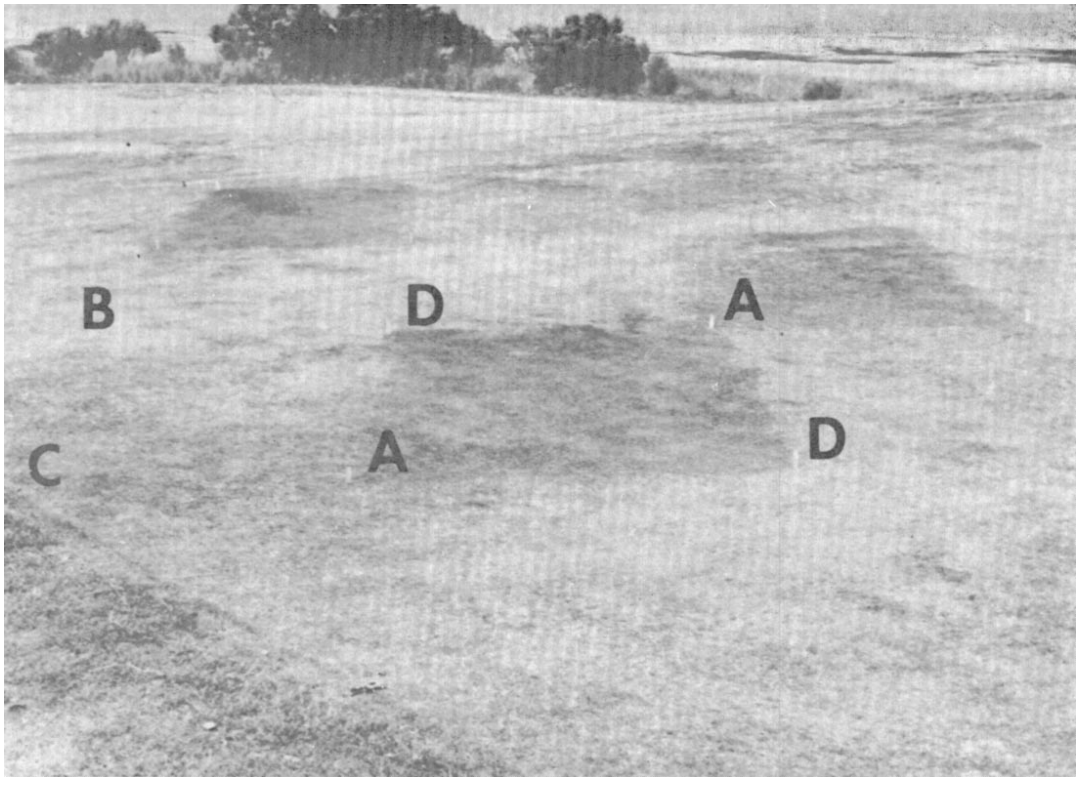

Fig. 2. Early growth of bermudagrass from winter dormancy in June in plots treated the previous summer with phenamiphos (A). Cool-season overseeded grasses died rapidly during hot weather and bermudagrass grew slowly in check plots (C) and plots treated with fensulfothion (B) or DBCP (D).

cm^3. Visual turf quality ratings were made each time soil samples were collected using a scale of 1–9, with 9 being excellent quality with dark green color and uniform turf and 1 being very poor quality with light green color, some bare soil, and weeds present.

A second experiment was established in another area on the same green the following year. The area had uniformly poor turf and an average of 522 *B. longicaudatus* and 1,271 *C. ornata* per 500 cm^3 of soil before treatments were applied on 19 June 1978. Phenamiphos 15G and fensulfothion 15G at 0.2 kg a.i. and a combination of phenamiphos at 0.07 kg a.i. and fensulfothion at 0.14 kg a.i. per 93 m^2 were applied and washed into the soil as previously described. Plots, 1.8 × 6.1 m, were arranged in a randomized complete block design with four replications. Sixty soil cores, 1 cm in diameter and 8.5 cm deep, were collected from each plot in this experiment and processed as described previously. Nematode assays and turf quality ratings were taken at monthly intervals for 1 yr after treatment. Percent of plot area covered with prostrate spurge (*Euphorbia supina* Raf.) in each plot was recorded in June 1979.

