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Host Status of 'Sealsle 1' Seashore Paspalum (*Paspalum vaginatum*) to *Belonolaimus longicaudatus* and *Hoplolaimus galeatus*[1]

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Abstract: *Belonolaimus longicaudatus* and *Hoplolaimus galeatus* are considered among the most damaging pathogens of turfgrasses in Florida. However, the host status of seashore paspalum (*Paspalum vaginatum*) is unknown. Glasshouse experiments were performed in 2002 and 2003 to determine the tolerance of 'SeaIsle 1' seashore paspalum to a population of *B. longicaudatus* and a population of *H. galeatus,* and to compare to 'Tifdwarf' bermudagrass for differences. Both nematode species reproduced well on either grass, but only *B. longicaudatus* consistently reduced root growth as measured by root length. *Belonolaimus longicaudatus* reduced root growth ($P \leq 0.05$) by 35% to 45% at 120 days after inoculation on both grasses. In 2003, higher inoculum levels of *H. galeatus* reduced root growth ($P \leq 0.05$) by 19.4% in seashore paspalum and by 14% in bermudagrass after 60 and 120 days of exposure, respectively. Percentage reductions in root length caused by *H. galeatus* and *B. longicaudatus* indicated no differences between grass species, although Tifdwarf bermudagrass supported higher soil population densities of both nematodes than SeaIsle 1 seashore paspalum.

Key words: *Belonolaimus longicaudatus,* bermudagrass, *Hoplolaimus galeatus,* host status, lance nematode, *Paspalum vaginatum,* seashore paspalum, sting nematode, tolerance.

Seashore paspalum (*Paspalum vaginatum*) is a warm-season turfgrass becoming increasingly popular for golf courses and other landscaping uses. Selection for fine leaf texture and its natural tolerance to drought and high salinity has caused seashore paspalum to become increasingly prevalent in coastal, salt-affected turfgrass sites (Duncan, 1999; Morton, 1973). One major limitation of cultivating turfgrasses in the sandy soils of the southeastern United States is the destruction of roots by phytoparasitic nematodes (Perry and Rhoades, 1982). The sting nematode (*Belonolaimus longicaudatus*) and the lance nematode (*Hoplolaimus galeatus*) are destructive pathogens on a variety of agricultural crops, including turfgrasses (Ahmad and Chen, 1980; Holdeman and Graham, 1953; Perry and Rhoades, 1982; Smart and Nguyen, 1991). Whereas *B. longicaudatus* is found primarily in the coastal plains of the southeastern United States (Christie, 1959; Holdeman, 1955), *H. galeatus* has a much wider distribution (Williams, 1973). *Belonolaimus longicaudatus* damages lateral roots as soon as they are formed, causing root-growth stunting, decreased water and nutrient uptake, and decreased rates of evapotranspiration (Busey et al., 1991; Johnson, 1970; Perry and Rhoades, 1982). *Hoplolaimus galeatus* enters the root tissue as a migratory endoparasite and is thought to damage roots by feeding and physical tunneling through the root cortex cell walls (Henn and Dunn, 1989; Krusberg and Sasser, 1956; Lewis and Fassuliotis, 1982; Perry et al., 1970; Williams, 1973).

Both nematodes have been reported as economically important pathogens of turfgrasses in the southeastern United States (Christie et al., 1954; Kelsheimer and Overman, 1953; Perry and Rhoades, 1982). *Belonolaimus longicaudatus* has been reported as a pathogen of many bermudagrasses (*Cynodon dactylon* and *Cynodon* spp. hybrids) and St. Augustinegrass (*Stenotaphrum secundatum*) cultivars (Busey et al., 1991; Giblin-Davis et al., 1992a, b; Johnson, 1970). Seven cultivars of St. Augustinegrass were discovered to have similar host suitability for *H. galeatus* in the glasshouse and in microplots (Henn and Dunn, 1989). However, root and shoot growth of 'FX-313' and 'Floratam' St. Augustinegrass were not affected by *H. galeatus* in a population dynamics and pathogenicity study (Giblin-Davis et al., 1995). Two populations of *B. longicaudatus* readily reproduced on 'Tifdwarf' bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) and caused extensive root damage (Giblin-Davis et al., 1992b; Johnson, 1970). A forage grass study determined that there was differential host suitability and susceptibility to *B. longicaudatus* in *Digitaria* spp., *Paspalum* spp., and *Chloris* spp. introductions (Boyd and Perry, 1969).

