

Resistance in *Stenotaphrum* to the Sting Nematode

Philip Busey,* Robin M. Giblin-Davis, and Barbara J. Center

ABSTRACT

Host resistance would be a valuable defense against the sting nematode, *Belonolaimus longicaudatus* Rau, a pathogen of many crops, including turfgrass. Sting nematode damage and host suitability were compared among diploid and polyploid *Stenotaphrum* genotypes. A time-course experiment compared diploid ($2n = 18$) 'FX-313' and polyploid ($2n = 30$) 'FX-10' St. Augustinegrasses [*Stenotaphrum secundatum* (Walter) Kuntze], planted in pots with 250 mL Margate fine sand (siliceous, hyperthermic Mollic Psammaquent). Nematode numbers were determined 42, 84, 126, 168, and 210 d after inoculating with 50 sting nematodes per pot. Root and shoot dry weights and transpiration rate were compared with uninoculated pots of each grass. Sting nematode numbers increased more rapidly on FX-313 than on FX-10, reaching a maximum 2580 nematodes (adults plus juveniles) per pot of FX-313, 84 d after inoculation, compared with 380 nematodes per pot of FX-10. Root damage by sting nematodes was severe in FX-313 but was minor in FX-10. Sting nematode numbers and root dry weight of inoculated FX-313 were essentially unchanging from 84 to 210 d after inoculation, which suggested possible nematode suppression due to nematode injury of roots. Transpiration rate, a nondestructive indicator of nematode effect, was reduced in inoculated FX-313, compared with uninoculated controls, throughout 84 to 168 d after inoculation, while FX-10 transpiration rate was not affected. While FX-313 was susceptible to the sting nematode, FX-10 was resistant through a mechanism of antibiosis. We subjected four polyploid and four diploid *Stenotaphrum* genotypes to the same procedure, but harvested 128 or 129 d after inoculation. Nematode numbers differed ($P < 0.001$) among genotypes, ranging from 980 per pot of FX-313 to 140 per pot of FX-10. Root dry weight of diploids was reduced 33% due to nematodes but polyploids showed no effect. Some good hosts such as pembagrass [*S. dimidiatum* (L.) Brongn] 'FL-2195' showed little or no damage, thus may represent resistance through a mechanism of tolerance.

THE STING NEMATODE is pathogenic to St. Augustinegrass (Busey et al., 1991), other turfgrasses (Perry et al., 1970), and field crops. A controlled laboratory procedure to study the dynamics of sting nematode parasitism (Giblin-Davis et al., 1992) is useful in chemical efficacy evaluations (Giblin-Davis et al., 1993) and resistance screening (Busey et al., 1991), and may aid in understanding mechanics of resistance.

Genotypic differences in sting nematode susceptibility occur among diploid ($2n = 18$) St. Augustinegrasses (Busey et al., 1991), but polyploid ($2n = 27$ to 33) St. Augustinegrasses have not been evaluated. 'Floritam',

a polyploid St. Augustinegrass ($2n \approx 32$), dominates the commercial sod market in Florida (Busey, 1986) and 'FX-10', also polyploid ($2n = 30$, Busey, 1990), was released for resistance to chinch bugs and seasonal drought (Busey, 1993). We have observed Floritam, FX-10, and 'Bitterblue', also a polyploid ($2n \approx 30$) St. Augustinegrass, persisting in sand soils prone to sting nematode colonization. Primary roots of polyploid St. Augustinegrasses tend to be thicker than diploids. Because nematodes strongly affect root systems and plant-water relations (Wilcox-Lee and Loria, 1987), the sting nematode relationship with polyploid St. Augustinegrasses should be assessed. 'Seville' and 'FX-313' are diploids that show differential susceptibility to the sting nematode, with FX-313 being the more susceptible (Busey et al., 1991). The purpose of this study was to compare diploid and polyploid *Stenotaphrum* genotypes as sting nematode hosts, considering plant performance and nematode population expansion over time. Host performance was assessed by measuring root and shoot growth as well as transpiration rate.

