Annals of Applied Nematology 2:46–49. 1988.

Evaluation of Three Nematicides for the Control of Phytoparasitic Nematodes in 'Tifgreen II' Bermudagrass[1]

ROBIN M. GIBLIN-DAVIS, J. L. CISAR, AND F. G. BILZ[2]

Abstract: Three nematicides were evaluated for control of *Belonolaimus longicaudatus, Hoplolaimus galeatus, Criconemella* spp., and *Meloidogyne* spp. in 'Tifgreen II' bermudagrass mowed at golf course fairway height (1.3 cm) in Fort Lauderdale, Florida. Bermudagrass plots were treated with fenamiphos (13.5 kg a.i./ha), oxamyl (13.5 kg a.i./ha), or 30% formaldehyde (6.4 liter a.i./ha). The plots treated with fenamiphos or formaldehyde were split 14 days later and one-half of each plot received two biweekly applications of formaldehyde. Forty-two days after the treatments were applied, the turfgrass vigor ratings and dry root weights in plots treated with fenamiphos were higher ($P < 0.05$) than the control, oxamyl, or formaldehyde treatments. The population levels of *B. longicaudatus* were suppressed ($P < 0.05$) in the fenamiphos, fenamiphos plus formaldehyde, and oxamyl treatments.

Key words: Belonolaimus longicaudatus, bermudagrass, chemical control, *Criconemella* spp., fenamiphos, formaldehyde, lance nematode, *Hoplolaimus galeatus, Meloidogyne* spp., oxamyl, ring nematode, root-knot nematode, sting nematode, turfgrass.

Warm-season turfgrasses, such as hybrid bermudagrass (*Cynodon* spp.), St. Augustinegrass (*Stenotaphrum* spp.), and bahiagrass (*Paspalum* spp.), grown on the coarse textured soils of southern Florida are susceptible to damage by phytoparasitic nematodes (2,7,9). *Belonolaimus longicaudatus* Rau, the sting nematode, is probably the most destructive and prevalent nematode parasite of bermudagrass (4,7,13) and other turfgrass species in Florida (9). Nonfumigant nematicides are the most common control agents for phytoparasitic nematodes attacking turfgrass (1,2,5–7,13). Few of these nematicides are highly effective for nematode control on turfgrass, and many of them are toxic to nontarget animals (7,8). Currently, there are only three nematicides labeled for nematode control on turfgrass in Florida: fenamiphos, ethoprop, and diazinon (2). Safe, effective materials, and expanded labels of effective compounds are needed for commercial and residential turfgrass. Our objective was to compare the efficacy of fenamiphos with oxamyl or formaldehyde for control of phytoparasitic nematodes in intensively managed bermudagrass.

MATERIALS AND METHODS

This study was conducted in May–June 1987 at the Fort Lauderdale Research and Education Center, Broward County, Florida, on 'Tifgreen II' bermudagrass (*Cynodon dactylon* × *C. transvaalensis* (Burt-Davy)), that was maintained under golf course fairway conditions. The study site was chosen because it was naturally infested with phytoparasitic nematodes that were relatively uniform in distribution. Pretreatment population densities (Pi) for *B. longicaudatus, Hoplolaimus galeatus* (Cobb) Thorne, *Criconemella* spp., and *Meloidogyne* spp. (juveniles and males) were not different ($P > 0.05$) within each species for all plots. The pooled means and standard deviations across treatments for the Pi of *B. longicaudatus, H. galeatus, Criconemella* spp., and *Meloidogyne* spp. were 165 ± 18, 102 ± 40, 626 ± 73, and 60 ± 11, respectively. The grass was mowed every other day at a 1.3-cm mowing height and all clippings were removed. Soil was classified as a Margate fine sand (siliceous, hyperthermic Mollic psammaquent); the surface horizon (upper 15 cm) contained 96% sand, 3% silt, 1% clay, 3% organic matter; pH 7.1. The saturated hydraulic conductivity at the site was 35.5 cm/hour and field capacity was

Received for publication 26 February 1988.

[1] Florida Agricultural Experiment Station Journal Series No. 8806.

