Host Range of a California Sting Nematode Population

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Abstract. Recently, sting nematodes were discovered associated with dying turfgrass in several golf courses in Coachella Valley, Calif. Based on their morphology and internal transcribed spacer (ITS) rDNA restriction pattern, the pests were identified as *Belonolaimus longicaudatus* Rau. This study was undertaken to determine the host status of 60 different plant species and cultivars for a California population of *B. longicaudatus*. The host range tests were conducted under greenhouse conditions at 25 ± 2 °C and ambient light. At the second-leaf stage, each pot was infested with 55 ± 12 adults or fourth-stage juveniles per 150 g of blow sand. The population densities determined after 7 weeks of incubation qualified >80% of the plants tested as good hosts with a reproduction factor (Rf = Pf/Pi) > 4. The majority of those were grasses, although reproduction was best on *Gossypium hirsutum* L. with Rf = 58.6. While *Capsicum annuum* L., *Medicago sativa* L., *Arachis hypogaea* L., *Euphorbia glyptosperma* Engelm., *Cucumis sativus* L., and *Daucus carota* L. were less suitable host plants with Rf < 4, only *Abelmoschus esculentus* (L.) Moench, *Citrullus lanatus* Thunb., and *Nicotiana tabacum* L. were nonhosts among the tested species. This sting nematode population had a high reproductive fitness on a majority of species tested and must be considered a major threat for most agricultural and horticultural crops grown in sandy soils.

Nematodes of the genus *Belonolaimus* Steiner include five ectoparasitic species endemic to sandy soils of the southern and midwestern United States (Smart and Nguyen, 1991). They are polyphagous feeders with a wide host range and potentially damage many economically important crops in soils with a minimum of 80% sand (Robbins and Barker, 1974). *Belonolaimus longicaudatus* Rau has been described as the most damaging species of the genus (Duncan et al., 1996; Perry and Rhoades, 1982; Smart and Nguyen, 1991; Todd, 1989). Host lists of several sting nematode populations were published previously (Abu-Gharbieh and Perry, 1970; Esser, 1976; Graham and Holdeman, 1953). However, *B. longicaudatus* and *B. gracilis* Steiner often have been confused (Rau, 1958). Differences in host reactions and fitness were reported for some *B. longicaudatus* populations of Florida, North Carolina, and Georgia (Abu-Gharbieh and Perry, 1970; Robbins and Barker, 1973), which suggested the occurrence of several physiological races within this species.

Recently, sting nematodes were discov-

ered associated with dying turfgrass in several golf courses in Coachella Valley, Calif. (Mundo-Ocampo et al., 1994). Based on its morphology (Mundo-Ocampo et al., 1994) and its rDNA internal transcribed spacer region (Cherry et al., 1997), the pest was identified as *B. longicaudatus*. This study was undertaken to determine the host status of 60 different plant species and cultivars for the Coachella population of *B. longicaudatus*. The results provide information needed to anticipate the potential problems with this nematode for plant industries in the southwestern United States.

Materials and Methods

The population of sting nematodes tested was collected from an infested green of a private golf course at Rancho Mirage, Calif. The nematode population was maintained on bermudagrass [*Cynodon dactylon* (L.) Pers.] in greenhouse pot cultures. California regulatory restrictions, which classified the sting nematode at the time of these experiments as an exotic pest, limited research on this nematode to quarantine facilities approved by the U.S. Dept. of Agriculture and the California Dept. for Food and Agriculture. Consequently, all laboratory and greenhouse research was conducted in the Dept. of Nematology Quarantine Facilities, Univ. of California, Riverside. Nematode inoculum was extracted from the greenhouse cultures using a modified sieving and centrifugal-flotation method (Jenkins, 1964). Nematodes were collected on a 45-µm opening sieve. After each extraction, nematodes were centrifuged at 400 g_n for 5 min. The upper 2 cm of surface water in each 50-mL tube was air aspirated, and the supernatant was saved in a beaker. The pellet was mixed with

