Revised Host Range and Studies on the Life Cycle of *Longidorus africanus*

**Craig Kolodge,** 1 **John D. Radewald,** 2 and **Fujio Shibuya** 2

**Abstract:** The host range of *Longidorus africanus* was demonstrated to be much wider than previously reported. All commercial crop plants tested, except two of four crucifers, were hosts of *L. africanus*. The nematode was widespread in fields, and soil type did not appear to be related to its distribution. The minimum time to complete a life cycle was 9 weeks at 28°C in a plant growth chamber. Field observations of population densities indicated, however, that in undisturbed field soils the life cycle required considerably less time than was indicated by growth chamber studies.

**Key words:** temperature, survey, distribution.

*Longidorus africanus* Merny was first recognized in 1969 as a pathogen of head lettuce in the Imperial Valley of southern California (12, 14). In greenhouse studies Lamberti (10) reported the nematode to be a pathogen of sorghum and sugar beets. Lamberti (11) also found in a lathhouse study that 11 of 40 plant cultivars tested supported reproduction of *L. africanus*. Cohn (2) reported grape and bur marigold as hosts of *L. africanus* and that the life cycle was completed in 3–4 months on both plants.

In 1968 we suspected *L. africanus* was a pathogen of carrot in the Imperial Valley, even though the nematode did not reproduce or cause damage on carrot in a lathhouse study (10). Our objectives were to investigate pathogenicity of *L. africanus* on crop plants grown in the Imperial Valley, to reinvestigate its host range and life cycle, and to determine its Valley distribution.

**MATERIALS AND METHODS**

A population of *L. africanus* was obtained from soil around roots of bermudagrass (*Cynodon dactylon* (L.) Pers.) in the Imperial Valley. The nematode was maintained for inoculum in the greenhouse on tomato (*Lycopersicon esculentum* Mill. cv. Tropic). Host range: Thirty-three plant cultivars (Table 1) were direct seeded and grown in 2,500 cm³ of pasteurized field soil (85% sand, 11% silt, 4% clay) in 15-cm-d plastic pots. Plants were maintained at a soil temperature of 27 ± 5°C on a greenhouse bench. Two weeks after germination, seedlings were thinned and four of the six single pot replicates per cultivar were infested with 10 adult and 20 mixed juvenile stages (hand picked) of *L. africanus*. Nematodes were washed into shallow depressions in the soil at the base of the plants. The two remaining pots of each cultivar served as noninfested controls. An additional treatment was a pot of moist fallow soil infested with 30 *L. africanus*. Nematodes were washed into shallow depressions in the soil at the base of the plants. The two remaining pots of each cultivar served as noninfested controls. An additional treatment was a pot of moist fallow soil infested with 30 *L. africanus*. All plants received full-strength Hoagland's nutrient solution weekly (9). Nematodes were extracted from the entire pot soil mass 8–12 weeks after infestation with an extraction efficiency of 50–60%. At termination all root systems were examined for symptoms of nematode damage. The experiment was performed twice.

**Field survey:** During June–August 1984, 39 fields in the Imperial Valley were sampled for *L. africanus*. Soil from around nine different crop plants and two dominant weed species was included in the survey. Soil types sampled included sandy loams (87% sand, 8% silt, 5% clay) to silty clays (17% sand, 58% silt, 25% clay). Samples were taken with PVC coring tubes (3.7 cm d × 15.0 cm long). The tubes were pressed into the soil, removed, and both ends capped to minimize loss of nematodes resulting from soil disturbance and drying. Nematodes were extracted using Cobb's...
### TABLE 1. Plant cultivars tested for suitability as hosts for *Longidorus africanus* and effect of different plant cultivars on its reproduction under greenhouse conditions.