At present, no published data exist on the host status of seashore paspalum to *H. galeatus* or *B. longicaudatus.* The objectives of this study were to (i) determine the tolerance and host suitability of SeaIsle 1 seashore paspalum to a population of *B. longicaudatus* and a population of *H. galeatus* and (ii) compare SeaIsle 1 seashore paspalum to Tifdwarf bermudagrass for differences in tolerance to a population of *B. longicaudatus* and a population of *H. galeatus.*

Materials and Methods

Experiments were performed to compare the relative tolerance of SeaIsle 1 seashore paspalum and Tifdwarf bermudagrass to *B. longicaudatus* and *H. galeatus.* Experiments were conducted during spring and summer 2002 and 2003 at the University of Florida Turfgrass Envirotron Glasshouse in Gainesville, Florida. Commercially available cultivars of *Paspalum vaginatum* and

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Cynodon dactylon × *C. transvaalensis* were evaluated in this experiment. SeaIsle 1 seashore paspalum was obtained from R. R. Duncan at the University of Georgia, and Tifdwarf bermudagrass was available from previous experiments. Currently, very few commercially cultivars of seashore paspalum are available. Therefore, SeaIsle 1 seashore paspalum was chosen for these experiments because it is one of the most common seashore paspalum cultivars currently available for public use. Nematode-free plugs of each grass were obtained by rooting aerial cuttings of stolons from each grass in tapered RLC-7 (UV Stabilized) Super "Stubby" Cells (cell depth = 14 cm., diam. = 3.8 cm., volume = 115 cm^3) (Ray Leach Single Cell Cone-tainer, Stuewe & Sons, Inc., Corvallis, OR) filled with 140 g of uninfested soil. Soil used for growth media consisted of 100% United States Golf Association (USGA) specification sand (USGA Green Section Staff, 1993). The soil texture was analyzed using the sieving method for testing a USGA root zone mix (Table 1). An absorbent cotton ball was placed at the bottom of each cell to prevent soil from escaping through the drain holes. The soil was then thoroughly wetted to allow for settling. A depression was made in each cell, and two aerial stolons were planted on opposing sides of the depression. Stolons (5 to 8 cm long) were terminal cuttings with two or three nodes. During the fall and winter months, the cells were placed on a glasshouse bench 1.25 m below an enclosed 1,000-watt metal halide growth lamp set on a 12-hour cycle to simulate the longer day-lengths required for optimal growth. The grasses were fertilized biweekly using a fertilizer solution (20%–20%–20% [$N–P_2O_5–K_2O$] plus trace levels of Mg, B, Cu, Fe, Mn, Mo, and Zn) at a rate equivalent to 49.0 kg N/ha/month, 21.6 kg P/ha/month, and 40.7 kg K/ha/month. Both grasses were allowed to develop a substantial root system for 4 weeks.

Plugs of seashore paspalum and bermudagrass obtained from the cells were transferred into 14.5×16-cm-diam. clay pots (1,500 cm^3) filled with 100% USGA specification sand. Roots were washed free of soil and trimmed to approximately 5 cm below the crown to promote fresh root growth. Two depressions were made in each pot on opposite sides, and two plugs of turfgrass were planted per pot. These experimental units were placed on a screened bench in an environmentally controlled glasshouse and irrigated as needed for 14 days to allow for adjustment to the new environment.

TABLE 1. Particle size distribution of experimental soil compared to the United States Golf Association root zone mix spefications (USGA Green Section Staff, 1993).

Sand type	Particle size	Experimental soil	USGA specifications
Fine Gravel	2.0 to 3.4 mm	0.1%[a]	Not more than 10% of the total particles in this range, including a maximum of 3% fine gravel (preferably none)
Very Coarse Sand	1.0 to 2.0 mm	3.7%	
Coarse Sand	0.5 to 1.0 mm	30.8%	Minimum of 60% of the particles must fall in this range
Medium Sand	0.25 to 0.50 mm	53.4%	
Fine Sand	0.15 to 0.25 mm	10.3%	Not more than 20%
Very Fine Sand	0.05 to 0.15 mm	1.7%	Not more than 5%

[a] Data are means of five replicates.