[2] Assistant Professor, Assistant Professor, and Biological Scientist III, Fort Lauderdale Research and Education Center, University of Florida, Institute of Food and Agricultural Sciences, 3205 College Avenue, Fort Lauderdale, FL 33314.

We thank Michelle Dupuis and Karen E. Williams for their assistance and Bill Howard, Rudolf Scheffrahn, and Stephen Verkade for critical review of the manuscript.

0.08 cm^3/cm^3 (11). Treatments, randomized in five complete blocks, were fenamiphos 10 G (13.5 kg a.i./ha), oxamyl 10 G (13.5 kg a.i./ha), 30% formaldehyde, (HD-Form-A-Turf, Hendrix and Dail, Greenville, NC) (6.4 liter a.i./ha), and a control. Plots were 0.8 × 1.9 m with a 20-cm border. Formaldehyde was diluted 1:96 (v/v) in deionized water, and a premeasured volume was uniformly applied with a plastic hand sprayer (Sprayco, Detroit, MI). Fenamiphos and oxamyl were broadcast uniformly over the plots with a shaker can. Fenamiphos and formaldehyde treated plots were divided in half 14 days after initial treatment and one-half of each plot was treated with two biweekly applications of formaldehyde at the same rate. Treatments were applied before 1000 hours and 1.3 cm water was applied within 20 minutes of the application. Fertilizer was applied 28 days after initial treatment with 4.8 g N/m^2 in a 16-4-8 formulation (N-P_2O_5-K_2O). Plots were irrigated with approximately 7.5 mm water every other day. Cumulative rainfall for this 42-day study was 245 mm.

Turfgrass vigor ratings, based on percentage of ground cover and density of the bermudagrass, were taken at the initiation of the experiment and again at the end (scale 1–10: 1 = bare ground, 5 = 50% coverage and medium density, 10 = 100% coverage and high density turfgrass). The ratio of the final turfgrass vigor rating divided by the initial rating for the different treatments was used to assess changes in plot performance. Phytotoxicity ratings were made 1 and 2 weeks after each treatment. Pooled root samples from six soil cores (1.9 × 10 cm) were washed on two nested sieves (openings of 1,700 and 850 μm) and all debris, leaves, stolons, and thatch were removed. The roots were weighed after oven drying at 60 C for 48 hours and again after ashing at 500 C for 24 hours.

Six soil cores (2.5 cm d and 10 cm deep) were taken at random from each plot just before treatment applications and 42 days later. The samples were stored in plastic bags and processed within 48 hours. Each sample was thoroughly mixed, and nematodes were extracted and quantified from a 100-cm^3 subsample processed by a modified sugar flotation-centrifugation method (3). The modification involved dividing each sample into four 50-ml tubes for sugar flotation to decrease soil volume and increase extraction efficiency per tube. All fractions were recombined after processing. The extracted volume was brought to 10 ml, and after mixing a 1-ml aliquot was removed, diluted, and counted. The data were subjected to analysis of variance, and means separation was performed with a Waller–Duncan k-ratio t-test at $P < 0.05$ and k = 100.

Results and Discussion

The pretreatment turfgrass vigor ratings averaged 7.1 ± 0.1 (range = 7.0–7.3) with no differences observed between plots. Bermudagrass ratings at the end of the experiment were 0.7 units higher in plots treated with fenamiphos and fenamiphos plus formaldehyde than in plots treated with oxamyl, formaldehyde, multiple applications of formaldehyde, and the control. The turfgrass rating ratio stayed close to 1.0 (no change) in the fenamiphos-treated plots, whereas there was a decline in turfgrass quality in the rest of the treatments (Fig. 1A). No phytotoxicity (leaf burning) was observed during the experiment in any of the treatments. The fenamiphos treatments resulted in a more than 25% dry root weight increase over the oxamyl, formaldehyde, multiple application of formaldehyde, and control treatments (Fig. 1B).

