MANAGEMENT PRACTICES AFFECTING PHYTOPARASITIC NEMATODES IN 'TIFGREEN' BERMUDAGRASS†

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ABSTRACT

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Winter overseeding of an established stand of 'Tifgreen' bermudagrass (*Cynodon magenissi*) with perennial ryegrass (*Lolium perenne* cv. CBS2) resulted in significant increases in the visual rating scores and ash root dry weights when compared with non-overseeded control plots. No significant effects were observed on population density estimates of *Belonolaimus longicaudatus, Hoplolaimus galeatus, Criconemella ornata,* or *Meloidogyne* spp. from overseeding throughout the 88-day study. A 2 × 2 factorial experiment evaluating the effects of lowering the mowing height of 'Tifgreen' bermudagrass from 1.30 to 0.65 cm and (or) fenamiphos application (22.4 kg a.i./ha broadcast) showed significant changes in the visual rating scores of the turfgrass 42 days after the treatments. A significant decline in the density of *B. longicaudatus* and an increase in turfgrass quality were associated with the nematicide treatment. Vertical distribution of phytoparasitic nematodes in the soil profile were examined in Tifgreen bermudagrass that was mowed at 1.30 and 0.65 cm for 56 days. Greater than 90% of the root biomass was recovered from the top 5 cm of soil and over 75% of juveniles and males of the *Meloidogyne* spp. were recovered from that depth. Mowing height and collection depth significantly affected *H. galeatus* densities. *Belonolaimus longicaudatus* numbers were significantly affected by mowing height but not by collection depth.

Key words: Belonolaimus longicaudatus, bermudagrass, chemical control, *Criconemella ornata, Cynodon magenissi,* fenamiphos, *Hoplolaimus galeatus, Lolium perenne, Meloidogyne* spp., mowing height, overseeding.

RESUMEN

Giblin-Davis, R. M., J. L. Cisar, F. G. Bilz, y K. E. Williams. 1991. Prácticas de manejo que afectan a nematodos fitoparásitos en pasto bermuda 'Tifgreen'. Nematrópica 21:59–69.

La resiembra en invierno de un césped establecido de pasto bermuda (*Cynodon magenissi*) con ballica (*Lolium perenne* cv. CB 52) resultó en un incremento significativo en valoraciones visuales y pesos secos radicales en comparación con parcelas de control sin resiembra. No se observaron efectos significativos sobre las estimaciones de las densidades poblacionales de *Belonolaimus longicandatus, Hoplolaimus galeatus, Criconemella ornata* o *Meloidogyne* spp. en el transcurso de los 88 días del estudio. Un experimento factorial de

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2 × 2 para evaluar los efectos de una menor distancia de corte en pasto bermuda 'Tifgreen' de 1.30 a 0.65 cm y (o) una aplicación de fenamifos (22.4 kg de i.a/ha) mostraron cambios significativos en la valoración visual del césped a los 42 días después de la aplicación. Se asocia una reducción en la población de *B. longicaudatus* con un incremento en la calidad del césped en el tratamiento con nematicida. Se examinó la distribución vertical de nematodos fitoparásitos en el perfil del suelo del pasto bermuda Tifgreen cortado a 1.30 y 0.65 cm a los 56 días. Más del 90% de la biomasa de la raíz se obtuvo de los primeros 5 cm del suelo, como también el 75% de los estadíos juveniles y machos de *Meloidogyne* spp. La altura de corte y la profundidad de recolección afectaron significativamente las densidades de *H. galeatus*. En cambio, la cantidad de *B. longicaudatus* se afectó en forma signficativa por la altura de corte, pero no por la profundidad de recolección.

Palabras clave: altura de corte, *Belonolaimus longicaudatus*, control químico, *Criconemella ornata, Cynodon magenissi*, fenamifos, *Hoplolaimus galeatus, Lolium perenne, Meloidogyne* spp., pasto bermuda, resiembra.

INTRODUCTION

Warm-season hybrid golf course bermudagrasses are susceptible to several phytoparasitic nematodes (2,8,14). High densities of several nematode species are correlated with chronic underperformance of the infested turfgrass, especially during times of stress (6,9). The few organophosphate nematicides that are labelled for management of nematodes in turfgrass are nematostatic at the concentrations achieved under field conditions and are short-lived in the golf course environment with efficacy lasting about 6 weeks (3,4,10). Information is needed about how cultural practices such as height of mowing cut or winter overseeding with perennial ryegrass affect phytoparasitic nematode densities. This information could help in the development of strategies to optimize nematicide efficacy and (or) provide for more efficient management of nematode densities.