A population of *B. longicaudatus* obtained from R. M. Giblin-Davis that originated from unmanaged field soil in the Sanford, Florida area was allowed to reproduce on 'FX 313' St. Augustinegrass. A population of *H. galeatus* was obtained from a 'Floradwarf' bermudagrass putting green at the G. C. Horn Turfgrass Field Laboratory in Gainesville, Florida, and maintained on Tifdwarf bermudagrass. Inocula were extracted from soil using a modified Baermann funnel method (McSorley and Frederick, 1991). In 2002, the source of the *H. galeatus* population was contaminated with other plant-parasitic nematodes and 100 individual *H. galeatus* of mixed life stages were handpicked to inoculate into 16 pots of each grass. Since the *B. longicaudatus* population was not contaminated, handpicking was not necessary. A solution of *B. longicaudatus* at various life stages in tap water was calibrated by counting nematodes from 1-ml aliquots on a grided counting slide (Hawksley and Sons Limited, Lancing, Sussex, UK) replicated 10 times. Approximate numbers of nematodes were measured with a pipett from water suspensions of inocula. *Belonolaimus longicaudatus* (107 ± 8) was inoculated into each of 16 pots of each grass. In 2003, *H. galeatus* and *B. longicaudatus* were obtained from the previous year's experiment, and inocula of both species were obtained using the same modified Baermann funnel method (McSorley and Frederick, 1991). Suspensions were made for each nematode and standardized to deliver approximately 200 nematodes per pot. *Hoplolaimus galeatus* (199 ± 13) and *B. longicaudatus* (211 ± 10) were inoculated into 20 pots of each grass, respectively. Greater numbers of nematodes were inoculated in the second year to achieve higher reproduction. In both years, nematodes were suspended in 50 ml of tap water and equally distributed into four cavities formed in the soil near the base of the plant. Uninoculated plants received 50 ml of tap water. After inoculation the cavities were closed with surrounding soil, and tap water was applied as needed to avoid wilting.

Pots were arranged in a randomized complete block design in the glasshouse on screened benches. Treatments were seashore paspalum and bermudagrass inoculated with the specified number of *H. galeatus* or *B. longicaudatus,* allowed to reproduce for 60 or 120 days, and uninoculated controls. In 2002, separate experi-

ments, consisting of a total of 64 pots each were performed for each nematode. Each experiment had eight treatments with eight replications. In 2003, the two nematode species were placed into the same experiment, allowing for fewer control pots and a higher number of replications. The second experiment had 12 treatments with 10 replications, for a total of 120 pots.

Throughout the course of the 2002 experiments, which lasted from 21 April 2002 to 10 September 2002, average monthly high and low temperatures in the glasshouse ranged from 31 °C to 34 °C, and 23 °C to 26 °C, respectively. In 2003, experiments began 28 February 2003 and ended 13 July 2003. Average monthly high and low temperatures ranged from 27 °C to 32 °C and 19 °C to 24 °C, respectively. An insecticide/miticide (Mavrik Aquaflow, Wellmark International, Schaumburg, IL) was applied at the labeled rate (0.14 ml a.i./liter of water) twice during the course of 2003 experiments for control of bermudagrass mites (*Eriophyes cynodoniensis* Sayed) and rhodesgrass mealybugs (*Antonina graminis* Maskell). Tifdwarf bermudagrass was fertilized on a biweekly basis with 40 ml of a solution consisting of 5,100 mg NH_4NO_3 (34% N), 3,177 mg KCl, 252 mg $Ca(H_2PO_4)_2$, 435 mg $CaSO_4$, 246 mg $MgSO_4$, 1.55 mg H_3BO_3, 0.34 mg $MnSO_4$, 0.58 mg $ZnSO_4$, 0.13 mg $CuSO_4$, and 3.5 mg $FeSO_4$ per 1 liter of deionized water. A separate fertilizer solution was made for SeaIsle 1 seashore paspalum. The KCl was doubled to compensate for the different potassium requirements of seashore paspalum (Duncan and Carrow, 2000). Total N for both grass species was 624 mg/pot for 120 days and 346 mg/pot for 60 days. Using scissors, the grass was trimmed biweekly to approximately 2.5 cm above the soil surface. Tissue clippings were collected in 15-cm × 23-cm envelopes using a spouted 2.84-liter sample pan (40.6 cm × 30.5 cm × 5 cm) (Seedburo, Chicago, IL) and dried at 75 °C for 48 hours to obtain cumulative shoot dry weight.