MATERIALS AND METHODS

Time-Course Experiment

Treatments were a grass genotype factor (FX-313 vs. FX-10 St. Augustinegrasses), a nematode inoculum factor (inoculated vs. uninoculated), and a harvest factor (grass plants harvested 42, 84, 126, 168, and 210 d after inoculation). The resulting 20 treatment combinations were arranged in a randomized complete-block design with six replicates, and assigned to experimental units, represented as 120 pots. In addition, six uninoculated pots of each grass were chosen randomly and harvested on the day of inoculation.

For establishment of grasses in pots, washed aerial sprigs of FX-313 and FX-10 were temporarily planted in autoclaved (90 min at 121 °C at 103 kPa) sieved silica sand (93% by weight of particles were between 0.18 mm and 0.50 mm in diam.) in 26 by 52 mm plastic trays for root development. After 9 or 10 d, sprigs were transplanted to square tapered pots (80 mm wide at the top, 60 mm wide at the bottom, and 75 mm deep). Drainage holes at the bottom of the pots were covered internally with an 0.3-mm pore diam. synthetic fabric, mounted by means of Super 77 Spray Adhesive (3M Brand, St. Paul, MN). Upon transplanting, sprigs were 50 to 100 mm long and had about three nodes, of which two had newly initiated roots. FX-10 sprigs were $2.63 \text{ g} \pm 0.27 \text{ SD}$ fresh wt., and FX-313 sprigs were $1.41 \text{ g} \pm 0.13 \text{ SD}$. Sprigs were planted with their roots distributed throughout the soil and with the proximal stolon node buried slightly. Pots were filled with 344.0 g moist soil (296.5 g soil dry wt.) to within 15 mm of the top of each pot; the soil volume at the end of the experiment

Abbreviations: OM, organic matter; ET, evapotranspiration; ANOVA, analysis of variance.

Fort Lauderdale Res. and Education Ctr., Univ. of Florida, 3205 College Ave., Fort Lauderdale, FL 33314. Contribution as Journal Series Paper no. R-02735 of the Florida Agric. Exp. Stn. Supported in part by the Florida Turfgrass Research Foundation. Received 26 Oct. 1992. *Corresponding author.

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was 250 cm³. Soil was Margate fine sand with pH 6.5 and 3.8% OM. Soil was sieved (2 mm), thoroughly mixed, and autoclaved (90 min at 121 °C at 103 kPa).

Nematodes from a stock culture maintained on FX-313 St. Augustinegrass were extracted by centrifugal-flotation (Jenkins, 1964) and hand picked under a dissecting microscope. On 30 July 1991, 27 d after transplanting, plants were inoculated with 50 sting nematodes per pot, mostly adults, pipetted in 2 mL water into a 10-mm-deep soil depression near the most proximal rooted node. One day after inoculation, all plants (including uninoculated controls) were sprayed to run-off with fluvalinate [N-(2-chloro-4-trifluoromethylphenyl)-DL-valine(alpha)-cyano(3-phenoxyphenyl)methyl ester] at 157 mg L⁻¹ a.i. to control mites. Pots were placed on a laboratory bench. A fluorescent light source provided 135 μmole m⁻² s⁻¹ photosynthetic photon flux density (≈ 6% of maximum solar radiation at latitude 26°N) at the top of the plant canopy, for 16 h d⁻¹. Daily maximum and minimum temperatures averaged 30.3 °C ± 1.1 SD and 25.4 °C ± 1.1 SD, respectively. Soil temperatures were generally 22 to 23 °C. Plants did not cover the soil, so to minimize evaporation, 0.4 g expanded polystyrene nuggets were placed on the soil surface of each pot. Pots were watered every 3 d to between 410 and 425 g total wt. per pot (including 16 g pot wt), and after each harvest the soil was flushed to leach away possible salt accumulation. Pots were fertilized 7 d before inoculation, and within 7 d after each harvest, with 18 mg N, 8 mg P, 15 mg K, 18 μg B, 45 μg Cu, 90 μg Fe, 45 μg Mn, 0.45 μg Mo, and 45 μg Zn per pot, dissolved in 15 mL water per pot. Nitrogen was 40% ammoniacal, 30% nitrate, and 30% urea. Plants were trimmed periodically to remove stolons surpassing the edges of the pots. All trimmings were dried, weighed, and added to the eventual shoot harvest (described below).