<table>
<thead>
<tr>
<th>Plant family and common name</th>
<th>Scientific and cultivar name</th>
<th>Final pop.</th>
<th>Percent change†</th>
<th>Host rating‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Moist fallow soil</td>
<td>11</td>
<td>−19</td>
<td></td>
</tr>
<tr>
<td>Poaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td><em>Sorghum bicolor</em> (L.) Moench cv. G-499 GBR</td>
<td>487</td>
<td>+4,327 B</td>
<td>B</td>
</tr>
<tr>
<td>Barley</td>
<td><em>Hordeum vulgare</em> L. cv. UC 566</td>
<td>300</td>
<td>+2,627 G</td>
<td>G</td>
</tr>
<tr>
<td>Bermudagrass</td>
<td><em>Cynodon dactylon</em> (L.) Pers. cv. Common</td>
<td>270</td>
<td>+2,355 G</td>
<td>G</td>
</tr>
<tr>
<td>Wheat</td>
<td><em>Triticum aestivum</em> L. cv. Ramona 70</td>
<td>196</td>
<td>+1,682 G</td>
<td>G</td>
</tr>
<tr>
<td>Oat</td>
<td><em>Avena sativa</em> L. cv. Sierra</td>
<td>53</td>
<td>+382 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Malvaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td><em>Gossypium hirsutum</em> L. cv. SJ-4</td>
<td>254</td>
<td>+2,209 G</td>
<td>G</td>
</tr>
<tr>
<td>Okra</td>
<td><em>Hibiscus esculentus</em> L. cv. Clemson Spineless</td>
<td>154</td>
<td>+1,300 G</td>
<td>G</td>
</tr>
<tr>
<td>Asteraceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce</td>
<td><em>Lactuca sativa</em> L. cv. Climas</td>
<td>254</td>
<td>+2,209 G</td>
<td>G</td>
</tr>
<tr>
<td>Sunflower</td>
<td><em>Helianthus annuus</em> L. cv. Mammoth</td>
<td>38</td>
<td>+245 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Fabaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snap bean</td>
<td><em>Phaseolus vulgaris</em> L. cv. Green Pod</td>
<td>649</td>
<td>+5,800 B</td>
<td>B</td>
</tr>
<tr>
<td>Lima bean</td>
<td><em>Phaseolus lunatus</em> L. cv. Baby Fordhook</td>
<td>577</td>
<td>+5,146 B</td>
<td>B</td>
</tr>
<tr>
<td>Alfalfa</td>
<td><em>Medicago sativa</em> L. cv. Moapa</td>
<td>88</td>
<td>+700 FP</td>
<td>FP</td>
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<tr>
<td>Pea</td>
<td><em>Pisum sativum</em> L. cv. Snowbird</td>
<td>63</td>
<td>+473 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Umbelliferae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td><em>Daucus carota</em> L. cv. Danvers 126</td>
<td>85</td>
<td>+673 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Carrot</td>
<td><em>Daucus carota</em> L. cv. Imperator</td>
<td>62</td>
<td>+464 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Carrot</td>
<td><em>Daucus carota</em> L. cv. Half-long Nantes</td>
<td>48</td>
<td>+336 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td><em>Cucumis sativus</em> L. cv. Improved Long Green</td>
<td>282</td>
<td>+2,464 G</td>
<td>G</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td><em>Cucumis melo</em> L. cv. Delicious 51</td>
<td>130</td>
<td>+1,082 FP</td>
<td>FP</td>
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<tr>
<td>Squash</td>
<td><em>Cucurbita pepo</em> L. cv. Golden Summer Crookneck</td>
<td>90</td>
<td>+718 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Zucchini</td>
<td><em>Cucurbita pepo</em> L. cv. Burpee Hybrid</td>
<td>62</td>
<td>+464 FP</td>
<td>FP</td>
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<tr>
<td>Watermelon</td>
<td><em>Citrullus lanatus</em> (Thunb.) Mansf. cv. Crimson Sweet</td>
<td>55</td>
<td>+400 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Solanaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggplant</td>
<td><em>Solanum melongena</em> L. cv. Black Beauty</td>
<td>348</td>
<td>+3,064 G</td>
<td>G</td>
</tr>
<tr>
<td>Tomato</td>
<td><em>Lycopersicon esculentum</em> Mill. cv. Pearson Improved</td>
<td>193</td>
<td>+1,655 G</td>
<td>G</td>
</tr>
<tr>
<td>Pepper</td>
<td><em>Capsicum annuum</em> L. cv. California Wonder</td>
<td>109</td>
<td>+891 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sugar beet</td>
<td><em>Beta vulgaris</em> L. cv. USH 10</td>
<td>453</td>
<td>+4,018 B</td>
<td>B</td>
</tr>
<tr>
<td>Spinach</td>
<td><em>Spinacia oleracea</em> L. cv. Bloomingsdale Large Standing</td>
<td>92</td>
<td>+736 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Lamiaceae</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Spearmint</td>
<td><em>Mentha spicata</em> L. cv. Burpee</td>
<td>52</td>
<td>+373 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Liliaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td><em>Allium cepa</em> L. cv. White Sweet Spanish</td>
<td>39</td>
<td>+255 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Cruciferae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td><em>Brassica oleracea</em> L. cv. De Cicco</td>
<td>30</td>
<td>+173 FP</td>
<td>FP</td>
</tr>
<tr>
<td>Cauliflower</td>
<td><em>Brassica oleracea</em> L. cv. Burpeeeana</td>
<td>6</td>
<td>−80 NH</td>
<td>NH</td>
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<tr>
<td>Cabbage</td>
<td><em>Brassica oleracea</em> L. cv. Yellows Resistant</td>
<td>2</td>
<td>−93 NH</td>
<td>NH</td>
</tr>
<tr>
<td>Radish</td>
<td><em>Raphanus sativus</em> L. cv. Scarlet Globe</td>
<td>21</td>
<td>+91 FP</td>
<td>FP</td>
</tr>
</tbody>
</table>