After 60 and 120 days, pots of each treatment from each block were brought into the laboratory for destructive analysis. This provided a total of 32 pots for each nematode at each sampling date in 2002 and a total of 60 pots at each sampling date in 2003. Shoots were trimmed as close to the soil as possible and saved for cumulative dry weight analysis. Then, using a stainless steel T-sampling tool, a root core (approximately 4-cm-diam. × 14 cm deep) was taken from the center of each pot to serve as a representative root sample. The remaining contents of each pot were emptied into individually labeled plastic bags and thoroughly hand mixed. A 100-cm^3 soil sample was taken from each bag, and nematodes were extracted using a modified centrifugal-sugar flotation technique (Jenkins, 1964). Nematodes in the entire soil sample were counted using an inverted light microscope at ×32 magnification.

Root cores were washed free of soil on a sieve with 1.7-mm-pore openings nested within a sieve with 75-µm-pore openings. Roots were removed from any aboveground growth and placed in a 50-ml disposable plastic centrifuge tube containing 30 ml of tap water. The 75-µm-pore sieve was then submerged in 5 cm of tap water to allow the finer roots to float out and separate from the soil. These fine roots were collected using forceps and placed into the 50-ml plastic centrifuge tubes. Five drops (0.25 ml) of a 1% methylene blue mixture was added to the 30 ml of tap water to stain the roots. After a minimum of 24 hours in the solution, the roots were removed, placed on a 75-µm-pore sieve, and washed free of excess dye. Stained roots were placed into a glass-bottom tray and scanned using a HP ScanJet 2cx desktop scanner (Hewlett Packard, Boise, ID) to create a black-and-white bitmap image of the roots (Kaspar and Ewing, 1997; Pan and Bolton, 1991). The GSRoot (Louisiana State University, Baton Rouge, LA) software program was used to analyze the bitmap images. This program measures root lengths and surface areas from scanned images. Root length data were recorded for seven diameter ranges (<0.05 mm, 0.05 to 0.10 mm, >0.10 to 0.20 mm, >0.20 to 0.30 mm, >0.30 to 0.40 mm, 0.40 to 0.50 mm, and >0.50 mm). The resulting values were summed to determine the total root length of each root sample. In 2003 at the final sampling date, *H. galeatus* in roots were counted to determine number of nematodes per gram of root in fresh-weight samples using a modified acid-fuchsin staining procedure (Byrd et al., 1983).

Total root lengths, small diameter (<0.02-mm) root lengths, and cumulative shoot dry weights were compared for both evaluation periods. The analysis of variance (ANOVA) procedure performed using SAS software (SAS Institute, Cary, NC) was used to analyze these three responses for differences between inoculated and uninoculated treatments within each grass species. Data for *B. longicaudatus* and *H. galeatus* were analyzed separately, even when the two experiments shared controls (2003 experiment).

The ANOVA procedure also was used to determine differences in tolerance between grass species by comparing final nematode population densities, total root length percent reduction, and cumulative shoot dry weight percent reduction. Total root length percent reduction for each grass was calculated by [100 × (total root length of inoculated—total root length of uninoculated)/total root length of uninoculated], and cumulative shoot dry weight percent reduction was calculated by [100 × (cumulative shoot dry weight of inoculated—cumulative shoot dry weight of uninoculated)/cumulative shoot dry weight of uninoculated]. Data for *B. longicaudatus* and *H. galeatus* were analyzed separately, even when the two experiments shared controls (2003 experiment). A difference in the tolerance of

grasses to the nematodes was determined to be significant when $P \leq 0.05$.