Bermudagrass grows slowly in southern Florida during the late fall and winter (November–March) when solar output and soil temperatures are low. Golf course superintendents often overseed with cool-season perennial ryegrasses to produce attractive putting greens. However, soil temperatures remain sufficiently warm that populations of phytoparasitic nematodes may increase with the increased root biomass produced by the new cool-season host. Hypothetically, the cultural practice of winter overseeding with perennial ryegrass could lead to increased densities of phytoparasitic nematodes which would be problematic to a bermudagrass host during initiation of growth in spring.

Defoliation and feeding of phytoparasitic nematodes have been reported to cause negative interactive effects on the growth of sideoats grama (*Bouteloua curtipendula* (Michaux) Torrey) from the North American mixed-grass prarie (5). The practice of lowering the mowing height (increasing defoliation) to achieve different heights of the putting surface may likewise reduce photosynthetic leaf area and reduce allocation of resources to the roots causing negative interactions with the feeding of phytoparasitic nematodes.

The purpose of this study was to determine if populations of phytoparasitic nematodes were affected by overseeding an established stand of 'Tifgreen' hybrid bermudagrass (*Cynodon magenissi* Hurcombe) with perennial ryegrass (*Lolium perenne* L.). An experiment also was conducted to determine if lowering the mowing height of Tifgreen bermudagrass from 1.30 cm to 0.65 cm and (or) fenamiphos application affected numbers of phytoparasitic nematodes. Lastly, vertical distribution of the phytoparasitic nematodes and roots were examined from Tifgreen bermudagrass which was mowed at 1.30 cm and 0.65 cm for 56 days.

MATERIALS AND METHODS

This study was conducted during January-April 1988 at the Fort Lauderdale Research and Education Center, Broward Co., Florida on Tifgreen (Tifton-328) bermudagrass. Prior to the start of the experiments, the turfgrass had been maintained under fairway conditions receiving about 10 g $N/m^2/year$ and mowings every other day at a 1.30-cm height of cut with all clippings being removed. The upper 15 cm of the soil horizon of the field plot area was classified as a Margate fine sand containing 96% sand, 3% silt, 1% clay with 3% organic matter. Soil pH was 7.1. The saturated hydraulic conductivity of the soil was 35.5 cm/hour and field capacity was 0.08 cm^3/cm^3 (13). To avoid moisture stress plots were irrigated with approximately 7.5 mm water every other day. Cumulative rainfall was 531 mm from 14 January 1988 to 29 February 1988 and 509 mm from 29 February 1988 to 11 April 1988. Soil temperature was monitored daily, except weekends, with a minimum-maximum thermometer placed 5 cm deep in the experimental field plot area.

Evaluation of turfgrass performance and nematode sampling: Turfgrass visual ratings were based upon the percentage of ground cover and density of the bermudagrass. Ratings were taken at the initiation of each experiment and again at the end (unless otherwise stated) using a scale of 1–10 where 1 = bare ground, 5 = 50% coverage and medium density, 10 = 100% coverage and high density turfgrass. Pooled root samples from six soil cores (1.9×10 cm = 250 cm^3 soil volume) were washed on two nested sieves (openings of 1 700 and 800 μm) and all debris, leaves, stolons, and thatch were removed manually. The roots were weighed after oven drying at 60 C for 48 hours and again after ashing at 500 C for 24 hours. In the vertical distribution study a cup cutter was used to obtain 0.5 L or 1.0 L of soil for each depth and soil was processed as above.

Six soil cores (2.5-cm diam and 10 cm deep) were taken at random from each plot before treatment applications and at the stated intervals. Samples were stored in plastic bags and processed within 48 hours. Each sample was mixed thoroughly, and nematodes were extracted and quantified from a 100-cm^3 subsample processed by a modified sugar-flotation-centrifugation method (3). The extracted volume was brought to 10 ml, and after mixing, a 1-ml aliquot was removed, diluted, and counted. The data were transformed to $\log_{10}(N + 1)$ prior to an analysis of variance.

