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

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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 cm^3 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*. 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

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TABLE 1. Plant cultivars tested for suitability as hosts for *Longidorus africanus* and effect of different plant cultivars on its reproduction under greenhouse conditions.

Plant family and common name	Scientific and cultivar name	Final pop.*	Percent change†	Host rating‡
Control	Moist fallow soil	11	−19	
Poaceae				
Sorghum	*Sorghum bicolor* (L.) Moench cv. G-499 GBR	487	+4,327	B
Barley	*Hordeum vulgare* L. cv. UC 566	300	+2,627	G
Bermudagrass	*Cynodon dacytlon* (L.) Pers. cv. Common	270	+2,355	G
Corn	*Zea mays* L. cv. Gldn. Cross Bantam	234	+2,027	G
Wheat	*Triticum aestivum* L. cv. Ramona 70	196	+1,682	G
Oat	*Avena sativa* L. cv. Sierra	53	+382	FP
Malvaceae				
Cotton	*Gossypium hirsutum* L. cv. SJ-4	254	+2,209	G
Okra	*Hibiscus esculentus* L. cv. Clemson Spineless	154	+1,300	G
Asteraceae				
Lettuce	*Lactuca sativa* L. cv. Climas	254	+2,209	G
Sunflower	*Helianthus annuus* L. cv. Mammoth	38	+245	FP
Fabaceae				
Snap bean	*Phaseolus vulgaris* L. cv. Green Pod	649	+5,800	B
Lima bean	*Phaseolus lunatus* L. cv. Baby Fordhook	577	+5,146	B
Alfalfa	*Medicago sativa* L. cv. Moapa	88	+700	FP
Pea	*Pisum sativum* L. cv. Snowbird	63	+473	FP
Umbelliferae				
Carrot	*Daucus carota* L. cv. Danvers 126	85	+673	FP
Carrot	*Daucus carota* L. cv. Imperator	62	+464	FP
Carrot	*Daucus carota* L. cv. Half-long Nantes	48	+336	FP
Cucurbitaceae				
Cucumber	*Cucumis sativus* L. cv. Improved Long Green	282	+2,464	G
Cantaloupe	*Cucumis melo* L. cv. Delicious 51	130	+1,082	FP
Squash	*Cucurbita pepo* L. cv. Golden Summer Crookneck	90	+718	FP
Zucchini	*Cucurbita pepo* L. cv. Burpee Hybrid	62	+464	FP
Watermelon	*Citrullus lunatus* (Thunb.) Mansf. cv. Crimson Sweet	55	+400	FP
Solanaceae				
Eggplant	*Solanum melongena* L. cv. Black Beauty	348	+3,064	G
Tomato	*Lycopersicon esculentum* Mill. cv. Pearson Improved	193	+1,655	G
Pepper	*Capsicum annuum* L. cv. California Wonder	109	+891	FP
Chenopodiaceae				
Sugar beet	*Beta vulgaris* L. cv. USH 10	453	+4,018	B
Spinach	*Spinacia oleracea* L. cv. Bloomingsdale Large Standing	92	+736	FP
Labiatae				
Spearmint	*Mentha spicata* L. cv. Burpee	52	+373	FP
Liliaceae				
Onion	*Allium cepa* L. cv. White Sweet Spanish	39	+255	FP
Cruciferae				
Broccoli	*Brassica oleracea* L. cv. De Cicco	30	+173	FP
Cauliflower	*Brassica oleracea* L. cv. Burpeeana	6	−80	NH
Cabbage	*Brassica oleracea* L. cv. Yellows Resistant	2	−93	NH
Radish	*Raphanus sativus* L. cv. Scarlet Globe	21	+91	FP

* 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.

(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.

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.

Plant	Fields sampled	Fields infested *L. africanus**
Cotton	6	2 (16)
Cantaloupe	7	1 (11)
Honeydew melon	1	0
Squash	2	0
Alfalfa	6	3 (5)
Sudan grass	4	1 (171)
Sorghum	4	1 (7)
Soybean	2	0
Asparagus	1	0
Bermudagrass	5	3 (36)
Portulaca	1	1 (8)
Total	39	12
Percent	100	31

* ( ) = number of *L. africanus*/644 cc of field soil.

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 cm^3 soil. The greatest populations of *L. africanus* occurred on sudan and bermudagrasses, with 171 and 101 per 644 cm^3 soil, respectively. The nematode was recovered from all soil types encountered.

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 strawberry (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. 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. 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.

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