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 occurrence of several physiological races within this species.

Recently, sting nematodes were discovered 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 in Rancho Mirage, Calif. (Mundo-Ocampo et al., 1994). The nematode population was maintained on bermondagrass (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-floation method described above. After each extraction, roots were washed and gently dried with absorbent paper. Root fresh weight was determined after 7 weeks by extracting the contents of each pot using the modified centrifugal-floation method described above. Nematodes were collected on a 45-µm opening sieve. After each extraction, nematodes were centrifuged at 400g 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, 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. Fifty nematode 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’ bermondagrass (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-floation method described above. After each extraction, roots were washed and gently dried with absorbent paper. Root fresh weight was determined after 7 weeks by extracting the contents of each pot using the sieving method described above. The results demonstrated both the nematode’s wide host range and its high reproductive fitness. On >80% of the plants tested, the sting nematode population had a high multiplication rate (RF >5) despite a fairly short test period (Table 1). About 60% 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-
Table 1. Host reactions to a California population of the sting nematode.

| Common name and cultivar | Scientific name | Family          | Rf  |
|--------------------------|-----------------|-----------------|-----|
| Okra ‘Clemson 80’        | Abelmoschus esculentus (L.) Moench | Malvaceae       | 0.4 ± 0.06 a* |
| Tobacco ‘Xanthi’         | Nicotiana tabacum L. | Solanaceae      | 0.5 ± 0.08 a  |
| Watermelon ‘Solid Gold’  | Citrullus lanatus Thunb. | Cucurbitaceae Juss. | 0.7 ± 0.2 a  |
| Brassica rapa            |                | Brassicaceae     | 0.9 ± 0.1* |
| Wheat ‘Yecora Rojo’      |                | Poaceae         | 2.2 ± 0.9 b  |
| Capsicum annuum          |                | Solanaceae      | 3.6 ± 0.6 b  |
| Alfalfa ‘CUF 10’         |                | Fabaceae        | 3.7 ± 0.7 b  |
| Pepper ‘California Wonder’ | Capsicum annuum L. | Solanaceae      | 3.8 ± 1.3 b  |
| Turnip ‘Seven Top’       | Brassica rapa L. | Brassicaceae     | 5.3 ± 1.3 cd |
| Prostrate pigweed        | Aamaranthus blitoides (S.) Watson | Amaranthaceae Juss. | 6.3 ± 1.6 cd |
| Lupine ‘Russell’ Hybrid’ | Lupinus hirsutus L. | Fabaceae        | 6.8 ± 1.3 cd |
| London rocket             | Sisymbrium irio L. | Brassicaceae     | 8.5 ± 1.8 cd |
| Zsayasgrass ‘Emerald’    | Zsystia sp. (L.) Merr. | Poaceae       | 9.2 ± 1.5 cd |
| Shepherdsparse            | Capsella bursa-pastoris (L.) Medic. | Brassicaceae | 10.0 ± 2.3 de |
| Lambquarters             | Chenopodium album L. | Chenopodiaceae Ventes. | 10.8 ± 2.1 de |
| Lettuce ‘Yuma’            | Lactuca sativa L. | Asteraceae Dumont. | 11.4 ± 3.2 de |
| Soybean ‘Norichief’      | Glycine max (L.) Merrill | Fabaceae | 11.5 ± 3.4 de |
| Purple nusedge           | Cyperus rotundus L. | Cyperaceae       | 12.2 ± 2.7 de |
| Tomato ‘Pixie’           | Lycopersicon esculentum Mill. | Solanaceae | 12.4 ± 6.1 de |
| Redish ‘Cherry Belle’    | Raphanus sativus L. | Brassicaceae     | 14.3 ± 5.0 de |
| Onion ‘Southport White Globe’ | Allium cepa L. | Liliaceae       | 14.5 ± 3.3 de |
| barley ‘603’             | Hordeum vulgare L. | Poaceae         | 15.8 ± 4.2 de |