Evapotranspiration rate was measured during the 7 d before each harvest, as a noninvasive indicator for comparing performance of inoculated vs. uninoculated plants. Pots were watered to 420 ± 1 g, followed after 3 d by reweighing, and the weight difference was the ET. This procedure was performed for two 3-d runs for each of the five harvests. Concurrently, six pots with the plants cut off at the soil level were used as a control to estimate soil evaporation; the mean water loss, 3.9 g pot⁻¹ d⁻¹, was subtracted from all other pot values to provide an estimate of plant transpiration rate, calculated on a daily basis. Because transpiration rate was similar between the two successive 3-d ET runs, data were combined as repeated measures within harvests.

For harvest, the soil was washed from the root ball in each pot, and nematodes were extracted from the entire soil volume by centrifugation-flotation (Jenkins, 1964). Nematode numbers per pot (juveniles plus adults) were estimated by counts from aliquots representing one-half of each sample. For a random subsample of 100 nematodes, the numbers of juveniles (J2-J3 and J4) and adults were counted separately, and their relative proportion was used to estimate their total number in the sample. Following nematode extraction, roots were cut from the plant stolons. Roots and shoots (leaves plus stolons) were dried at ≈ 60 °C for 72 h and weighed.

Data for each of six harvests (0–210 d after inoculation) were separately analyzed by ANOVA. Variables analyzed were: number of nematodes per pot; root and shoot dry weights (destructive harvest of 24 pots per harvest, plus 12 uninoculated plants harvested at 0 d); and clipping yield and transpiration rate (diminishing from 120 pots at 42 d to 24 pots at 210 d). Effects of genotype, inoculum, and their interaction were tested based on a pooled error mean square, which included block and block interactions mean squares. Because the higher level interaction (e.g., genotype × block) did not have a larger ($P = 0.25$) mean square than its lower level interaction (e.g., genotype × inoculum × block), mean squares were pooled (Sokal and Rohlf, 1981). Because Bartlett's test showed that variances of nematode numbers were not homogeneous ($P <$

0.05), data were square-root transformed for analysis, but arithmetic means are presented. The functional responses of nematode number and plant performances over time were not evaluated in a continuous model (e.g., curvilinear regression) because it would not be reasonable to model for the long plateau and changes in slope based on the few dates of observation.

Resistance Screening Experiment

There were eight *Stenotaphrum* genotypes, representing four diploids, $2n = 18$ ('Florida Common', Seville, 'FX-305', and FX-313) and four polyploids (Bitterblue, Floratam, FX-10, and 'FL-2195'). All were *S. secundatum*, except FL-2195 ($2n \approx 60$) was a pambagrass from Mauritius. The 16 treatment combinations (eight genotypes inoculated and uninoculated) were arranged in a randomized complete-block design with eight replicates. In contrast to the time-course experiment, all plants were harvested at 128 or 129 d after inoculation. Other procedures, and environmental conditions, were the same, except as indicated below.

Grass sprigs were established temporarily in commercial nursery mix in plastic trays for root development and were transplanted subsequently to square tapered pots filled with moist Margate fine sand soil (300.9 g soil dry wt.). From 20 to 29 Jan 1992, after 16 d (range ± 5 d) of transplant rooting, pots were inoculated with 50 sting nematodes per pot. Fluvalinate was not applied. Day of inoculation was a blocking variable. Photosynthetic photon flux density was 173 μmole m⁻² s⁻¹ for 16 h d⁻¹. Pots were watered every 3 d to between 410 and 420 g. Pots were fertilized as described previously, 7 d (range = ± 5 d) before inoculation, and again on 38 and 94 d (range = ± 5 d) after inoculation. Pots were not flushed with water to leach away possible salt accumulation.

Evapotranspiration was measured during paired 3-d runs, at both 76 and 112 d after inoculation. Sixteen pots with the plant cut off at the soil level were used as a control to estimate soil evaporation; the mean water loss, 3.8 g pot⁻¹ d⁻¹, was subtracted from all other pot values to provide an estimate of daily plant transpiration rate per pot. Entire blocks were harvested on staggered dates, in agreement with their differing dates of inoculation. Number of juvenile nematodes was not tallied separately from adults. Data were analyzed by ANOVA, except for nematode numbers, which were analyzed by a general linear model, due to a missing value for one pot. Ploidy levels and ploidy levels × inoculum interaction were also contrasted.