* Mean of four replicates.
† Expressed as percentage change in fallow soil population.
‡ Host rating scale: B = best host. G = good host. FP = fair–poor host. NH = nonhost.
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(1) decanting–sieving technique (850–120-μm-pore sieves) and Baermann funnels with 98-μm-pore polyester sieves.

Life cycle: Three different experiments were conducted on the life cycle of L. africanus.

In experiment 1, sixty 15-cm-d plastic pots were each filled with steamed sandy loam soil (69% sand, 13% silt, 18% clay). Ten adult and twenty assorted juvenile stages of L. africanus were hand picked and placed on 2-week-old Tropic tomato seedlings. Infested plants were watered and placed in a growth chamber at 28 C. Plants were watered as needed and fertilized weekly with full-strength Hoagland's solution. Nematodes were extracted from five pots of plants each week starting 4 weeks after nematode infestation. Nematodes were washed from the sieve and observed directly. The life cycle from adult to adult was considered complete when 31 adults were recovered (15).

In experiment 2, the time required for L. africanus to develop from egg to adult was determined. Eggs of L. africanus were collected from soil of greenhouse stock cultures using a modified Flegg–McNamara method (5). Following centrifugation at 200 g of a 1 part soil:2 parts 50% aqueous sugar suspension for 6 minutes, the supernatant was poured into a liter of tap water. This suspension containing eggs was rinsed onto a 45-μm-pore sieve, and the residue was back-washed into a beaker. Ten eggs were removed from the suspension with a Pasteur pipette and placed on the roots of a 2-week-old Tropic tomato seedling growing in sandy loam soil in a growth chamber at 25 C. Five pots of plants were examined for nematodes weekly for 5 weeks. The experiment was performed twice.

In experiment 3, three-week-old lettuce seedlings growing in steamed sandy loam soil in 15-cm-d plastic pots were infested with five adult female L. africanus per pot. Infested plants were maintained in a greenhouse at a soil temperature of 27 ± 5 C. Developmental observations started 4 weeks after infestation; five pots of plants were examined each week for nematode life stages. The life cycle was considered complete when six females were recovered from a pot.

RESULTS

Host range: Numbers of L. africanus were higher on 31 of the 33 plant cultivars tested than in the moist fallow control (Table 1). Cauliflower and cabbage failed to support nematode reproduction. On the basis of nematode population increase, the best hosts were snap bean, lima bean, sorghum, and sugar beet. There were no significant differences in above-ground growth among plants tested in infested vs. noninfested soil. Evidence of L. africanus root damage was observed as small root-tip galls on the fine lateral roots of most plants, especially on carrots, lima bean, lettuce, cucumber, okra, eggplant, pepper, and wheat.

Field survey: Of the 39 fields sampled, 12 were infested with L. africanus; the nematode was most frequently found associated with bermudagrass (Table 2). The soil population densities of L. africanus on most crops sampled was low, 16 or fewer per 644 cm³ soil. The greatest populations of L. africanus occurred on sudan and bermudagrasses, with 171 and 101 per 644 cm³ soil, respectively. The nematode was recovered from all soil types encountered.

<table>
<thead>
<tr>
<th>Table 2. A survey of fields in the Imperial Valley of southern California for Longidorus africanus. Soil samples consisted of four cores per sample with one sample per field.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
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<tr>
<td>-------</td>
</tr>
<tr>
<td>Cotton</td>
</tr>
<tr>
<td>Cantaloupe</td>
</tr>
<tr>
<td>Honeydew melon</td>
</tr>
<tr>
<td>Squash</td>
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<tr>
<td>Alfalfa</td>
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<tr>
<td>Sudan grass</td>
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<tr>
<td>Sorghum</td>
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<tr>
<td>Soybean</td>
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<tr>
<td>Asparagus</td>
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<tr>
<td>Bermudagrass</td>
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<tr>
<td>Portulaca</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Percent</td>
</tr>
</tbody>
</table>

* ( ) = number of L. africanus/644 cc of field soil.
Life cycle: *Longidorus africanus* completed its life cycle from adult to adult in experiment 1 on tomato in 7 weeks in a growth chamber at 28 C. This conclusion was based on one of five replicates from which 33 adult females and 587 juveniles were recovered. At 8 and 9 weeks, 48–62 adult females were recovered from other replicates. In experiment 2 on tomato, the life cycle from egg to adult occurred in 4 weeks in a growth chamber at 25 C. Of the total eggs inoculated, 11% were later recovered as vermiform nematodes.

