ROOT REDUCTIONS OF ST. AUGUSTINEGRASS (*STENOTAPHRUM SECUNDATUM*) AND HYBRID BERMUDAGRASS (*CYNODON DACTYLON* × *C. TRANSVAALENSIS*) INDUCED BY *TRICHODORUS OBTUSUS* AND *PARATRICHODORUS MINOR*

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ABSTRACT

Crow, W. T. and J. K. Welch. 2004. Root reductions of St. Augustinegrass (*Stenotaphrum secundatum*) and hybrid bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) induced by *Trichodorus obtusus* and *Paratrichodorus minor*. Nematropica 34:31-37.

Trichodorus spp. and *Paratrichodorus* spp. are considered damaging ectoparasitic nematodes on many crops. Two species commonly associated with warm-season turfgrasses in the southeastern United States are *Trichodorus obtusus* and *Paratrichodorus minor*. An earlier experiment indicated that *T. obtusus* might be the more damaging of these two species to St. Augustinegrass. Anecdotal field observation suggests that similar differences between these species might occur on bermudagrass. Glasshouse experiments were conducted to compare reductions in root length on 'Floratine' St. Augustinegrass and 'TifEagle' bermudagrass caused by *T. obtusus* and *P. minor* with each other and the unrelated ectoparasitic sting nematode, *Belonolaimus longicaudatus*. Each type of grass was grown in 1,500 cm^3 clay pots that were inoculated with one of the three nematode species, or remained uninoculated as controls. Root systems were evaluated after 100 days, and root lengths and nematode population densities were compared among treatments. *Trichodorus obtusus* caused reductions in St. Augustinegrass roots when compared with the uninoculated controls in two trials, whereas *P. minor* caused reductions in St. Augustinegrass roots in only one trial. All three nematode species caused reductions in bermudagrass roots in two trials, but reductions caused by *T. obtusus* were greater than those caused by *P. minor*.

Key words: Bermudagrass, *Cynodon dactylon*, *Paratrichodorus minor*, *Stenotaphrum secundatum*, stubby-root nematode, St. Augustinegrass, *Trichodorus obtusus*, turfgrass.

RESUMEN

Crow, W. T. y J. K. Welch. 2004. Reducciones de raices de pasto San Agustín (*Stenotaphrum secundatum*) y pasto Bermuda híbrido (*Cynodon dactylon* × *C. transvaalensis*) inducido por *Trichodorus obtusus* y *Paratrichodorus minor*. Nematropica 34:31-37.

Trichodorus spp. y *Paratrichodorus* spp. son considerados como nemátodos ectoparasíticos dañinos a muchos cultivos. Dos especies asociadas generalmente a pastos golferos de estacion caliente en el sureste de los Estados Unidos son *Trichodorus obtusus* y *Paratrichodorus minor*. Un experimento anterior indicó que *T. obtusus* podría ser el mas dañoso de los dos para pasto San Agustín. Observaciones anecdotales de campo sugieren que diferencias similares entre estas especies podrían ocurrur en pasto Bermuda. Experimentos de invernadero fueron llevados a cabo para comparar reducciones en longitud de raices en pasto San Agustín 'Floratine' y pasto Bermuda 'TifEagle' causados por *T. obtusus* y *P. minor* entre ellos y el nemátodo ectoparasítico, *Belonolaimus longicaudatus*. Cada tipo de cesped fue cultivado en botes de barro de 1500 cm^3 inoculados con uno de las tres especies de nemátodo, o permanecieron no-inoculados como controles. Los sistemas de raices fueron evaluados después de 100 dias, y longitud de raices y densidades de populaciones de nemátodos fueron comparadas entre tratamientos. *Trichodorus obtusus* causó reducciones en raices de pasto San Agustín en comparación a los controles no-inoculados en dos ensayos, mientras que *P. minor* causó reducciones en raices de pasto San Agustín solamente en un ensayo. Todos las tres especies de nemátodos causaron reducciones de raices en pasto Bermuda en dos ensayos, pero las reducciones causadas por *T. obtusus* fueron más grandes que las reducciones causadas por *P. minor*.

Palabras clave: pasto Bermuda, *Cynodon dactylon*, *Pratrichodorus minor*, *Stenotaphrum secundatum*, pasto San Agustín, *Trichodorus obtusus*, pasto golfero.