RESULTS

Time-Course Experiment

Nematode numbers differed between FX-10 and FX-313 ($P < 0.001$) on each sampling date throughout 42 to 210 d after inoculation (Fig. 1A). Sting nematode numbers increased rapidly on FX-313, reached a maximum of 2580 nematodes (adults plus juveniles) per pot 84 d after inoculation, and then declined gradually to 1900 per pot by 210 d. Sting nematode numbers increased less on FX-10, reached a peak of only 380 nematodes per pot 84 d after inoculation, and declined to 190 per pot by 210 d. The frequency of sting nematode juveniles (out of the total adults plus juveniles) peaked at 75% by 42 d after inoculation, and declined steadily to 47% by 210 d. The rate of decline in relative proportion of juveniles was the same for FX-313 and FX-10, although FX-10 had a slightly higher relative proportion of juveniles than FX-313 ($P < 0.05$). No sting nematodes were detected in uninoculated controls.

Plant performance variables differed between FX-313

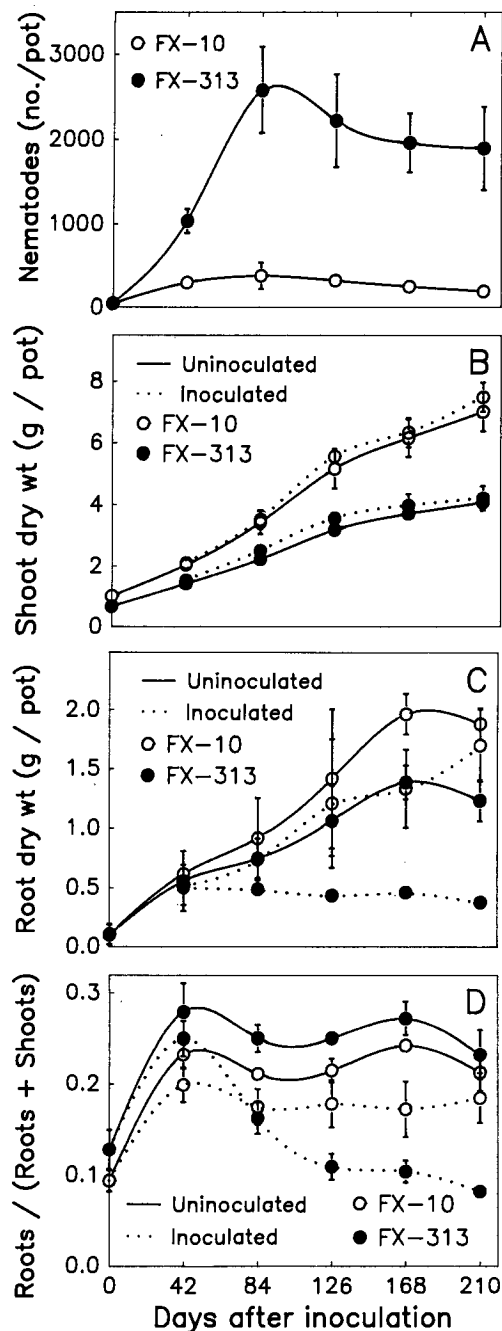


Fig. 1. (A) Sting nematode numbers per pot, (B) shoot dry weight, (C) root dry weight, and (D) root weight ratio of FX-313 and FX-10 St. Augustinegrasses. Means of six replicates. Splined curves connect means of six observations \pm standard deviation.

and FX-10 at multiple dates of observation, which was explained by their different initial sprig sizes. Shoot and root dry weight were greater ($P < 0.01$) for FX-10 than FX-313, throughout 42 to 210 d after inoculation (Fig. 1B, 1C). Transpiration rate was greater ($P < 0.01$) for FX-10 throughout 84 to 210 d after inoculation; and clipping yield was usually greater for FX-10 (data not shown). Shoot dry weight increased slightly in inoculated plants compared with uninoculated controls ($P < 0.05$) at 126 d after inoculation (Fig. 1B).