Results

Inoculation with *B. longicaudatus* reduced root growth as measured by root length in both turfgrasses throughout the duration of the both experiments, whereas *H. galeatus* reduced root growth at only one sampling date for each grass (Tables 2, 3). In the 2002 trial, the *B. longicaudatus* population reduced total root length in both seashore paspalum and bermudagrass ($P \leq 0.05$) at 120 days after inoculation, but only in seashore paspalum at the 60-day sampling (Table 2). In 2003, *B. longicaudatus* extensively suppressed total root length in seashore paspalum and bermudagrass ($P \leq 0.05$) at 60 and 120 days after inoculation (Table 2). In both years, lengths of small-diameter roots (<0.02-mm) on plants inoculated with *B. longicaudatus* were less than ($P \leq 0.01$) uninoculated plants for both grasses and sampling dates. Lengths of small-diameter roots on seashore paspalum inoculated with *B. longicaudatus* ranged from 489 ± 217 mm to 574 ± 228 mm compared to uninoculated plants having lengths ranging from 670 ± 104 mm to 1,037 ± 126 mm. Bermudagrass followed a similar trend, with lengths of small-diameter roots ranging from 470 ± 109 mm to 741 ± 147 mm and 624 ± 133 mm to 1,219 ± 175 mm for inoculated and uninoculated plants, respectively.

Belonolaimus longicaudatus reproduced well on both grasses, indicating they were suitable hosts. In both trials, *B. longicaudatus* reproduction varied among replicates, with bermudagrass supporting higher populations ($P \leq 0.05$) than seashore paspalum at all sampling dates, except the 120-day evaluation period in 2002 (Table 4). Cumulative shoot dry weight was not different from controls when either turfgrass was inoculated with *B. longicaudatus* (Table 2).

In 2002, *H. galeatus* did not reduce root length or shoot dry weight in either grass (Table 3). However, in 2003, *H. galeatus* reduced root growth ($P \leq 0.05$) in seashore paspalum and bermudagrass after 60 and 120 days of exposure, respectively (Table 3) but did not reduce cumulative shoot dry weight.

Both grasses supported reproduction of *H. galeatus* in both years. Bermudagrass was a more suitable host at

Table 2. Cumulative shoot dry weight and total root lengths of 'SeaIsle 1' seashore paspalum and 'Tifdwarf' bermudagrass 60 and 120 days after initial inoculations of 107 ± 8 (2002) and 211 ± 10 (2003) *Belonolaimus longicaudatus*.

Cultivar	DAI[a]	Treatment[b]	Dry shoot weight (g)	Root length (mm)
			2002 trial	
Tifdwarf	60	U	6.2 ± 3.4[c]	951 ± 212[c]
		I	6.6 ± 2.5	762 ± 234
	120	U	13.2 ± 3.8	1,597 ± 312*
		I	11.7 ± 3.0	947 ± 589
SeaIsle 1	60	U	13.9 ± 3.2	1,489 ± 287*
		I	11.6 ± 3.0	1,150 ± 281
	120	U	24.4 ± 6.7	1,647 ± 152***
		I	21.5 ± 4.2	1,044 ± 337
			2003 trial	
Tifdwarf	60	U	4.6 ± 1.2	1,525 ± 192*
		I	4.3 ± 1.9	1,107 ± 386
	120	U	13.3 ± 4.0	2,385 ± 468***
		I	13.4 ± 3.2	1,380 ± 354
SeaIsle 1	60	U	7.9 ± 2.3	1,602 ± 301**
		I	5.3 ± 1.3	984 ± 456
	120	U	21.6 ± 4.5	2,217 ± 315***
		I	20.6 ± 4.3	1,185 ± 467

[a] DAI = Days after inoculation.
[b] I = inculated and U = uninoculated.
[c] Data are means of 8 (2002) or 10 (2003) replicates ± standard deviations. *, **, *** Indicate unincolulated different from inoculated significant $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively, according to the analysis of variance.

Table 3. Cumulative shoot dry weight and total root lengths of 'SeaIsle 1' seashore paspalum and 'Tifdwarf' bermudagrass 60 and 120 days after initial inoculations of 100 (2002) and 199 ± 13 (2003) *Hoplolaimus galeatus*.

Cultivar	DAI[a]	Treatment[b]	Dry shoot weight (g)	Root length (mm)
			2002 trial	
Tifdwarf	60	U	6.2 ± 1.9[c]	927 ± 130[c]
		I	7.2 ± 2.2	920 ± 203
	120	U	14.1 ± 3.0	936 ± 344
		I	11.9 ± 1.9	993 ± 192
SeaIsle 1	60	U	11.1 ± 2.0	1,244 ± 272
		I	11.5 ± 2.0	1,216 ± 257
	120	U	22.8 ± 2.9	1,170 ± 223
		I	23.0 ± 3.8	1,164 ± 275
			2003 trial	
Tifdwarf	60	U	4.6 ± 1.2	1,525 ± 192
		I	4.6 ± 1.9	1,697 ± 490
	120	U	13.3 ± 4.0	2,385 ± 468*
		I	11.9 ± 1.8	2,050 ± 425
SeaIsle 1	60	U	7.9 ± 2.3	1,602 ± 301*
		I	5.9 ± 1.6	1,276 ± 350
	120	U	21.6 ± 4.5	2,217 ± 315
		I	21.0 ± 4.0	2,098 ± 410