INTRODUCTION

Nematodes in the genera *Trichodorus* and *Paratrichodorus*, commonly called the stubby-root nematodes, cause damage to a wide range of plants. *Paratrichodorus minor* (Colbran) Siddiqi was one of the first ectoparasitic nematodes shown to cause plant disorders (Christie and Perry, 1951). In the southern United States, stubby-root nematodes are important pathogens on numerous vegetable and agronomic crops (Perry and Rhodes, 1982), and vector Tobacco Rattle Virus on potato (*Solanum tuberosum* L.) (Weingartner *et al.*, 1993).

Stubby-root nematodes were first implicated as pathogens of turfgrasses by Kelsheimer and Overman (1953). This unspecified stubby-root nematode species was associated with damage to St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze) lawns near Tampa, FL. In subsequent studies, *P. minor* was shown to damage St. Augustinegrass (Rhoades, 1962), and creeping bentgrass (*Agrostis palustris* Huds.) (Sikora and Taylor, 1974). *Trichodorus obtusus* Cobb caused root and shoot weight reductions of St. Augustinegrass in a greenhouse experiment (Rhoades, 1965) and was associated with damaged areas in seashore paspalum (*Paspalum vaginatum* Swartz) lawns (Hixson and Crow, 2004).

Some nematode diagnostic services in the southern United States have action thresholds for stubby-root nematodes on turfgrasses (Crow *et al.*, 2003; Davis *et al.*, 2001; Dickerson *et al.*, 2000). These thresholds have been largely based on field observations. In the past, the University of Florida Nematode Assay Laboratory has used a single action threshold for all species of stubby-root nematodes on turfgrasses (Dunn and Noling, 1997). During the past 4 years, the University of Florida Nematode Assay Laboratory has conducted nematode diagnosis on approximately 20,000 turfgrass samples. The two species of stubby-root nematodes most often found in these turfgrass nematode assays from Florida are *T. obtusus* and *P. minor. Trichodorus obtusus* is most common in St. Augustinegrass lawns, but also is found on bermudagrass (*Cynodon dactylon* (L.) Pers. and *Cynodon* hybrids) growing on lawns, golf courses, and athletic fields. *Paratrichodorus minor* is found more often on golf course bermudagrass, but also is found in St. Augustinegrass lawns. Both species are found associated with other turf species grown in Florida such as centipedgrass (*Eremochloa ophiuroides* (Munro) Hack.), zoysiagrass (*Zoysia* spp.), and seashore paspalum (W. T. Crow, unpublished data).

Rhoades (1965) compared reductions in St. Augustinegrass root and shoot weights after 9 months between pots inoculated with either *P. minor* or *T. obtusus*. He concluded that, while both nematodes caused damage to St. Augustinegrass, *T. obtusus* was the more damaging of the two. Field observations also have indicated that *T. obtusus* might be more damaging to bermudagrass than *P. minor*. If *T. obtusus* and *P. minor* differ in the amount of damage they cause to turfgrasses, using separate action thresholds would result in fewer unnecessary nematicide applications and thereby reduce the potential for ground and surface water contamination. The objective of this research is to compare the amount of root reduction caused by *T. obtusus* and *P. minor* on two common warm-season turfgrass species used throughout the southeastern United States.

MATERIALS AND METHODS

We compared the root reductions caused by *T. obtusus* and *P. minor* with each other and with an unrelated ectoparasitic nematode (*Belonolaimus longicaudatus*) on 'TifEagle' bermudagrass and 'Floratine' St. Augustinegrass. Two trials were conducted for each turf species during 2002 and 2003 at the Turfgrass Envirotron glasshouses on the campus of the University of Florida in Gainesville, Florida.

Soil used in these experiments was a U.S. Golf Association specification rootzone sand (Anonymous, 1993). Soil was placed in 1,500 cm^3 clay pots and sprigged with nematode-free stolons of either 'TifEagle' bermudagrass or 'Floratine' St. Augustinegrass. The stolons were allowed 3 weeks to grow roots prior to adding nematode inoculum. There were 20 pots of each grass species used in each experiment.