On lettuce in the greenhouse in experiment 3, *L. africanus* completed development from adult to adult in 9 weeks. Six or more adult females were recovered from three of the five replicate pots, and fourth-stage juveniles were recovered as early as 6 weeks after soil infestation.

**DISCUSSION**

Our survey showed *L. africanus* is widely distributed in the Imperial Valley. The nematode has apparently gone unrecognized for years as a pest of some crops in the area. Its original detection as causing a seedling disease of lettuce (14) came about after commercial growers adopted precision planting to achieve uniform plant spacing. Precision planting consists of placing 2–3 seeds per hill with 25-cm plant spacing in the row, whereas broadcast row seeding, practiced earlier, placed seed 2–3 cm apart in the row. When field laborers hand thinned the broadcast seeded lettuce, they undoubtedly removed the stunted, nematode-damaged seedlings and left the more uniform vigorous plants without ever recognizing the cause of the stunting.

We considered a host any cultivar which supported development and reproduction of *L. africanus* (15). Relative host status was based on nematode population build-up after 2–3 months. *L. africanus* reproduced on all plants tested, except cabbage and cauliflower. In a similar host range study with *L. macrosoma* Hooper, *Brassica* spp. were also found to be the least favorable hosts (7). McElroy (13) reported that populations of *Xiphinema bakeri* Williams were reduced below those surviving in fallow soil when exposed to crucifers and cucurbits. According to our findings, certain members of the Cruciferae appear to be the best choices as rotational crops for managing *L. africanus* and perhaps other longidorid species in the field. Our results differed markedly from the host-range studies on these same crops by Lamberti (10). Sensitivity of *L. africanus* to extraction from soil and cultural growing conditions has been reported (4,6) and may have been the cause of the large discrepancy between the two studies.

The revised host range supports the association of *L. africanus* with six field crops previously reported to be nonhosts (Radewald, unpubl.). The wide distribution and plant associations of *L. africanus* in the Imperial Valley is consistent with the results of our greenhouse studies. Several weeds, especially bermudagrass, appear to be excellent hosts of this nematode, favoring its persistence and maintenance of population densities in the absence of commercial crop hosts. Purslane is a prevalent annual weed in California row crops (8). Its suitability as a host for *L. africanus* from many field samplings not reported herein demonstrates the importance of weed control during cropping as well as fallow periods. *L. africanus* can survive in moist fallow soil for at least 3 months at 25 C and probably longer. With the short cropping cycles practiced in the Imperial Valley, an alternate host would not be necessary for economically damaging population densities of this nematode to carry over from one crop to the next.

In greenhouse studies at 20 C, the life cycle of *Longidorus elongatus* De Man from adult to adult was 4–5 months on straw- berry (17). On the same host at 30 C, *L. elongatus* completed its development from egg to adult in 9 weeks (16). We observed a similar increase in the development rate of *L. africanus* with increasing temperature. Cohn (3) found the life cycle was completed in 3–4 months at 20–30 C, whereas we showed that *L. africanus* completed a life cycle in 9 weeks on tomato at 28 C.
Variable greenhouse temperature probably was responsible for the longer life cycle in our studies using lettuce. In the host range studies, however, the nematode population built up more rapidly on lettuce than on tomato, suggesting a shorter life cycle on lettuce than tomato and indicating a need for additional research.

Soil temperatures during summer in the Imperial Valley often exceed 28 C at 30–60 cm deep. We have found population densities of 1,150 $L. \text{africanus}$ per 500 cm$^3$ soil at these depths on damaged lettuce seedlings in the fall following a summer crop of sugar beets. Such large population densities indicate a short life cycle under field conditions and multiple generations of this nematode during a growing season.

The population dynamics of $L. \text{africanus}$ in the field should be thoroughly investigated. We have found that damage to lettuce seedlings is minimal in late fall plantings when soil temperature drops below 22 C.

**Literature Cited**