[a] DAI = Days after inoculation.
[b] I = inoculated and U = uninoculated.
[c] Data are means of 8 (2002) or 10 (2003) replicates ± standard deviations. * Indicate uninocolulated different from inoculated significant $P \leq 0.05$, according to the analysis of variance.

Table 4. Final population densities (nematodes/100 cm^3 of soil) on 'SeaIsle1' seashore paspalum and 'Tifdwarf' bermudagrass 60 and 120 days after initial inoculation of 100 (2002) and 199 ± 13 (2003) *Hoplolaimus galeatus* and 107 ± 8 (2002) and 211 ± 10 (2003) *Belonolaimus longicaudatus*.

	2002		2003	
Cultivar	60 DAI[a]	120 DAI[a]	60 DAI[a]	120 DAI[a]
	B. longicaudatus			
Tifdwarf	445 ± 330*[b]	495 ± 530[b]	273 ± 220*[b]	1,236 ± 714*[b]
SeaIsle 1	107 ± 86	148 ± 81	90 ± 97	559 ± 366
	H. galeatus			
Tifdwarf	30 ± 16	312 ± 188*	58 ± 28**	171 ± 134
SeaIsle 1	22 ± 13	80 ± 47	15 ± 8	116 ± 33

[a] DAI = Days after inoculation
[b] Data are means of 8 (2002) or 10 (2003) replicates ± standard deviations, *, ** Indicate Tifdwarf different from SeaIsle 1 significant at $P \leq 0.05$ and $P \leq 0.01$, respectively, according to the analysis of variance.

two sampling dates, supporting higher soil populations ($P \leq 0.05$) than seashore paspalum after 60 days (2003) and 120 days (2002) of feeding and reproducing (Table 4). Root extraction of *H. galeatus* by Baermann tray extraction resulted in low recovery in 2002. However, in 2003, roots were stained and revealed that *H. galeatus* readily entered the roots of both grasses. Nematodes were exclusively found within the root cortex and tended to aggregate in random, nonspecific areas of the roots. Final root population means were 63 ± 69 and 88 ± 55 per gram of root fresh weight for bermudagrass and seashore paspalum, respectively. Populations of *H. galeatus* within the roots did not indicate a difference in host suitability between the two grasses.

Root-length percentage reductions and cumulative shoot dry-weight reductions calculated from root and shoot growth data were used to compare the effects of *B. longicaudatus* or *H. galeatus* between seashore paspalum and bermudagrass. Differences in cumulative shoot dry-weight percentage reductions between grasses were not observed in either year for *B. longicaudatus* or *H. galeatus*. *Hoplolaimus galeatus* did not cause reductions in root growth in the 2002 trial. Therefore, root-length percentage reductions showed no difference between the two grasses. In the 2003 trial, *H. galeatus* did suppress seashore paspalum root growth even though soil populations were below reported threshold levels for bermudagrass (Crow et al., 2003). Root-length percentage reductions demonstrated a difference ($P \leq 0.05$) between the two grass species 60 days after inoculation, with seashore paspalum having a 19.4% root length reduction and bermudagrass having a 14% nonsignificant increase in root length compared to uninoculated plants.

Belonolaimus longicaudatus reduced root growth in both grasses, but root-length percentage reductions did not indicate a difference in susceptibility between seashore paspalum and bermudagrass. In 2002, root-length percentage reduction averaged 13.7% for bermudagrass and 20.2% for seashore paspalum at the 60-day sampling. At 120 days after inoculation, root-length percentage reduction averaged between 35% and 40% for both grasses. In the second year of the study, root-length percentage reduction after 60 days was 26.7% and 38.4% for bermudagrass and seashore paspalum, respectively. At the final sampling date, root length reductions continued on the same trend, with root-length percentage reductions above 39% for both grasses.