There was a genotype \times inoculum interaction for root

dry weight ($P < 0.01$) at 84, 126, and 210 d after inoculation, based on severe nematode damage to FX-313, relative to uninoculated controls. In absolute values, inoculated FX-313 root dry weight declined slightly throughout 42 to 210 d (Fig. 1C), while uninoculated FX-313 root dry weight generally increased. FX-10 root dry weight generally increased, regardless of inoculation. The failure of inoculated FX-313 to increase root mass after 42 d explains the subsequent failure of nematodes to increase in numbers (Fig. 1A), namely that root growth and nematode reproduction had reached mutual equilibrium. In contrast, nematodes on FX-10 decreased progressively in numbers after 84 d, despite the increasing root biomass.

The earliest and most sensitive plant response to nematodes was root weight ratio [roots/(roots + shoots)] (Fig. 1D). Root weight ratio showed an inoculum effect ($P < 0.05$) within 42 d after inoculation and a large ($P < 0.001$) genotype \times inoculum interaction throughout 84 to 210 d. Root weight ratio for uninoculated plants and inoculated FX-10 was fairly steady, between 0.17 and 0.29 throughout 42 to 210 d. Inoculated FX-313 plants, however, showed a sharp decline after 42 d, and by 210 d only 0.08 of total biomass was represented by roots. Another useful ratio was number of nematodes per g root dry weight. FX-313 reached 5590 nematodes g^{-1} root dry wt. by 84 d after inoculation, and declined to 5050 g^{-1} root dry wt. by 210 d after inoculation. FX-10 reached 570 nematodes g^{-1} root dry wt. 42 d after inoculation, and declined to 120 g^{-1} root dry wt. 210 d after inoculation.

Transpiration rate was strongly reduced ($P < 0.01$) by nematodes throughout 84 to 126 d after inoculation, compared with uninoculated plants (8.4 and 9.2 $g\ pot^{-1}\ d^{-1}$, for inoculated and uninoculated, respectively) and this reduction was last detected 168 d after inoculation ($P < 0.05$). There was no genotype \times inoculum interaction in transpiration rate, but FX-313 transpiration rate was consistently reduced throughout 84 to 168 d after inoculation, while FX-10 was not affected.

Resistance Screening Experiment

Stenotaphrum genotypes differed ($P < 0.001$) as hosts of the sting nematode, with FX-313 and FX-10 representing the high and low extremes, respectively, in nematode numbers per pot (Table 1). Most of the difference among genotypes was due to ploidy level; diploids supported larger nematode numbers than polyploids. FX-10 and Floratam were poor hosts. Nematode numbers were smaller than in the time-course experiment.

Shoot dry weight increased due to nematode inoculum, compared with uninoculated controls ($P < 0.01$), but there was no genotype \times inoculum interaction. Root dry weight and root weight ratio were severely reduced by sting nematode inoculum ($P < 0.001$), and there were interactions for root dry weight and root weight ratio ($P < 0.001$) involving both genotype \times inoculum and ploidy \times inoculum. Because of the wide range among genotypes in uninoculated root dry weight, nematode damage was calculated on a relative basis for each genotype \times block pair as:

$$\text{damage} = 100 (1 - \text{inoculated/uninoculated}) \%$$

Table 1. Means and analysis of variance of shoot and root dry weight, transpiration rate, and number of sting nematodes harvested in eight St. Augustinegrass genotypes inoculated (I) with 50 sting nematodes per pot or uninoculated (U). Means of eight replicates.