RESULTS AND DISCUSSION

Significant improvements in turf quality were detected after 4 wk in plots treated with phenamiphos and fensulfothion but not in DBCP-treated plots (Fig. 1). Lower numbers of *B. longicaudatus* were detected after 4 wk in both experiments with all nematicides. In the 1977 experiment, significant reductions in later months were detected only in the phenamiphos treatment in November, whereas significant reductions in numbers of this nematode were detected for up to 12 months with a similar rate of phenamiphos in the 1978 experiment. Treatment with fensulfothion alone reduced the numbers of *B. longicaudatus* for only 1 month following treatment in both experiments. Numbers of this nematode were significantly higher in the fensulfothion alone treatment in the 1978 experiment than in other treatments in September

Table 1. Number of *Belonolaimus longicaudatus* and *Criconemella ornata* per 500 cm³ of soil, turf quality, and correlation coefficients following treatment of a bermudagrass golf green with selected nematicides in August 1977.

Treatment (a.i./93 m²)	Date sampled				
	Sept. 77	Nov. 77	June 78	Aug. 78	June 79
	No. *B. longicaudatus*/500 cm³ soil				
Phenamiphos (0.2 kg)	160 a†	160 a	106 a	265 a	270 a
Fensulfothion (0.2 kg)	100 a	990 b	823 a	673 ab	335 a
DBCP (0.45 kg)	325 ab	1,650 b	406 a	890 b	420 a
Check	1,400 b	1,490 b	752 a	525 ab	190 a
	No. *C. ornata*/500 cm³ soil				
Phenamiphos (0.2 kg)	1,320 a	300 b	1,148 a	6,779 a	1,425 a
Fensulfothion (0.2 kg)	1,445 a	2,900 a	1,507 a	7,568 a	1,470 a
DBCP (0.45 kg)	610 a	1,250 b	677 a	4,898 a	2,135 a
Check	2,080 a	1,800 b	1,751 a	5,770 a	1,670 a
	Turf quality‡				
Phenamiphos (0.2 kg)	6.3 a	7.5 a	8.7 a	7.0 a	7.6 a
Fensulfothion (0.2 kg)	6.3 a	7.0 a	4.0 b	4.5 bc	4.3 b
DBCP (0.45 kg)	4.8 b	5.5 a	4.0 b	6.3 ab	4.3 b
Check	2.8 b	4.3 b	4.0 b	2.8 c	4.5 b
	Correlation coefficients of turf quality to nematodes				
B. longicaudatus	−.59*§	−.47	−.25	+.06	−.35
C. ornata	−.30	+.11	−.10	−.23	−.15

†Duncan's multiple-range test. Different letters indicate that means are significantly different at P = 0.05.

‡Turf quality ratings were 1–9, with 9 being the best quality and 1 very poor quality. Evaluations in November were on cool season overseeded grasses and other times were on bermudagrass only.

§Significant correlations at P = 0.05 (*).

and March. Significant correlations between numbers of *B. longicaudatus* and turf quality were obtained for only September in the 1977 experiment and for all months for 1 yr in the 1978 experiment (Tables 1 and 2). Control of *B. longicaudatus* for up to 7 months and improved turf quality for 12 months with fensulfothion as previously reported (13) was not observed in these experiments in North Carolina.

Treatment with phenamiphos reduced the numbers of *C. ornata* significantly, compared to the check, only in January and June of the 1978 experiment and not at any time in the 1977 experiment. Fensulfothion treatments did not reduce the numbers of *C. ornata* at any time in either experiment, but resulted in significantly higher numbers of this nematode than in the check in November of both experiments and in March of the 1978 experiment. Turf quality was not correlated with *C. ornata* densities in the 1977 experiment, but was negatively correlated in September and November of the 1978 experiment (Tables 1 and 2). Additional research with *C. ornata* alone is needed to determine the importance of this nematode on bermudagrass and overseeded golf greens.

The best turf quality ratings in both experiments were obtained with phenamiphos at 0.2 kg a.i. per 93 m², and the effects were evident for up to 2 yr after treatment. Treatment with fensulfothion resulted in better turf quality than the check one month after treatment in both experiments and in November and August of the 1977 experiment (Tables 1 and 2). The combination of phenamiphos and fensulfothion resulted in turf quality equal to that obtained with phenamiphos alone at a higher rate for 9 months but not 12 months after treatment (Table 2). Results indicate that more than 0.07 kg a.i. of phenamiphos per 93 m² is needed for control of the nematode for 1 yr. Treatment with phenamiphos alone at

Table 2. Number of *Belonolaimus longicaudatus* and *Criconemella ornata* per 500 cc of soil, turf quality, and correlation coefficients following treatment of a bermudagrass golf green with selected nematicides in June 1978.