Experiment 1: Each plot (1 × 2 m) was verticut and not overseeded or verticut and overseeded with 250 g of *L. perrene* cv. CBS2 on 14 January 1988 (Julian date = 14). Both treatments were replicated five times in a completely randomized design. Visual ratings, root dry weights, and population density estimates of phytoparasitic nematodes were made at the start of the experiment (14 January 1988; Julian date = 14), at 46 days post-treatment (29 February 1988; Julian date = 61), and at the termination of the experiment at 88 days post-treatment (11 April 1988; Julian date = 103).

Experiment 2: A 2 × 2 factorial experiment on 1 × 2 m plots of Tifgreen bermudagrass was initiated on 29 February 1988 (Julian date = 61). Four treatments were replicated five times in a randomized complete-block design. Treatments consisted of a nematicide application (10 G formulation of fenamiphos applied at the rate of 22.4 kg a.i./ha broadcast) or no nematicide application on grass which was mowed at 1.30 cm or at 0.65 cm starting on the treatment date. Experimental plots had been maintained at 1.30 cm prior to the start of the experiment. Visual ratings, root dry weights, and nematode counts were made at the start of the experiment and 42 days later on 11 April 1988 (Julian date = 103). Root dry weights and nematode counts were transformed with $\log_{10}$ (N + 1) prior to analysis with a 2-way analysis of variance (12).

Experiment 2 was prolonged for an extra 14 days in three plots chosen at random that received no nematicide and were mowed at each of the two mowing heights. Six 2.5-cm-diam cores were taken in each plot for each of four depths (0–5, 6–10, 11–20, and 21–30 cm) and were extracted to determine numbers of phytoparasitic nematodes as described previously. A 10.5-cm-diam putting cup cutter was used to obtain 0.5 L (0–5 and 6–10-cm depths) or 1.0 L (11–20 and 21–30-cm depths) of soil to be washed for root analysis as described above.

RESULTS AND DISCUSSION

Visual ratings of turfgrass plots were improved significantly 46 and 88 days after overseeding with perennial ryegrass (Table 1). Root biomass in overseeded plots was significantly greater 46 days after overseeding but not at 0 or 88 days (Table 1).

Table 1. Comparison of visual ratings, root weight, and population densities of *Belonolaimus longicaudatus*, *Hoplolaimus galeatus*, *Criconemella ornata*, and *Meloidogyne* spp. in 'Tifgreen' bermudagrass at 0, 46, and 88 days after overseeding with perennial ryegrass.

						No. of nematodes/100 cm^3 of soil					
	Visual rating[x]		Ash dry weight (mg)[y]			*B. longicaudatus*			*H. galeatus*		
Treatment	46 days	88 days	0 days	46 days	88 days	Pi[z]	Pm	Pf	Pi	Pm	Pf
Bermudagrass	2.8±0.5**	4.5±0.8*	81.5±12.9	110.8± 27.1*	264.9± 95.3	116±97	178±147	260±258	1 163±299	1 082±374	1 216±351
Bermudagrass overseeded with ryegrass	8.0±0.4	5.6±0.4	70.2±16.5	332.5±187.9	423.7±116.2	134±64	137±123	118±109	1 284±438	1 544±520	1 338±288
						C. ornata			*Meloidogyne* spp.		
						359±121	372±273	536±601	31±23	54±65	2±2
						559±446	632±566	672±616	30±24	56±64	1±2

*, ** indicates a significant difference at $P < 0.05$ and $P < 0.01$, respectively, between means in a column.

[x]Rating for both treatments was 2.5 ± 0.5 prior to verticutting and overseeding.

[y]Roots were harvested from six random cores 1.9 × 10 cm (250 cm^3); data were transformed with $\log_{10}$ (N + 1) prior to analysis.

[z]Pi = population density at beginning of experiment on 14 January 1988 (Julian date = 14); Pm = population density at middle of experiment on 29 February 1988 (Julian date = 61); and Pf = final population density on 11 April 1988 (Julian date = 103). Data for Pi, Pm, and Pf were transformed prior to analysis with $\log_{10}$ (N + 1).