Genotype	Dry weight						Nematodes harvested†			
	Shoots		Roots		Ratio [roots/ (roots/shoots)] +		Transpiration rate		Absolute	Relative
	U	I	U	I	U	I	U	I	I	I
— g pot ⁻¹ —										
Diploids										
FX-313	2.87	2.93	0.78	0.43***	0.21	0.13***	8.0	7.5	980 a	2400 a
Florida Common	3.67	4.24**	1.41	0.64***	0.28	0.13***	14.0	13.5	660 bc	1290 b
FX-305	3.10	3.05	1.36	1.00	0.31	0.24**	11.8	9.6*	610 bc	670 c
Seville	3.65	3.85	1.34	1.19	0.27	0.23	10.3	9.5	510 cd	510 c
Mean (diploids)	3.32	3.52	1.22	0.82***	0.27	0.18***	11.0	10.0	690	1220
Polyploids										
Bitterblue	4.31	4.53	1.98	1.73	0.32	0.28*	11.5	10.4	760 ab	460 c
FL-2195	2.94	3.15	2.50	2.68	0.46	0.46	11.8	11.9	660 bc	250 d
Floritam	4.12	4.49	2.00	2.17	0.33	0.33	10.6	11.2	340 d	170 de
FX-10	4.08	4.33	1.51	1.41	0.27	0.25*	8.2	9.2*	140 e	100 e
Mean (polyploids)	3.86	4.13	2.00	2.00	0.34	0.33	10.5	10.7	470	240
Mean (overall)	3.59	3.82**	1.61	1.41***	0.30	0.26***	10.8	10.4	580	740
Source	df	Analysis of variance mean squares‡								
Ploidy	1	10.49***	30.64***	0.4002***	0.26	6.27***	41.47***			
Genotype (Ploidy)	6	5.34***	2.48***	0.0795***	63.32***	2.62***	3.94***			
Inoculum	1	1.72**	1.32***	0.0778***	5.51	—	—			
Ploidy × Inoculum	1	0.04	1.31***	0.0353***	10.75*	—	—			
Genotype (Ploidy) × Inoc	6	0.16	0.23**	0.0055**	2.94	—	—			
Blocks	7	0.26	0.17**	0.0060**	3.34	0.27	0.63			
Error	105	0.22	0.06	0.0011	2.17	0.22	0.32			

*** ** Uninoculated vs. Inoculated differ based on a pairwise *t*-test, or mean squares significant, at $P < 0.05$, 0.01 , or 0.001 , respectively.

† Within nematode columns, means followed by the same letter are not different by the Waller-Duncan *k*-ratio *t*-test, $k = 100$, $P = 0.05$.

‡ Nematode numbers (absolute and relative) were square-root transformed for analysis and means comparison, but original values are reported for genotype means.

Diploids averaged 33% damage due to nematodes but polyploids showed no effect. Florida Common and FX-313 showed very severe damage, 54 and 43% root dry wt. reduction, respectively, and FX-305 showed moderate damage, 23% root dry wt. reduction. Nematode number per g root dry weight magnified the extremes in resistance, with the four polyploids showing the lowest densities (Table 1). There was a ploidy level × inoculum interaction for transpiration rate, with the diploids showing slightly reduced transpiration rate due to inoculum, and the polyploids showing a slight increase.

DISCUSSION

Within *Stenotaphrum* there were two extremes in host association to the sting nematode. First, highly susceptible diploid hosts (FX-313, Florida Common, and FX-305) supported rapid nematode population increase, suffered severe root damage, and (in time-course data on FX-313) attained an eventual equilibrium between nematode population and roots. Such equilibrium may be viewed as a negative feedback—as root growth was curbed, nematode reproduction was suppressed by the lack of available food. Nematodes enhanced St. Augustinegrass shoot dry weight, and reduced transpiration rate, but these effects were too slight and too transient to be useful in bioassay. At the opposite extreme, polyploids FX-10 and Floritam supported slight nematode increase and showed little or no plant performance effects, thus they were resistant through a mechanism of antibiosis. These host extremes operated on the nematode, were easily distinguished in nematode numbers 42 d after in-

oculation (Fig. 1A), and thus were detected without uninoculated controls.

A third host pattern may have operated in Bitterblue and Seville (*S. secundatum*), and FL-2195 (*S. dimidiatum*). These were suitable hosts but showed little or no nematode damage under laboratory conditions, within 128 to 129 d, thus they may be resistant through a mechanism of tolerance. In contrast to antibiosis, it would be more difficult to detect host tolerance, because of the overlap of plant performances, the need to retain uninoculated controls, and the need to extend evaluation beyond 42 d, to obtain host performance data.