Inoculum of *P. minor* and *B. longicaudatus* originated from a potato field near Hastings, Florida, and was maintained on 'Common' bermudagrass in the glasshouse. *Trichodorus obtusus* inoculum was collected from a St. Augustinegrass lawn in Gainesville, Florida. All nematodes used for inoculum were collected using a modified Baermann funnel method (McSorley and Frederick, 1991). Because *P. minor* and *B. longicaudatus* were from pure cultures, a nematode solution was adjusted to add the approximate number of nematodes in a 5 ml aliquot. *Trichodorus obtusus* for the first St. Augustinegrass trial were hand picked, and the exact number of nematodes was added to each 5 ml aliquot. In the second St. Augustinegrass trial and both bermudagrass trials, *T. obtusus* were standardized in water to provide the approximate number of nematodes in a 5 ml aliquot. Five pots of each grass species were inoculated with each nematode species and another 5 pots of each grass species served as uninoculated controls. *Paratrichodorus minor* and *T. obtusus* were inoculated at the rate of 28 nematodes/100 cm^3 of soil, *B. longicaudatus* was inoculated at the rate of 7 nematodes/100 cm^3 of soil. *Belonolaimus longicaudatus* was inoculated at a lower rate than the other species because the action threshold level for *B. longicaudatus* in Florida was 25% of those used for stubby-root nematodes (Dunn and Noling, 1997).

After inoculation, each species of grass was arranged in a randomized-block design on a screen bench in the glasshouse and maintained for 100 days. The grass was watered in 100 ml increments as needed, using a beaker to avoid splashing among pots. Fertilization was applied using a 20-20-20 (N-P_2O_5-K_2O) fertilizer at the rate of 49 kg N/ha/month. Soil temperatures throughout the trials averaged 27°C. Natural sunlight was the only source of lighting.

Root length analysis was used to compare the amount of root reduction caused by each nematode species on each grass. After 100 days a 4-cm-diam. × 16.75-cm-deep (the depth of the pot) core was removed from the center of each pot. Roots were extracted from the core, stained, and scanned on a flatbed scanner (Crow *et al.*, 2000) to create a digital image of the root system for analysis using GSRoot software (Louisiana State University, Baton Rouge, LA). This program allows measurement of root lengths of different diameter ranges from a single sample and was used previously to quantify damage caused by *B. longicaudatus* to cotton roots (Crow *et al.*, 2000). The two root diameter ranges used were *i*) fine roots (≤0.2-mm-diam.), and *ii*) the total of all root diameters. Evaluation of aboveground plant parts were not included because these measurements are often not reliable indicators of nematode damage on turf in greenhouse tests (Busey *et al.*, 1993; Giblin-Davis *et al.*, 1992; Rhoades, 1962; Tarjan and Busey, 1985). The remaining soil in each pot was thoroughly mixed and nematodes were extracted from a 100 cm^3 subsample using a centrifugal-flotation method (Jenkins, 1964) to estimate nematode reproduction.

The root length data from the two trials of each grass species were tested for heterogeneity of slope, if the slopes were not heterogeneous the data from the two trials were combined into a single data set for analysis. Root length data were analyzed using analysis of variance and treatment means were separated according to Duncan's multiple-range test. Both *T. obtusus* and *P. minor* had the same initial inoculation density. Therefore, nematode reproduction was compared between these two nematode species using the T-test.

RESULTS

St. Augustinegrass

'Floratine' St. Augustinegrass supported increases in population density for *B. longicaudatus* and *P. minor* in both trials. However, population densities of *T. obtusus* increased only in trial 1 (Table 1). Due to great variation in population densities, there were no differences ($P \leq 0.05$) in final population density in either trial between *T. obtusus* and *P. minor* according to T tests. The root data from the two trials were found to be heterogeneous, so they were analyzed separately. Both *T. obtusus* and *P. minor* caused root reductions in the first trial (Table 2), but only *T. obtusus* caused root reductions in the second trial ($P \leq 0.05$). In trial 1, compared to the uninoculated controls *T. obtusus* and *P. minor* each caused a 42% reduction in roots of ≤0.2 mm-diam. In trial 2, *T. obtusus* caused a 50% decrease in roots ≤0.2 mm-diam., whereas there were no root reductions ($P \leq 0.05$) resulting from inoculation with *B. longicaudatus.*

Bermudagrass

Population densities of *B. longicaudatus* and *T. obtusus* increased on 'TifEagle' bermudagrass in both trials, whereas population densities of *P. minor* increased only in trial 1. There were no differences ($P \leq 0.05$) in final population density between *T. obtusus* and *P. minor* according to T tests in either trial (Table 1) due to great varia-

Table 1. Reproduction of *Trichodorus obtusus*, *Paratrichodorus minor*, and *Belonolaimus longicaudatus* on 'Floratine' St. Augustinegrass and 'TifEagle' bermudagrass in glasshouse trials.