Belonolaimus longicaudatus population densities (Pf) were suppressed ($P < 0.05$) after 42 days in plots receiving fenamiphos, fenamiphos plus formaldehyde, and oxamyl (Fig. 2). All other nematode species examined were not affected by any of the treatments or treatment combinations. The pooled means and standard deviations across treatments for the Pf of *H. galeatus*, *Criconemella* spp., and *Meloidogyne* spp. (juveniles and males) were 114 ± 63, 669 ±

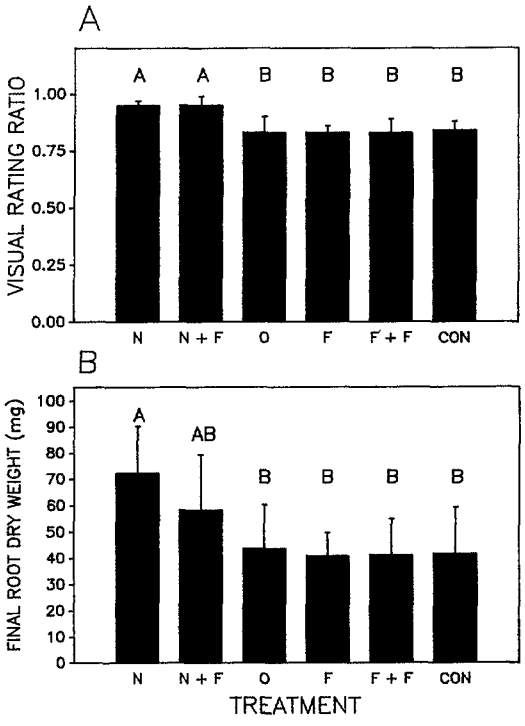

FIG. 1. Evaluation of Tifgreen II bermudagrass performance relative to nematicide treatment. A) Turfgrass performance ratio (final pretreatment) relative to treatment. B) Final dry root weight per six cores (1.9 × 10 cm) of soil relative to treatment. Treatments: N = fenamiphos 10 G at 13.5 kg a.i./ha; N + F = N + two biweekly applications of 30% formaldehyde at 6.4 liter a.i./ha; O = oxamyl 10 G at 13.5 kg a.i./ha; F = 30% formaldehyde at 6.4 liter a.i./ha; F + F = F + two biweekly applications of 30% formaldehyde at 6.4 liter a.i./ha. Error bar in up position; bars with the same letter are not different based on a Waller–Duncan k-ratio *t*-test ($P > 0.05$).

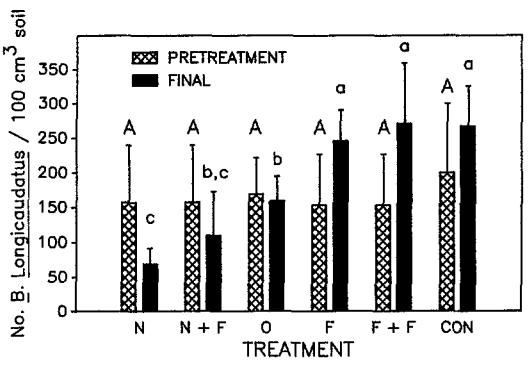

FIG. 2. Comparison of *Belonolaimus longicaudatus* population densities per 100 cm³ soil before and 42 days after nematicide treatment. Error bar in up position; bars with the same capital letter are not different based on Waller–Duncan k-ratio *t*-test comparisons ($P > 0.05$); bars with the same lower case letters are not different based on Waller–Duncan k-ratio *t*-test comparisons ($P > 0.05$).

142, and 58 ± 20, respectively. The Pf of *B. longicaudatus* was negatively correlated with final visual ratings ($r = -0.41$, $P = 0.025$) and dry root weight at harvest ($r = -0.51$, $P = 0.004$). The dry root weight at harvest was positively correlated with the ratio of final pretreatment vigor ratings ($r = 0.53$, $P = 0.003$) and final ratings of bermudagrass vigor ($r = 0.45$, $P = 0.014$). No correlations existed for the other nematodes surveyed.

Fenamiphos at 11.2 kg a.i./ha gave a fourfold increase in dry root weight and more than a 3.0 turfgrass rating increase (scale = 1–10) in 6 months in 'Ormond' bermudagrass infested with *B. longicaudatus* (7). Turfgrass quality ratings and the number of *B. longicaudatus* were negatively correlated for up to a year after treatment with 21.5 kg a.i./ha of fenamiphos (5). Fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone soil residues at 2.5–10 cm peaked at 7 or 30 days and declined to low levels by 60 days in a golf-green experiment in California (8). Different soil types, nematicide rates, mowing heights, history of soil conditioning to pesticides, cultural practices, weather, and subjectivity in the rating system between observers could all affect the turfgrass visual rating divergence between our study and others. We observed significant dry root weight differences in only 42 days, which suggests that fenamiphos affects nematode damage on roots, or stimulates root growth by itself, or both.