| Zsayasgrass ‘De Anza’    | Zsystia sp. (L.) Merr. | Poaceae       | 16.1 ± 3.7 ef |
| Yellow nusedge           | Cyperus esculentus L. | Cyperaceae       | 16.5 ± 4.5 ef |
| Wild mustard             | Brassica kaber (D.C.) L.C. Wheeler | Brassicaceae | 17.2 ± 6.1 ef |
| Spinich ‘Bloomsdale’     | Spinacia oleracea L. | Chenopodiaceae Ventes. | 18.4 ± 4.3 ef |
| Purslane                  | Portulaca oleracea L. | Portulacaaceae Juss. | 19.2 ± 4.1 ef |
| Soybean ‘Hosoray’        | Glycine max (L.) Merrill | Fabaceae | 19.2 ± 4.8 ef |
| Pearl millet             | Pennisetum glaucum L. | Poaceae         | 20.6 ± 4.5 ef |
| Bermuda grass ‘Sahara’    | Cydonon dactylon (L.) Pers. | Poaceae | 20.7 ± 5.1 ef |
| Zsayasgrass ‘Victoria’   | Zsystia sp. (L.) Merr. | Poaceae       | 20.9 ± 4.7 ef |
| Cowpea ‘Iron Clay’       | Vigna unguiculata (L.) Walp. | Fabaceae | 21.2 ± 6.2 ef |
| Sorghum ‘Red Top’        | Sorghum bicolor (L.) Moench | Poaceae | 22.0 ± 5.8 ef |
| Dallisgrass              | Paspalum dilatatum Poir. | Poaceae | 22.5 ± 4.3 ef |
| Tall fescue ‘Short Top’  | Festuca arundinacea Schreb. | Poaceae | 23.8 ± 5.2 ef |
| Kentucky bluegrass       | Poa pratensis L. | Poaceae         | 25.0 ± 6.0 fg |
| Bush bean ‘Blue Lake Bush’ | Phaseolus vulgaris L. | Fabaceae | 26.8 ± 4.3 fg |
| Bermuda grass ‘Arizona common’ | Cydonon dactylon (L.) Pers. | Poaceae | 27.9 ± 3.9 fg |
| Cowpea ‘Pinkeye Purple Hull’ | Vigna unguiculata (L.) Walp. | Fabaceae | 30.6 ± 5.6 fg |
| Corn ‘Golden Jubilee’    | Zea mays L. | Poaceae         | 30.6 ± 8.1 fg |
| Black nightshade         | Solanum nigrum L. | Solanaceae      | 32.7 ± 6.5 fg |
| Creeping bentgrass       | Agrostis stolonifera L. | Poaceae | 33.0 ± 4.4 fg |
| Eggplant ‘Bambino’       | Solanum melongena L. | Solanaceae      | 33.5 ± 3.6 fg |
| Sudangrass               | Sorghum sudanense Staph. | Poaceae | 33.9 ± 4.8 fg |
| Italian ryegrass         | Lolium multiflorum Lam. | Poaceae | 36.1 ± 5.9 fg |
| Perennial ryegrass       | Lolium perenne L. | Poaceae         | 43.1 ± 6.3 fg |
| Lima bean ‘Henderson Bush’ | Phaseolus limensis Macfadd. | Fabaceae | 44.6 ± 8.1 fg |
| Tall fescue ‘Marathon’   | Festuca arundinacea Schreb. | Poaceae | 48.5 ± 9.3 f–h |
| Smutgrass                | Sporobolus indicus (L.) R. Br. | Poaceae | 49.7 ± 11 f–h |
| Crabgrass                | Digitaria sanguinalis (L.) Scop. | Poaceae | 50.7 ± 7.2 f–h |
| Western wheatgrass       | Elymus repens (Rybd.) Gould | Poaceae | 50.1 ± 6.5 f–h |
| Sorghum ‘Sanita’         | Sorghum bicolor (L.) Moench | Poaceae | 52.3 ± 10.3 f–h |
| Winter rye               | Secale cereale L. | Poaceae         | 57.0 ± 12 gh |
| Cotton ‘Maxxa’           | Gossypium hirsutum L. | Malvaceae       | 58.6 ± 9.3 gh |

*Rf values (final population/initial population; Rf < 1 = nonhosts; Rf 1–4 = poor hosts; Rf > 4 = good hosts.

*Mean separation by Fisher’s protected LSD of transformed log (Rf + 1) at P ≤ 0.05.

*Rf values of the repeated experiment with nonhost plants.
rized as nonhosts with RF < 1 (Table 1). *Cynodon dactylon* ‘Arizona common’ was a suitable control for the two complete sets of experiments, with no significant differences in the RF 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 (*Citrus lansanut*). 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.

*Citrus lansanut*, *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* (Rydb.) 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* ≤ 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 this 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* Steaph., 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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