	St. Augustinegrass				Bermudagrass			
	Trial 1		Trial 2		Trial 1		Trial 2	
Nematode	Pi	Pf	Pi	Pf	Pi	Pf	Pi	Pf
B. longicaudatus	7[a]	208[b] ± 176[c]	7	58 ± 42	7	189 ± 94	7	178 ± 177
P. minor	48	504 ± 153	48	77 ± 41	48	199 ± 74	48	35 ± 26
T. obtusus	48	821 ± 362	48	40 ± 42	48	98 ± 49	48	49 ± 25

Data are means of 5 replications.
[a]Number of nematodes inoculated/100 cm^3 of soil.
[b]Final population density/100 cm^3 of soil 100 days after inoculation.
[c]Standard deviation.

Table 2. Root lengths of 'Floratine' St. Augustinegrass as influenced by inoculation with *Trichodorus obtusus*, *Paratrichodorus minor*, or *Belonolaimus longicaudatus* in glasshouse trials 100 days after inoculation.

	Trial 1		Trial 2	
Treatment[a]	Length of fine roots (mm)[b]	Length of total roots (mm)[c]	Length of fine roots (mm)	Length of total roots (mm)
Uninoculated	645 a	1221 a	448 a	823 a
B. longicaudatus	600 a	1123 a	334 ab	628 ab
P. minor	372 b	678 b	341 ab	611 ab
T. obtusus	377 b	701 b	224 b	411 b

Data are means of 5 replications. Means followed by common letters are not different ($P \leq 0.05$) according to Duncan's multiple-range test.
[a]Pots were either uninoculated, or were inoculated with 48 *T. obtusus*, 48 *P. minor*, or 7 *B. longicaudatus*/100 cm^3 of soil.
[b]Roots with diameters ≤0.2 mm.
[c]Roots of all diameter ranges.

tion in population densities. The root data from the two trials were not heterogeneous, so they were combined for analysis. All three nematode species caused root reductions ($P \leq 0.05$) compared to the uninoculated controls (Table 3). However, the reductions to roots ≤0.2 mm-diam. were greater in bermudagrass inoculated with *T. obtusus* and *B. longicaudatus* than in bermudagrass inoculated with *P. minor*. Reductions in these fine roots were 22%, 41%, and 36% for *P. minor*, *T. obtusus*, and *B. longicaudatus*, respectively compared to the uninoculated controls.

DISCUSSION

The experiment with St. Augustinegrass was conducted over a much shorter period of time than the one conducted by Rhoades (1965) (100 days vs. 9 months), and the parameters evaluated were different (root lengths verses root weight). However, the results of both studies were

Table 3. Root lengths of 'TifEagle' bermudagrass as influenced by inoculation with *Trichodorus obtusus*, *Paratrichodorus minor*, or *Belonolaimus longicaudatus* in glasshouse trials 100 days after inoculation.

Treatment[a]	Small root length (mm)[b]	Total root length (mm)[c]
Uninoculated	511 a	808 a
B. longicaudatus	302 c	514 bc
P. minor	392 b	629 b
T. obtusus	288 c	476 c

Data are means of two trials, each with 5 replications. Means followed by common letters are not different ($P \leq 0.05$) according to Duncan's multiple-range test.
[a]Pots were either uninoculated, or were inoculated with 48 *T. obtusus*, 48 *P. minor*, or 7 *B. longicaudatus*/100 cm^3 of soil.
[b]Roots with diameters ≤0.2 mm.
[c]Roots of all diameter ranges.

similar. In the experiments presented here, only *T. obtusus* caused reductions in root length on St. Augustinegrass in both trials. Rhoades (1965) reported that *T. obtusus* caused a greater reduction in root weight than did *P. minor.* Therefore, *T. obtusus* appears to be more damaging than *P. minor* on St. Augustinegrasses. The lack of root damage caused by *B. longicaudatus* on 'Floratine' St. Augustinegrass is not surprising. Busey *et al.* (1993) found that polyploid cultivars of *S. secundatum* were more resistant to *B. longicaudatus* than were diploid cultivars in pot studies. 'Floratine' St. Augustinegrass, the cultivar used in these studies, is a polyploid cultivar. The vast majority of St. Augustinegrass grown in Florida are polyploid cultivars, in fact 80% of the St. Augustinegrass sod produced in Florida is a single polyploid cultivar 'Floratam' (Haydu *et al.*, 1998). This may help explain why stubby-root nematodes are diagnosed as a problem on St. Augustinegrass in Florida more often than sting nematodes (W. T. Crow, unpublished data).

