Root-Knot Nematode Resistance in Pearl Millet From West and East Africa

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ABSTRACT

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Resistance to *Meloidogyne incognita* is important to provide stability to pearl millet production and to reduce nematode populations that can damage crops grown in rotation with pearl millet. The objectives of this study were to determine whether resistance to *M. incognita* exists in pearl millet from West and East Africa, and to determine if heterogeneity for resistance exists within selected cultivars. Resistance was assessed as nematode egg production per gram of root in greenhouse trials. Seventeen pearl millet cultivars of diverse origin were evaluated as bulk (S_0) populations. All African cultivars expressed some level of resistance. P3Kollo was among the least resistant of the African cultivars, Zongo and Gwagwa were intermediate, and SoSat-C88 was among the most resistant. Thirty selfed (S_1) progeny selections from SoSat-C88, Gwagwa, Zongo, and P3Kollo were evaluated for heterogeneity of resistance within cultivar. Reactions were verified in 13 S_2 progeny of each of the four cultivars. In S_1 evaluations, each of these cultivars was heterogeneous for resistance. Progeny reaction varied from highly resistant to highly susceptible. Patterns of apparent segregation of resistance varied among the four cultivars. Discrete resistant and susceptible phenotypes were identified in Zongo progeny, and it was estimated that two dominant genes for resistance segregated in this cultivar. Averaged across progenies, egg production on the four cultivars was less ($P \leq 0.001$) than on the susceptible hybrid HGM-100, but was not different from resistant hybrid TifGrain 102. Reproduction of *M. incognita* on the S_2 progeny tended to confirm the results from inoculations of S_1 progeny. Heritability of nematode reproduction (standardized as the ratio of the value to HGM-100) determined by parent-offspring regression was 0.54. Realized heritability determined by divergent selection was 0.87.

Additional keywords: Southern root-knot nematode

Sub-Saharan Africa is the primary center of diversity for pearl millet (*Pennisetum glaucum* (L.) R. Br.). Cultivars throughout this region are maintained as open-pollinated cultivars ranging from traditional landraces, which are relatively unimproved and sometimes contaminated by cross-pollination with wild relatives, to improved cultivars maintained in a relatively pure state. Consistent with its cross-pollinating reproductive behavior, pearl millet lines from West and East Africa are genetically heterogeneous. Germ plasm from this region has the potential to be sources of resistance to diseases and pests for crop improvement programs (16–18).

In the United States, pearl millet is grown primarily in the southern region, where nematodes are important constraints in cropping systems. *Meloidogyne* spp. are

the most economically important plant-parasitic nematodes in the southern United States as well as in West Africa, with *Meloidogyne incognita* being the dominant species in both regions (2,11,12). Pearl millet is a known host for *M. incognita* (6–8), but the importance of the nematode in African production settings is not clear. If *M. incognita* is not a yield constraint for pearl millet in African production, resistance would be a selectively neutral trait and there should be little reason for high levels of resistance to be maintained in pearl millet from Africa. However, if nematodes do reduce yields, resistance should confer a reproductive advantage and it should be possible to identify resistance in African cultivars.

Resistance to *M. incognita* in pearl millet should provide stability to pearl millet production and reduce nematode populations that can damage crops grown in rotation with pearl millet. One source of resistance to *M. incognita* has been identified to date (14). Identifying new sources of resistance will help in breeding new nematode-resistant cultivars. The objectives of this study were to (i) determine whether resistance to the southern root-knot nematode (*M. incognita*) exists in pearl millet cultivars from West and East Africa and (ii)

determine whether heterogeneity for resistance exists within selected cultivars.

MATERIALS AND METHODS

General methods. *M. incognita* race 3 was cultured on tomato (*Lycopersicon esculentum* cv. Rutgers). Nematode eggs used for inoculum were extracted from tomato roots with 0.5% NaOCl within 4 h of application (4). The soil used in the experiments was a loamy sand (82% sand, 9% silt, 7% clay, 1% organic matter) that had been steam heated at 100°C for 6 h. Treatments (pearl millet cultivar or selection) were completely randomized on two neighboring benches in a greenhouse where soil temperatures varied between 20 and 35°C. Plants were fertilized with a slow-release formulation (14-14-14, N-P-K) and watered one to two times per day as needed. At the end of the experiments, the root systems were washed free of soil, patted dry, and weighed. Nematode eggs were extracted from the pearl millet roots by cutting the entire root system into approximately 5-cm pieces, placing the pieces in a 1-liter flask, and agitating for 4 min in a 1% NaOCl solution (4). Eggs were collected and rinsed with tap water on nested 150- and 25- μ m-pore sieves, and counted using a dissecting microscope.

In each experiment, pearl millet panicles were bagged to obtain selfed seed which was used in the subsequent experiment. S_1 seed harvested from experiment 1 was used to plant experiment 2, and S_2 seed harvested from experiment 2 was used to plant experiment 3.