Soil temperature at 5 cm ranged from 8–35 C during experiment 1. In the first 46 days, soil temperatures at 5 cm ranged from 8–29 C and the average mean daily temperature was 21.5 ± 2.7 C, whereas during the last 42 days the temperatures ranged from 16–35 C and the mean daily soil temperature was 25.2 ± 1.9 C. Temperatures during the last 42 days were in the range of early spring temperatures in North America and were conducive to survival and reproduction of *B. longicaudatus* (11). A population of *B. longicaudatus* from Tifton, Georgia, U.S.A. reproduced best between 25–30 C with some reproduction occurring at 20 and 35 C (11). However, there were no significant differences in the numbers of any of the phytoparasitic nematodes surveyed at 0, 46, or 88 days after overseeding (Table 1). Comparisons of the numbers of nematodes/g of root dry weight for each sample period showed no significant differences. Apparently, the populations of phytoparasitic nematodes were not able to respond to the increased root biomass produced by this management practice. Differential host status between the ryegrass and bermudagrass cultivars used and host preference of nematode populations that have been adapted for many years to one host are all factors that may have prevented the populations of *B. longicaudatus* from increasing. Also, soil temperatures in the first 46 days of experiment 1 were about 21 C which may have been suboptimal for populational response to increased root biomass.

Crop rotation, a nematode control strategy effective for nematode management in many agronomic crops, could be feasible in a perennial system such as turfgrass if an aesthetically pleasing intercrop with nematode suppressive qualities could be identified or genetically engineered. Of course the best strategy would be to identify or develop grasses that could be grown the entire year and would have resistance to phytoparasitic nematodes, but grasses with these characteristics are not available. One aspect that is critical in such a strategy is the ability to kill the intercrop plant when it is no longer needed without reducing the vigor of the bermudagrass. In the management practice of overseeding bermudagrass with cool-season grasses, temperature, humidity, and herbicides are factors that regulate which grass species predominates. The results from experiment 1 suggest that intercropping with an aesthetically acceptable suppressive plant(s) for management of *B. longicaudatus* would probably have to be done during the spring (soil temperatures 25–35 C) when the nematodes would be active but not during the summer when soil temperatures might be suppressive. Further research is needed to assess the host status of different ryegrass and bentgrass cultivars at optimal temperatures for *B. longicaudatus* and other common phytoparasitic nematodes in turf.

A mean squares table is presented for the 2 × 2 factorial used in experiment 2 (Table 2). The means and standard deviations for columns

Table 2. Mean squares from a 2 × 2 factorial experiment with five blocks to evaluate the effects of a change in mowing height from 1.30 cm to 0.65 cm and (or) the application of fenamiphos on 'Tifgreen' bermudagrass visual ratings, root dry weights at 0 and 42 days after treatment, and populations of *Belonolaimus longicaudatus, Hoplolaimus galeatus, Criconemella ornata,* and *Meloidogyne* spp.

Source of variation	df	*Visual rating*[v] 0 days	42 days	Ash dry weight (mg)[w]	*B. longicaudatus* Pi[x]	Pf	*H. galeatus* Pi	Pf	*C. ornata* Pi	Pf	*Meloidogyne* spp. Pi	Pf
Height of cut (H)[y]	1	0.05	7.20**	55818.40	0.06	0.01	0.01	0.00	0.02	0.23	0.22	0.16
Nematicide (N)[z]	1	0.05	5.00**	1365.90	0.00	2.90**	0.01	0.03	0.05	0.00	0.01	0.47
H × N	1	0.05	0.00	12829.53	0.04	0.10	0.01	0.08	0.00	0.01	0.53	0.00
Block	4	0.44	0.79	7838.63	0.45	1.48**	0.03	0.03	0.15	0.30	0.79	0.59
MS Error	12	0.32	0.41	12507.45	0.16	0.20	0.01	0.02	0.10	0.16	0.35	0.43

$*P < 0.05$, $**P < 0.01$.

[v]Initial visual rating (0 days) taken at start of experiment on 29 February 1988 (Julian date = 61); visual rating at the end of the experiment (42 days) taken on 11 April 1988 (Julian date = 103).

[w]Roots were harvested from six random cores 1.9 × 10 cm (250 cm^3).