1.5 M sucrose and recentrifuged at 350 g_n for 30 to 40 s. The supernatant was collected and combined with the supernatant from the first centrifugation. Nematodes were collected by pouring the supernatant through a 25-µm pore sieve. Most of the J2 and J3 were eliminated with successive additional sieving by passing nematode suspensions through a 90-µm pore sieve and decanting for 5 to 10 min. The nematode suspension was counted under low magnification. Sixty different plant species and cultivars derived from 14 different botanical families were tested. Seeds were planted in 7-cm-diameter pots filled with 150 g of steam-pasteurized blow sand and maintained in the greenhouse at 25 ± 2 °C in ambient light. The large number of plant species and greenhouse space limitations required that the host range tests be conducted in consecutive trials. Each trial included 'Arizona common' bermudagrass (*C. dactylon*) as a control. Each treatment consisted of four replicates. Two additional pots without nematodes were used as controls for each treatment. The treatments were arranged in a randomized complete block. At the second-leaf stage, each pot was infested with a freshly extracted nematode suspension consisting of 55 ± 12 adults or J4 nematodes (female : male ratio ≈ 3:2). The plants received 20 mL fertilizer solution (10 g of Miracle Gro per 4 L water, 15N–30P–15K, Scotts Miracle Gro Products, Port Washington, N.Y.) each week. Nematode population density was determined after 7 weeks by extracting the contents of each pot using the modified centrifugal-flotation method described above. After each extraction, roots were washed and gently dried with absorbent paper. Root fresh weight was taken from both inoculated and noninoculated plants. A reproductive factor (Rf) for each plant–nematode combination was calculated by dividing the final sting nematode population by the initial inoculum (Seinhorst, 1967).

All data were subjected to analysis of variance. Means comparison of the Rf was performed on transformed log (x + 1) data with the Fisher's protected least significance difference (LSD) test. Means comparison of weights of the infested and healthy roots was accomplished with the F test. The trial was repeated for plants that classified as nonhost plants.

Results and Discussion

The tests demonstrated both the nematode's wide host range and its high reproductive fitness. On >80% of the plant species tested, the sting nematode population had a high multiplication rate (Rf > 5) despite a fairly short test period (Table 1). About 10% of the plants tested were poorly suited for the nematode population (Rf < 5). The population declined only under *Abelmoschus esculentus*, *Nicotiana tabacum*, and *Citrullus lanatus*. Furthermore, no juveniles were recovered from those plants. Adults of the sting nematode recovered from pots with *A. esculentus* and *N. tabacum* appeared particularly frail and malnourished. Hence, those plants were catego-

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Table 1. Host reactions to a California population of the sting nematode.