Experiment 1. Seventeen pearl millet cultivars of diverse origin (Table 1) were evaluated in two trials to determine whether resistance to *M. incognita* existed in West and East African cultivars. The pearl millet evaluated in this study consisted of traditional, experimental, and improved cultivars that, together, are adapted to most of the growing zones in West and East Africa. The U.S. hybrid HGM-100 was included as a susceptible control. For each pearl millet cultivar, 10 S_0 seed were planted in a 11-cm-diameter circle within a 23-cm-diameter pot containing 6 liters of soil. Seed were sown on 26 November 2002 (trial 1) and 13 March 2003 (trial 2). Plants were thinned to five per pot and inoculated with 10,000 eggs of *M. incognita* 28 days (trial 1) and 19 days (trial 2) after planting. Eggs were distributed in a shallow trench inside the planting circle and covered with soil. For each cul-

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tivar within a trial, there were eight replications (pots), each containing five plants. Nematode eggs were extracted from roots 71 and 67 days after inoculation in trial 1 and trial 2, respectively.

Experiment 2. Four cultivars (SoSat-C88, Gwagwa, Zongo, and P3Kollo) were selected to determine whether heterogeneity for resistance to *M. incognita* could be identified within cultivars. These four cultivars were selected based upon their relative levels of resistance in experiment 1, their diversity of origin and level of improvement (Table 1), their significance in African production settings, and available quantities of S_1 seed. S_1 progeny of 30 randomly selected S_0 plants from the four cultivars in experiment 1 were evaluated for nematode reproduction. Because of limited greenhouse space, plants of P3Kollo and Zongo were tested together (experiment 2a) and plants of Gwagwa and SoSat-C88 were tested together (experiment 2b). Each experiment included U.S. hybrids HGM-100 and TifGrain 102 as the susceptible and resistant controls, respectively. Two S_1 seed were planted in 10-cm² pots containing 700 cm³ of soil. Seed were sown on 28 October 2003 for P3Kollo and Zongo and on 24 February 2004 for Gwagwa and SoSat-C88 and thinned to one plant per pot after germination. Pots were inoculated with 8,200 eggs of *M. incognita* 28 and 23 days after planting for experiments 2a and 2b, respectively. The eggs were distributed between two holes (approximately 2 cm deep) at the base of the plant. For each experiment, there were five replicate pots per S_1 progeny selection. Nematode eggs were extracted from roots 84 and 90 days after inoculation in experiments 2a and 2b, respectively.

Experiment 3. The level of resistance to *M. incognita* was evaluated in progeny from 13 plants (S_1) from each of the four cultivars to verify results obtained in experiment 2. S_2 progeny from 10 putatively resistant and 3 putatively susceptible S_1

plants within each cultivar were selected based upon relative eggs per gram of root and seed availability. A greater number of putatively resistant progeny was evaluated to identify false-resistant classifications and to advance resistant selections for future studies. The number of progeny advanced for each cultivar was limited in order to test all the selections in a single experiment. HGM-100 and TifGrain 102 were included as susceptible and resistant controls, respectively.

Two S_2 seed were planted in 10-cm² pots containing 700 cm³ of soil. Seed were sown on 1 November 2004 and thinned to one plant per pot after germination. Pots were inoculated with 8,200 eggs of *M.*

incognita 28 days after planting. The eggs were distributed between two holes (approximately 2 cm deep) at the base of the plant. For each experiment, there were five replicate pots per progeny selection. Nematode eggs were extracted from roots 85 days after inoculation.

Statistical analysis. Mixed model analysis of variance (PROC MIXED, v. 7; SAS Institute, Cary, NC) was used to analyze data from all three experiments. In the first experiment, cultivar was classified as a fixed effect and trial was classified as a random effect. Fisher's least significant difference (LSD) test was used to determine differences ($P \leq 0.05$) among the cultivars. In the second and third experi-

Fig. 1. Reproduction of *Meloidogyne incognita* race 3 on 17 pearl millet cultivars from West and East Africa. Data are the mean of two experiments. Each experiment contained eight replicate pots of each cultivar and five plants per pot. The dashed line indicates 10% of the level of reproduction of HGM-100 (the susceptible control). HGM-100 had greater ($P \leq 0.05$) nematode reproduction than all the African cultivars. Bars with the same letter are not different ($P \leq 0.05$).