[x]Pi = initial population density estimate taken at start of experiment on 29 February 1988 (Julian date = 61). Data was transformed prior to analysis with $\log_{10}(N + 1)$; Pf = final population density estimate on 11 April 1988 (Julian date = 103). Data was transformed prior to analysis with $\log_{10}(N + 1)$.

[y]Bermudagrass was mowed every other day at 1.30 cm and clippings were retained. Starting 29 February 1988 (Julian date = 61) half of the plots were mowed at 0.65 cm.

[z]10 G formulation of fenamiphos was applied at the rate of 22.4 kg a.i./ha on 29 Febraury 1988.

in Table 2 with significant effects follow. In bermudagrass which was mowed at 1.30 cm, the visual ratings and *B. longicaudatus* counts 42 days after treatment were 4.5 ± 0.8 and 260 ± 258 for no fenamiphos and 5.5 ± 0.8 and 36 ± 41 for fenamiphos-treated plots. In bermudagrass which was mowed at 0.65 cm, the visual ratings and *B. longicaudatus* counts 42 days after treatment were 3.3 ± 0.7 and 160 ± 178 for no fenamiphos and 4.3 ± 0.6 and 47 ± 42 for fenamiphos-treated plots. Thus, lowering the mowing height of Tifgreen bermudagrass from 1.30 to 0.65 cm decreased visual rating scores at 42 days whereas application of fenamiphos increased the scores (Table 2). Final root dry weights were not affected by treatments (Table 2). A significant decline in the density of *B. longicaudatus* was associated with the nematicide treatment. This supports earlier reports that fenamiphos is effective in suppressing *B. longicaudatus* populations in bermudagrass turf (3,4,6) and suggests that within 42 days of changing the mowing height from 1.30 to 0.65 cm that no significant gross population changes in the phytoparasitic nematodes were evident. Also, no interaction between fenamiphos application and mowing height was observed.

There was a significant difference in the dry weight of roots recovered at different depths of collection (df = 3, 16; F = 37.62; P = 0.0001). There were no significant differences due to mowing height of cut and there was no interaction between mowing height and collection depth. Greater than 90% of the root biomass was recovered from top 5 cm of soil (Table 3). There were no significant differences in *Meloidogyne* spp. or *C. ornata* population densities attributable to mowing height or depth of collection and there was no interaction between these variables. Over 75% of the *Meloidogyne* spp. juveniles and males were recovered from the 0–5 cm deep samples (Table 3). This is not surprising since root-knot nematodes are endoparasites. Mowing height significantly affected *B. longicaudatus* densities (df = 1, 16; F = 5.73; P = 0.0293). There were no significant effects due to depth of collection and no interaction between mowing height and collection depth. Mowing height (df = 1, 16; F = 8.18; P = 0.0113) and depth of collection (df = 3, 16; F = 54.97; P = 0.0001) significantly affected *H. galeatus* densities, but there was no interaction between variables. Long-term changes in mowing height may further accentuate the differences in the distribution of roots and nematodes. In previous studies (1,7), the number of *B. longicaudatus* in sandy soils was high in the upper 15 cm prior to planting soybean and highest in the top 30 cm after planting. Tap roots of soybean plants can be found to a depth of 200 cm and secondary roots can reach a depth of 180 cm, but most of the roots are in the top 15 cm (1).

Routine soil samples for estimating densities of nematodes in bermudagrass in the sandy soils of Florida usually are taken to a depth of

Table 3. Mean densities of *Belonolaimus longicaudatus, Hoplolaimus galeatus, Criconemella ornata,* and *Meloidogyne* spp. and percentage phytoparasitic nematodes per 100 cm^3 of soil and root weights and percentage total weight per 500 cm^3 of soil at different depths under 'Tifgreen' bermudagrass mowed at 0.65 cm and 1.30 cm[x].