Common name and cultivar and designation	Scientific name	Family	Rf ²
Okra 'Clemson 80'	<i>Abelmoschus esculentus</i> (L.) Moench	Malvaceae	0.4 ± 0.06 a ^y
Tobacco 'Xanthi'	<i>Nicotiana tabacum</i> L.	Solanaceae	0.6 ± 0.2 ^x
Watermelon 'Solid Gold'	<i>Citrullus lanatus</i> Thunb.	Cucurbitaceae Juss.	0.5 ± 0.08 a
Ridgeseed spurge	<i>Euphorbia glyptosperma</i> Engelm.	Euphorbiaceae Juss.	0.2 ± 0.06 ^x
Squash 'Prelude'	<i>Cucurbita maxima</i> L.	Cucurbitaceae Juss.	0.7 ± 0.2 a
Cucumber 'Kidma'	<i>Cucumis sativus</i> L.	Cucurbitaceae Juss.	0.9 ± 0.1 ^x
Carrot 'Goldmine'	<i>Daucus carota</i> L.	Apiaceae	2.2 ± 0.9 b
Peanut 'GFA Spanish'	<i>Arachis hypogaea</i> L.	Fabaceae	2.3 ± 0.7 bc
Alfalfa 'CUF 10'	<i>Medicago sativa</i> L.	Fabaceae	2.6 ± 0.9 bc
Pepper 'California Wonder'	<i>Capsicum annuum</i> L.	Solanaceae	3.1 ± 0.8 bc
Wheat 'Yecora Rojo'	<i>Triticum aestivum</i> L.	Poaceae	3.6 ± 0.6 bc
Turnip 'Seven Top'	<i>Brassica rapa</i> L.	Brassicaceae	3.7 ± 0.7 bc
Prostrate pigweed	<i>Amaranthus blitoides</i> (S.) Watson.	Amaranthaceae Juss.	3.8 ± 1.3 bc
Lupine 'Russell's Hybrid'	<i>Lupinus hirsutus</i> L.	Fabaceae	5.3 ± 1.3 cd
London rocket	<i>Sisymbrium irio</i> L.	Brassicaceae	6.1 ± 2 cd
Zoysiagrass 'Emerald'	<i>Zoysia</i> sp. (L.) Merr.	Poaceae	6.3 ± 1.6 cd
Shepherdspurse	<i>Capsella bursa-pastoris</i> (L.) Medic.	Brassicaceae	6.8 ± 1.3 cd
Lambsquarters	<i>Chenopodium album</i> L.	Chenopodiaceae Venten.	8.5 ± 1.8 cd
Lettuce 'Yuma'	<i>Lactuca sativa</i> L.	Asteraceae Dumort.	9.2 ± 1.5 cd
Soybean 'Norchief'	<i>Glycine max</i> (L.) Merrill	Fabaceae	10.0 ± 2.3 de
Purple nutsedge	<i>Cyperus rotundus</i> L.	Cyperaceae	10.8 ± 2.1 de
Potato 'California White'	<i>Solanum tuberosum</i> L.	Solanaceae	11.4 ± 3.2 de
Cantaloupe 'Sierra Gold'	<i>Cucumis melo</i> L.	Cucurbitaceae Juss.	11.5 ± 3.4 de
Annual bluegrass	<i>Poa annua</i> L.	Poaceae	12.2 ± 2.7 de
Tomato 'Pixie'	<i>Lycopersicon esculentum</i> Mill.	Solanaceae	12.4 ± 6.1 de
Radish 'Cherry Belle'	<i>Raphanus sativus</i> L.	Brassicaceae	12.7 ± 4.1 de
Onion 'Southport White Globe'	<i>Allium cepa</i> L.	Liliaceae	13.1 ± 5.2 de
Barley '603'	<i>Hordeum vulgare</i> L.	Poaceae	13.6 ± 4.5 de
Zoysiagrass 'De Anza'	<i>Zoysia</i> sp. (L.) Merr.	Poaceae	14.3 ± 5.0 de
Yellow nutsedge	<i>Cyperus esculentus</i> L.	Cyperaceae	14.5 ± 3.3 de
Wild mustard	<i>Brassica kaber</i> (D.C.) L.C. Wheeler	Brassicaceae	15.8 ± 4.2 de
Spinach 'Bloomsdale'	<i>Spinacia oleracea</i> L.	Chenopodiaceae Venten.	16.1 ± 3.7 ef
Purslane	<i>Portulaca oleracea</i> L.	Portulacaceae Juss.	16.5 ± 4.5 ef
Soybean 'Horosay'	<i>Glycine max</i> (L.) Merrill	Fabaceae	17.2 ± 6.1 ef
Pearl millet	<i>Pennisetum glaucum</i> L.	Poaceae	18.4 ± 4.3 ef
Bermudagrass 'Sahara'	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	19.2 ± 4.8 ef
Zoysiagrass 'Victoria'	<i>Zoysia</i> sp. (L.) Merr.	Poaceae	20.6 ± 4.5 ef
Cowpea 'Iron Clay'	<i>Vigna unguiculata</i> (L.) Walp.	Fabaceae	20.7 ± 5.1 ef
Sorghum 'Red Top'	<i>Sorghum bicolor</i> (L.) Moench	Poaceae	20.9 ± 4.7 ef
Dallisgrass	<i>Paspalum dilatatum</i> Poir.	Poaceae	21.2 ± 6.2 ef
Tall fescue 'Short Top'	<i>Festuca arundinacea</i> Schreb.	Poaceae	22.0 ± 5.8 ef
Kentucky bluegrass	<i>Poa pratensis</i> L.	Poaceae	22.5 ± 4.3 ef
Bush bean 'Blue Lake Bush'	<i>Phaseolus vulgaris</i> L.	Fabaceae	23.8 ± 5.2 ef
Bermudagrass 'Arizona common'	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	25.0 ± 6.0 fg
Cowpea 'Pinkeye Purple Hull'	<i>Vigna unguiculata</i> (L.) Walp.	Fabaceae	26.8 ± 4.3 fg
Corn 'Golden Jubilee'	<i>Zea mays</i> L.	Poaceae	27.9 ± 3.9 fg
Black nightshade	<i>Solanum nigrum</i> L.	Solanaceae	30.0 ± 5.6 fg
Creeping bentgrass	<i>Agrostis stolonifera</i> L.	Poaceae	30.6 ± 8.1 fg
Eggplant 'Bambino'	<i>Solanum melongena</i> L.	Solanaceae	32.7 ± 6.5 fg
Sudangrass	<i>Sorghum sudanense</i> Staph.	Poaceae	33.0 ± 4.4 fg
Italian ryegrass	<i>Lolium multiflorum</i> Lam.	Poaceae	33.5 ± 3.6 fg
Perennial ryegrass	<i>Lolium perenne</i> L.	Poaceae	33.9 ± 4.8 fg
Lima bean 'Henderson Bush'	<i>Phaseolus limensis</i> Macfad.	Fabaceae	36.1 ± 5.9 fg
Tall fescue 'Marathon'	<i>Festuca arundinacea</i> Schreb.	Poaceae	43.1 ± 6.3 fg
Smutgrass	<i>Sporobolus indicus</i> (L.) R. Br.	Poaceae	44.6 ± 8.1 fg
Crabgrass	<i>Digitaria sanguinalis</i> (L.) Scop.	Poaceae	48.5 ± 9.3 f-h
Western wheatgrass	<i>Elymus smithii</i> (Rybd.) Gould	Poaceae	49.7 ± 11 f-h
Sorghum 'Sanita'	<i>Sorghum bicolor</i> (L.) Moench	Poaceae	50.0 ± 7.2 f-h
Winter rye	<i>Secale cereale</i> L.	Poaceae	50.1 ± 6.5 f-h
Cotton 'Maxxa'	<i>Gossypium hirsutum</i> L.	Malvaceae	52.3 ± 10.3 f-h
			57.0 ± 12 gh
			58.6 ± 9.3 gh