Considering that different mechanisms of resistance may operate in *Stenotaphrum*, confounded by negative feedback (nematode suppression due to reduced roots), a simplified approach for evaluating resistance is to calculate the density of sting nematodes relative to root dry weight. Based on the present data, and allowing at least 126 d for root/nematode equilibrium to occur, one would expect <300 nematodes g⁻¹ root dry wt. for a resistant plant such as FX-10, Floritam, or FL-2195. Although nematode density values were lower for FX-313 than in previous reports (Busey et al., 1991; Giblin-Davis et al., 1992), we have always encountered >2000 nematodes g⁻¹ root dry wt. for this highly susceptible genotype.

Most examples of crop resistance to nematodes involve relatively immobile pathogens with highly evolved host-parasite associations. These include the sedentary endoparasitic cyst and root-knot nematodes and migratory endoparasitic nematodes (Trudgill, 1991). The sting nematode is ectoparasitic throughout its life cycle and

has a generalized herbivorous association with young host feeder roots, which probably allows for its wide host range, and could be an impediment in the search for resistance. Nevertheless, we observed great differences in nematode numbers and root damage. Polyploid *Stenotaphrum* genotypes which were more generally resistant, tend to have thicker primary roots than diploids. Root architecture should be considered as a possible basis for resistance. For example, Todd (1991) pointed out that the greater suitability of sorghum [*Sorghum bicolor* (L.) Moench] as a host for *Belonolaimus* sp., compared in the greenhouse with maize (*Zea mays* L.), may be due to the greater amount of secondary roots in the sorghum. Grasses grown as turf, such as St. Augustinegrass, must contend with indirect root damage caused by humans (e.g., compaction and defoliation) as well as continual grazing of roots by nematodes. The discovery of resistance to the sting nematode could have important practical and ecological applications. Future research should consider host suitability for other geographic isolates of the sting nematode.

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REFERENCES

- Busey, P. 1986. Morphological identification of St. Augustinegrass cultivars. *Crop Sci.* 26:28–32.
- Busey, P. 1990. Polyploid *Stenotaphrum* germplasm: Resistance to the polyploid damaging population southern chinch bug. *Crop Sci.* 30:588–593.
- Busey, P., R.M. Giblin-Davis, C.W. Riger, and E.I. Zaenker. 1991. Susceptibility of diploid St. Augustinegrasses to *Belonolaimus longicaudatus*. *Suppl. J. Nematol.* 23:604–610.
- Busey, P. 1993. Registration of FX-10 St. Augustinegrass. *Crop Sci.* 33:214–215.
- Giblin-Davis, R.M., P. Busey, and B.J. Center. 1992. Dynamics of *Belonolaimus longicaudatus* parasitism on a susceptible St. Augustinegrass host. *J. Nematol.* 24:432–437.
- Giblin-Davis, R.M., J.L. Cisar, G.H. Snyder, and C.L. Elliott. 1993. Effects of fenamiphos or fenamiphos sulfone on the survival of the sting nematode, *Belonolaimus longicaudatus* in vitro. *Int. Turfgrass Soc. J.* 7: (in press).
- Jenkins, W.R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. *Plant Dis. Rep.* 48:692.
- Perry, V.G., G.C. Smart, Jr., and G.C. Horn. 1970. Nematode problems of turfgrasses in Florida and their control. p. 489–492. *In Proc. of the Florida State Horticultural Society Annu. Meeting*, 83. Miami Beach, FL. 27–29 Oct. 1970. Florida State Hort. Soc.
- Sokal, R.R., and F.J. Rohlf. 1981. *Biometry*. 2nd ed. W.H. Freeman & Company, San Francisco.
- Todd, T.C. 1991. Effect of cropping regime on populations of *Belonolaimus* sp. and *Pratylenchus scribneri* in sandy soil. *Suppl. J. Nematol.* 23:646–651.
- Trudgill, D.L. 1991. Resistance to and tolerance of plant parasitic nematodes in plants. *Annu. Rev. Phytopathol.* 29:167–192.
- Wilcox-Lee, D. and R. Loria. 1987. Effects of nematode parasitism on plant-water relations. p. 260–266 *In J.A. Veech and D.W. Dickson (ed.)*. *Vistas on nematology: A commemoration of the twenty-fifth anniversary of the Society of Nematologists*. Soc. of Nematologists, Hyattsville, MD.