All three nematode species caused root reductions on 'TifEagle' bermudagrass in both trials. However, *T. obtusus* caused greater root reductions than did *P. minor.* This supports anecdotal field observation indicating that *T. obtusus* is the more damaging of these two species on bermudagrass.

These experiments support our field observations that *T. obtusus* causes more damage to turfgrasses than does *P. minor.* Because these two species are readily distinguished under low magnification microscopy, the University of Florida Nematode Assay Laboratory now uses separate action thresholds for *T. obtusus* and *P. minor* on turfgrasses (Crow *et al.*, 2003).

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LITERATURE CITED

ANONYMOUS. 1993. USGA recommendations for a method of putting green construction. USGA Green Section Record 31:1-3.

BUSEY, P., R. M. GIBLIN-DAVIS, and B. J. CENTER. 1993. Resistance in *Stenotaphrum* to the sting nematode. Crop Science 33:1066-1070.

CHRISTIE, J. R., and V. G. PERRY. 1951. A root disease of plants caused by a nematode of the genus *Trichodorus.* Science 113:491-493.

CROW, W. T., D. W. DICKSON, R. MCSORLEY, D. P. WEINGARTNER, and G. L. MILLER. 2000. Yield and root reduction of cotton induced by *Belonolaimus longicaudatus.* Journal of Nematology 32:205-209.

CROW, W. T., J. W. NOLING, R. A. KINLOCH, J. R. RICH, and R. A. DUNN. 2003. Florida Nematode Management Guide. Florida Cooperative Extension Service, SP-54. University of Florida, Gainesville, FL, USA.

DAVIS, R. F., P. BERTRAND, J. D. GAY, R. E. BAIRD, G. B. PADGETT, E. A. BROWN, F. F. HENDRIX, and J. A. BALSDON. 2001. Guide for interpreting nematode assay results. Georgia Cooperative Extension Service Circular 834. University of Georgia, Athens, GA, USA.

DICKERSON, O. J., J. H. BLAKE, and S. A. LEWIS. 2000. Nematode guidelines for South Carolina. Clemson University Cooperative Extension Service, EC 703. Clemson University, Clemson, SC, USA.

DUNN, R. A., and J. W. NOLING. 1997. Florida Nematode Management Guide. Florida Cooperative Extension Service, SP-54. University of Florida, Gainesville, FL, USA.

GIBLIN-DAVIS, R. M., J. L. CISAR, F. G. BILZ, and K. E. WILLIAMS. 1992. Host status of different bermudagrasses (*Cynodon* spp.) for the sting nematode, *Belonolaimus longicaudatus.* Supplement to Journal of Nematology 24:749-756.

HAYDU, J. J., L. N. SATTERTHWAITE, and J. L. CISAR. 1998. An economic and agronomic profile of Florida's sod industry in 1996. Economic Information Report EIR 98-x. University of Florida, Gainesville, FL.

HIXSON, A. C., and W. T. CROW. 2003. First report of plant-parasitic nematodes on seashore paspalum. Plant Disease 88:680.

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

KELSHEIMER, E. G., and A. J. OVERMAN. 1953. Notes on some ectoparasitic nematodes found attacking lawns in the Tampa Bay area. Florida State Horticultural Society Proceedings 66:301-303.

McSORLEY, R., and J. J. FREDERICK. 1991. Extraction efficiency of *Belonolaimus longicaudatus* from sandy soil. Journal of Nematology 23:511-518.

PERRY, V. G. and H. L. RHOADES. 1982. The Trichodorid Nematodes. Pp. 183-186 *in* R. D. Riggs, ed. Nematology in the southern region of the United States. Southern Cooperative Series Bulletin 276. University of Arkansas Agricultural Publications: Fayetteville, AR.

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

RHOADES, H. L. 1965. Parasitism and pathogenicity of *Trichodorus proximus* to St. Augustine grass. Plant Disease Reporter 49:259-262.

SIKORA, R. A., and D. P. TAYLOR. 1974. Pathogenicity of *Trichodorus christiei* to creeping bentgrass. Mededelingen van de Faculteit Landbouwwetenschappen Rijksuniversiteit Gent 39:1713-1718.

TARJAN, A. C., and P. BUSEY. 1985. Genotypic variability in bermudagrass damage by ectoparasitic nematodes. HortScience 20:675-676.

WEINGARTNER, D. P., R. MCSORLEY, and R. W. GOTH. 1993. Management strategies in potato for nematodes and soil-borne diseases in subtropical Florida. Nematropica 23:233-245.

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