^yRf values (final population/initial population; Rf <1 = nonhosts; Rf 1-4 = poor hosts; Rf >4 = good hosts.^xMean separation by Fisher's protected LSD of transformed log (Rf + 1) at P ≤ 0.05.^zRf values of the repeated experiment with nonhost plants.

rized as nonhosts with $R_f < 1$ (Table 1). *Cynodon dactylon* 'Arizona common' was a suitable control for the two complete sets of experiments, with no significant differences in the R_f for this host between the two trials ($P > 0.05$). All of the Poaceae, which constituted 50% of the experimental plants, were good hosts. Two species in the Cucurbitaceae (*Cucurbita maxima* L. and *Cucumis sativus* L.) were poor hosts and one was a nonhost (*Citrullus lanatus*). The Solanaceae included representatives from both nonhosts, such as *N. tabacum*, and good hosts, such as *Solanum nigrum* L., *S. melongena* L., *Solanum tuberosum* L., and *Lycopersicon esculentum* Mill.

Citrullus lanatus, *A. esculentus*, and *N. tabacum* were reported as nonhost plants of *B. longicaudatus* (Perry and Rhoades, 1982; Robbins and Barker, 1973; Smart and Nguyen, 1991). This California sting nematode population appeared to be most similar in its host preference to populations from Georgia and perhaps Florida (Abu-Gharbieh and Perry, 1970; Dickson, personal communication), but clearly differed from a North Carolina population (Robbins and Barker, 1973).

The capability of the nematode population to multiply rapidly and to parasitize *Elymus smithii* (Rybd.) Gould, *C. dactylon*, *Gossypium hirsutum* L., *S. melongena*, *Lactuca sativa* L., *Allium cepa* L., and *Sporobolus indicus* (L.) R. Br. at an early plant vegetative stage resulted in a strong and significant reduction in root weight compared with plants grown in sting nematode-free soil ($P \leq 0.05$, data not shown). Smart and Nguyen (1991) reported that as little as three sting nematodes per 100 g of soil could result in significant yield loss in a field production situation. The absence of a significant root weight reduction for other good hosts might have resulted from their capacity to compensate for the nematode damage. Tolerance to the sting nematode in some grasses was

observed previously in field and greenhouse trials (Boyd and Perry, 1969; Giblin-Davis et al., 1992). Moreover, root weight was not reduced in any of the plants categorized as poor or nonhosts.

Cherry et al. (1997) hypothesized that the California sting nematode population was introduced from the eastern United States. In Caribbean countries, infestations with sting nematodes are typically restricted to commercial golf courses. Most of the sod was imported from commercial producers in the southeastern United States. Similarly, in California the current known distribution of the sting nematode is restricted to a few golf courses in the Coachella Valley. However, our data demonstrated that its wide host range is not restricted to horticultural grasses or agricultural crops. Many weeds, such as *Euphorbia glyptosperma* Engelm., *Sisymbrium irio* L., *Paspalum dilatatum* Poir., *Portulaca oleracea* L., *Sorghum sudanense* Staph., and *Cyperus esculentus* L., can serve as hosts for *B. longicaudatus*. In sandy irrigated soils of the southwestern United States, this nematode constitutes a major threat to most plant industries.

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