	Dry root weight		*B. longicaudatus*		*H. galeatus*		*C. ornata*		*Meloidogyne* spp.	
Soil depth (cm)	mg	%[y]	No. nematodes	%	No. nematodes	%	No. nematodes	%	No. nematodes	%
					0.65 cm mowing height					
0–5	$965.5^{a} \pm 216.0$[z]	99	$183^{ab} \pm 146$	26	$1\,517^{a} \pm 115$	56	$173^{a} \pm 110$	9	$186^{a} \pm 146$	77
6–10	$7.7^{bc} \pm 8.0$	<1	$200^{ab} \pm 173$	28	$530^{b} \pm 56$	20	$377^{a} \pm 241$	20	$10^{a} \pm 10$	4
11–20	$1.5^{bc} \pm 1.6$	<1	$117^{ab} \pm 71$	32	$277^{c} \pm 21$	17	$277^{a} \pm 171$	28	$20^{a} \pm 26$	17
21–30	$0.8^{c} \pm 1.3$	<1	$50^{b} \pm 40$	14	$100^{d} \pm 46$	7	$413^{a} \pm 541$	43	$3^{a} \pm 6$	2
					1.30 cm mowing height					
0–5	$962.3^{a} \pm 69.3$	92	$263^{a} \pm 64$	21	$1\,227^{a} \pm 285$	37	$120^{a} \pm 125$	6	$997^{a} \pm 990$	91
6–10	$79.0^{b} \pm 129.4$	7	$263^{a} \pm 49$	22	$733^{b} \pm 280$	23	$620^{a} \pm 733$	29	$50^{a} \pm 36$	5
11–20	$4.3^{bc} \pm 5.6$	<1	$227^{a} \pm 35$	37	$463^{b} \pm 64$	28	$547^{a} \pm 320$	51	$20^{a} \pm 10$	3
21–30	$0.3^{c} \pm 0.5$	<1	$123^{ab} \pm 76$	20	$200^{c} \pm 89$	12	$153^{a} \pm 137$	14	$3^{a} \pm 6$	1

[x]Three plots maintained at each mowing height were sampled separately for nematodes and for roots at each depth. Mowing height of cut was lowered from 1.30 cm to 0.65 cm 56 days prior to sampling.
[y]Percentage of total recovered from all depths combined.
[z]Mean ± standard deviation. Means followed by different letters in a column are significantly different according to a Waller-Duncan k-ratio t-test ($P < 0.05$; $k = 100$).

10–20 cm. The 20-cm sampling depth should be acceptable for the harvest of > 50% of the phytoparasitic nematodes present in the top 30 cm (assuming 100% or equal extraction efficiency for each species). Seasonal variability in the distribution pattern of the different nematode species in soil planted to bermudagrass and maintained for long periods at different mowing heights should be undertaken.

LITERATURE CITED

1. BRODIE, B. B. 1976. Vertical distribution of three nematode species in relation to certain soil properties. Journal of Nematology 8:243–247.
2. 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.
3. GIBLIN-DAVIS, R. M., J. L. CISAR, and F. G. BILZ. 1988. Evaluation of three nematicides for the control of phytoparasitic nematodes in Tifgreen II bermudagrass. Annals of Applied Nematology (Journal of Nematology 20, Supplement) 2:46–49.
4. GIBLIN-DAVIS, R. M., J. L. CISAR, and F. G. BILZ. 1988. Response of nematode populations and growth of fairway managed bermudagrass to application of fertilizer and fenamiphos. Nematrópica 18:117-127.
5. INGHAM, R. E., and J. K. DETLING. 1986. Effects of defoliation and nematode consumption on growth and leaf gas exchange in *Boutloua curtipendula*. Oikos 46:23–28.
6. 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.
7. McSORLEY, R., and D. W. DICKSON. 1990. Vertical distribution of plant-parasitic nematodes in sandy soil under soybean. Journal of Nematology 22:90–96.
8. NUTTER, G. C., and J. R. CHRISTIE. 1958. Nematode investigations on putting green turf. Florida State Horticultural Society Proceedings 71:445–449.
9. 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.
10. PETERSON, D., W. WINTERLIN, and L. R. COSTELLO. 1986. Nemacur residues in turfgrass. California Agriculture 40:26–27.
11. ROBBINS, R. T., and K. R. BARKER. 1974. The effects of soil type, particle size, temperature, and moisture on reproduction of *Belonolaimus longicaudatus*. Journal of Nematology 6:1–6.
12. SAS INSTITUTE. 1985. SAS User's Guide: Statistics, 5th ed. SAS Institute, Carey, North Carolina, U.S.A.
13. 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.
14. WINCHESTER, J. A., and E. O. BURT. 1964. The effect and control of sting nematodes on Ormond bermuda grass. Plant Disease Reporter 48:625–628.

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