Discussion

Results indicate slight differences in host suitability but no major differences in plant damage between the two grasses. Bermudagrass tended to be a more suitable host for *B. longicaudatus* and *H. galeatus* throughout the experiment. Lower final population densities of *B. longicaudatus* with root-length percentage reductions equal to bermudagrass suggest that seashore paspalum could be a less tolerant host. As *H. galeatus* did not consistently suppress root growth in either grass, seashore paspalum cannot be assumed to be more or less tolerant than bermudagrass.

Population densities of *B. longicaudatus* after 120 days were high in 2003 as opposed to 2002. Higher inoculation levels and the earlier starting date in 2003 could have resulted in enhanced reproduction. Further, populations in the glasshouse may peak during the late spring and early summer months and decline thereafter as late-summer and early-fall temperatures dominate. Robbins and Barker (1974) reported that reproduction of two populations of *B. longicaudatus* were greatest at 25 °C to 30 °C, and minimal reproduction occured at 20°. Neither grass had a reduction in cumulative top growth even though root growth was suppressed by *B. longicaudatus*. Johnson (1970) and Giblin-Davis et al. (1992b) reported similar results for top growth tissue weights for 'Tifdwarf' bermudagrass. The proposed hypothesis was that root growth suppression caused by *B. longicaudatus* could stimulate the production of more photosynthetic material to overcome the damaged root system (Giblin-Davis et al., 1992b). In our experiments, mowing frequency and height did not simulate typical golf course mowing practices. Golf courses tend to have intense aboveground defoliation due to mowing, causing an immense amount of stress on the root system. This only amplifies the root damage by *B. longicaudatus*.

Both grass species were suitable hosts for the nematodes. The lack of root growth suppression caused by *H. galeatus* is different from the reaction of the two grasses to the more virulent nematode, *B. longicaudatus*. *Hoplolaimus galeatus* caused a slight reduction in root growth for both grasses in the second year of the study, even though reproduction appeared to be relatively low. In February and March 2003, during the 60-day experimental time period, temperatures and day-lengths were not optimal for warm-season turfgrass growth. These environmental factors may have slowed root growth and allowed the higher inoculum levels of *H. galeatus* to reduce root lengths compared to uninoculated controls. Time course experiments with 'Floratam' and 'FX-313' St. Augustinegrass indicated that *H. galeatus* had no effect on plant growth even though soil counts of *H. galeatus* exceeded 40 nematodes/100 cm^3 of soil, the proposed action threshold (Crow et al., 2003), for 84 days within the course of the experiment (Giblin-Davis et al., 1995).

Tarjan and Busey (1985) reported that 'Tifdwarf' and 'Tifgreen' bermudagrass inoculated with a mixed sample of phytoparasitic nematodes (including *B. longicaudatus* and *H. galeatus*) caused 36% to 39% root dry weight reductions. These root reductions appeared to correlate with increases in *H. galeatus* population levels. In our experiments, *B. longicaudatus* alone caused ap-

proximately the same amount of root reduction, while *H. galeatus* failed to consistently affect root growth. However, *H. galeatus* penetrated the roots of both grasses. In field situations, many other pathogens and climatic stresses can enhance the pathogenic effects of nematodes on turfgrasses. Glasshouse and laboratory work with soybean suggested that greater plant damage resulted from inoculation with both *H. galeatus* and fungi in the genera *Rhizoctonia, Fusarium,* and *Macrophomina* than with either pathogen alone (McGawley et al., 1984). Further investigation is needed to determine if *H. galeatus* may be having a synergistic effect with other pathogens and (or) nematodes in the soil environment in causing damage to turfgrass roots.

In conclusion, our research suggests that the tolerance of SeaIsle 1 seashore paspalum to *B. longicaudatus* and *H. galeatus* was not different than Tifdwarf bermudagrass. There are limitations in extrapolating damaging thresholds from glasshouse experiments to field situations; consequently, action thresholds cannot be predicted from our data. Glasshouse experiments reduce the effects of climate and other pathogens on plant growth. Exposing the plant to one pathogen and (or) stress at a time allows one to determine damage potential exclusive of all other negative effects on plant growth. Further experimentation is needed to determine the effects of *B. longicaudatus* and *H. galeatus* on different cultivars of seashore paspalum, and growth in field conditions.

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