Treatment (a.i./93m²)	Date sampled					
	July 78	Sept. 78	Nov. 78	Jan. 79	Mar. 79	June 79
	No. *B. longicaudatus*/500 cm³ soil					
Phenamiphos (0.2 kg)	25 a†	18 a	50 a	20 a	60 a	120 a
Fensulfothion (0.2 kg)	428 a	1,360 b	1,200 b	455 b	710 c	725 b
Phenamiphos (0.07 kg) + Fensulfothion (0.14 kg)	18 a	193 a	740 b	165 a	200 a	695 b
Check	1,033 b	703 ab	1,060 b	510 b	465 b	895 b
	No. *C. ornata*/500 cm³ soil					
Phenamiphos (0.2 kg)	2,623 a	985 a	840 a	556 a	830 a	1,210 a
Fensulfothion (0.2 kg)	4,280 a	6,210 b	4,090 b	1,476 b	2,700 b	1,980 ab
Phenamiphos (0.07 kg) + Fensulfothion (0.14 kg)	3,438 a	2,375 a	3,190 b	750 a	1,450 a	2,365 b
Check	4,578 a	4,630 ab		2,940 ab	1,435 a	2,225 b
	Turf quality‡					
Phenamiphos (0.2 kg)	8.3 a	7.8 a	8.5 a	6.5 a	7.5 a	9.0 a
Fensulfothion (0.2 kg)	6.8 a	4.3 b	5.3 b	5.3 ab	6.5 ab	1.5 c
Phenamiphos (0.07 kg) + Fensulfothion (0.14 kg)	8.0 a	7.0 a	7.5 a	6.8 a	7.5 a	6.0 b
Check	2.3 b	4.0 b	4.0 b	4.5 b	6.0 b	2.3 c
	Correlation coefficients for turf quality to nematodes					
B. longicaudatus	−.79**§	−.61*	−.82**	−.66**	−.66**	−.63**
C. ornata	−.39	−.58*	−.63**	−.48	.29	−.33

†Duncan's multiple-range test. Different letters indicate that means are significantly different at P = 0.05.

‡Turf quality ratings were 1–9, with 9 being the best quality and 1 being very poor quality. Evaluations in November, January, and March were on overseeded cool season grasses. Other times were on bermudagrass.

§Significant correlations at P = 0.05 (*) or P = 0.01 (**).

0.2 kg a.i. per 93 m² provided good turf quality for up to 2 yr; however, turf quality and the number of *B. longicaudatus* were not correlated for more than 1 yr after treatment in the 1977 experiment (Table 1). Phenamiphos is known to have residual activity for several months (14), and these results suggest residual activity against *B. longicaudatus* for up to 1 yr. Since the numbers of nematodes were about the same in all treatments after 2 yr, the improved turf quality into the second year was probably the result of the development of a better root system the previous year.

The percent area covered with prostrate spurge in June 1979, one year after treatment, was 0.3, 21.3, 4.8, and 20% for phenamiphos, fensulfothion, phenamiphos plus fensulfothion, and the check, respectively (LSD 17, $P = 0.05$). The reduction of spurge cover with phenamiphos at 0.2 kg a.i. was related to better nematode control and better growth of the bermudagrass allowing it to compete with the weed. A similar reduction in the amount of spurge concomitant with the control of *B. longicaudatus* has been reported previously (1).

The quality of the warm season bermudagrass and the cool season overseeded grasses were improved more by the treatment with phenamiphos than with the other nematicides. Apparently the longer residual activity of this nematicide prevented the nematode densities from returning to levels high enough to damage the overseeded grasses in the fall, winter, and spring, and the bermudagrass could resume growth more rapidly in the spring from winter dormancy. The poor quality of turf in June 1978 in the 1977 experiment in plots not

treated with phenamiphos was due to the rapid death of the overseeded winter grasses in hot weather prior to the regrowth of the bermudagrass (Fig. 2). This early regrowth of bermudagrass was probably due to the formation of healthier rhizomes, stolons, and root systems the previous summer.

Such long-term responses of turf infested with *B. longicaudatus* and control of this nematode with phenamiphos, or other nematicides, have not been reported previously. Phenamiphos provided superior control of *B. longicaudatus* and turf quality for a longer time compared to fensulfothion and DBCP and would be the best chemical to use on turf where this nematode is a problem. Differences between the two experiments and other reports may be due to the time of application of the nematicides (Lucas, unpublished data). Additional information is needed to determine the best time and frequency of nematicide application for adequate control of *B. longicaudatus* and maintenance of good turf quality.

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