Oxamyl was tested in this experiment because it has systemic activity and has some activity against phytoparasitic nematodes in range grasses (10,12). It is not currently labeled for turfgrass; if efficacious, however, it would provide another management option. We applied oxamyl at 13.5 kg a.i./ha because this was the highest cost-effective rate relative to the fenamiphos commercial standard. There was some suppression of *B. longicaudatus* by oxamyl,

relative to the control and formaldehyde treatments (Fig. 2), but no concomitant increase was observed in turfgrass quality (Fig. 1A, B). Formaldehyde was tested because of preliminary in vitro evidence that it was toxic to *B. longicaudatus* at the concentration tested (unpubl.). The formulation evaluated did not control nematodes when applied alone or in multiple applications, and it did not improve the performance of fenamiphos when applied over it (Figs. 1, 2).

Although the pretreatment turfgrass vigor ratings of bermudagrass were above 7, the densities of *B. longicaudatus* were more than 16 times the estimated threshold that justifies control measures (2). In addition, *H. galeatus, Criconemella* spp., and *Meloidogyne* spp. were above estimated threshold levels. These inconsistencies suggest the need for refinement of the damage functions for different nematode species in turfgrasses and the need for a better understanding of the nature of polyspecific nematode communities (4).

Literature Cited

1. Brodie, B. B., and G. W. Burton. 1967. Nematode population reduction and growth response of bermuda turf as influenced by organic pesticide applications. Plant Disease Reporter 51:562–566.

2. Dunn, R. A. 1983. Turf nematodes: diagnosis and control. Nematology Plant Protection Pointer-18, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

3. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Disease Reporter 48:692.

4. Johnson, A. W. 1970. Pathogenicity and interaction of three nematode species on six bermudagrasses. Journal of Nematology 2:36–41.

5. Lucas, L. T. 1982. Population dynamics of *Belonolaimus longicaudatus* and *Criconemella ornata* and growth response of bermudagrass and overseeded greens following treatment with nematicides. Journal of Nematology 14:358–364.

6. Peacock, C. H., and R. A. Dunn. 1986. Effects of nematicide formulations on turfgrass nematodes. Soil and Crop Science Society of Florida Proceedings 45:185–188.

7. Perry, V. G., G. C. Smart, Jr., and G. C. Horn. 1970. Nematode problems of turfgrasses in Florida and their control. Florida State Horticultural Society Proceedings 83:489–492.

8. Peterson, D., W. Winterlin, and L. R. Costello. 1986. Nemacur residues in turfgrass. California Agriculture 40:26–27.

9. Rhoades, H. L. 1962. Effects of sting and stubby-root nematodes on St. Augustine grass. Plant Disease Reporter 46:424–427.

10. Smolik, J. D. 1977. Effect of nematicide treatment on growth of range grasses in field and glasshouse studies. Pp. 257–260 *in* J. K. Marshall, ed. Proceedings of below-ground ecosystem symposium. Range Science Series No. 26, Colorado State University, Fort Collins.

11. Snyder, G. H., E. Burt, and J. M. Davidson. 1981. Nitrogen leaching in bermudagrass turf: Effect of nitrogen sources and rates. Pp. 313–324 *in* R. W. Sheard, ed. Proceedings of the Fourth International Turfgrass Research Conference. Ontario Agricultural College and International Turfgrass Society, Ontario, Canada.

12. Van Bezooijen, J. 1984. Vydate in low dosage and as slow release formulation to control nematode damage in grasses. Mededelingen Faculteit Landbouwwetenschappen Rijksuniversiteit Gent 49:597–604.

13. Winchester, J. A., and E. O. Burt. 1964. Effect and control of sting nematodes on Ormond bermuda grass. Plant Disease Reporter 48:625–628.