Table 1. Pearl millet cultivars from West and East Africa evaluated for resistance to *Meloidogyne incognita* race 3

Cultivar	Origin and type	Other information
SoSank	Niger improved	SoSat-C88 × Ankoutess derivative
SoSat-C88	Mali improved	Souna × Sanio derivative
GGT	Niger experimental	Gros Grain Tardif—derivative of photoperiod-sensitive accession from Benin (IP 10437)
Zatib	Niger improved	Derivative of two local landraces
Ankoutess	Niger (north) local	...
Taram	Niger improved	Derivative of local from Tara, Niger
GGP V6	Niger experimental	Gros Grain Précoce—derived from Iniani landraces from Togo
HKP GMS	Niger improved	Haïni Kiré Précoce—"shibra" removed through grid mass selection
Sadore local	Niger (west) local	...
Gwagwa	Nigeria local	...
Zongo	Niger (east) local	...
¾ HK-B78	Niger experimental	Dwarf cultivar with Haïni Kiré parentage
Ugandi	Sudan improved	Composite from recurrent selection
LCIC 9702	Nigeria improved	GB 8735 parentage
Ex-Bornu	Nigeria local	Recurrent selection from local landrace
P3Kollo	Niger improved	Derivative of two local landraces
Mansouri	Sudan improved	Mass selection from local landrace
HGM-100	U.S. hybrid	Susceptible control
TifGrain 102	U.S. hybrid	Resistant control

ment, the selections were classified as a fixed effect and Dunnett's test was used to determine which progeny selections were different from the susceptible control HGM-100. Differences among the cultivars in experiments 2a and 2b also were determined by pooling the progeny data ($n = 150$ for the African cultivars and $n = 5$ for HGM-100 and TifGrain 102) and using Fisher's LSD test to separate the means for each experiment.

The number of genes conferring resistance in Zongo was estimated by χ^2 tests using data from experiment 2. These tests assumed that the Zongo S_0 population was in Hardy-Weinberg equilibrium, resistance was dominant, and allele frequencies were 0.5. The χ^2 values were calculated based upon the expected ratios of resistant (R) and susceptible (S) phenotypes in the S_1 progeny for one (5R:3S) or two (55R:9S) dominant genes conferring resistance.

Heritability of root-knot nematode reproduction (eggs per gram of root) was estimated by two methods using data pooled across the four cultivars selected. In order to correct for the differences in nematode reproduction in the two trials of experiment 2, all data were standardized as the proportion of eggs produced on the HGM-100 control. Heritability by parent-offspring regression was calculated as $2/3b$, where b is the regression coefficient resulting from regression of S_2 progeny mean on S_1 parental value (13). In the second method, realized heritability (h^2_R) was calculated as $h^2_R = (\bar{X}_{\text{high } S_2} - \bar{X}_{\text{low } S_2}) / (\bar{X}_{\text{high } S_1} - \bar{X}_{\text{low } S_1})$, where $\bar{X}_{\text{high } S_n}$ and $\bar{X}_{\text{low } S_n}$ are the means of the progeny lines selected for high and low nematode reproduction, respectively (3).

RESULTS

Experiment 1. When evaluated as bulked cultivars (five plants per pot), all African accessions had lower ($P < 0.05$) levels of *M. incognita* reproduction compared with the susceptible control HGM-100 (Fig. 1). SoSank, SoSat-C88, GGT, and Zatib were more ($P < 0.05$) resistant than Mansouri, P3Kollo, and Ex-Bornu. Genotypes or cultivars are considered highly resistant if reproduction is $<10\%$ that of the susceptible control and moderately resistant if reproduction is $>10\%$ but statistically less than the susceptible control (5). Based on these criteria, Ex-Bornu, P3Kollo, and Mansouri appear to be moderately resistant, whereas the other cultivars are highly resistant to *M. incognita*.

Experiment 2. Data from experiments 2a and 2b could not be compared directly because nematode reproduction differed in magnitude. Greater reproduction occurred in the test of P3Kollo and Zongo than in the test of Gwagwa and SoSat-C88. Therefore, reactions between pearl millet populations can be compared only relative to the HGM-100 and TifGrain 102 controls. In each cultivar, the progeny varied from

Fig. 2. Reproduction of *Meloidogyne incognita* race 3 on randomly selected S_1 progeny of four pearl millet cultivars from West Africa, evaluated in two greenhouse trials. P3Kollo and Zongo were grown in fall 2003, and Gwagwa and SoSat-C88 were grown in spring 2004. TifGrain 102 (TG) and HGM-100 (HGM) are the resistant and susceptible controls, respectively. Selections to the left of the dotted line differ from HGM-100 ($P \leq 0.05$). None of the resistant selections were more resistant than TifGrain 102.

highly resistant (<10% the reproduction on HGM-100) to susceptible (reproduction similar to HGM-100) (Fig. 2).

The distribution of nematode reproduction in S₁ progeny varied among P3Kollo, Zongo, Gwagwa, and SoSat-C88 (Fig. 2). P3Kollo progeny exhibited a continuum of

reproduction from low (resistant) to high (susceptible). Most of the Zongo progeny were highly resistant, and only a few progeny were susceptible. Averaged across progenies, nematode reproduction was greater ($P = 0.0006$) on P3Kollo (11,449 eggs/g of root) than on Zongo (5,134

eggs/g of root). Gwagwa contained a greater number of susceptible genotypes than did SoSat-C88. Averaged across progenies, nematode reproduction was greater ($P = 0.02$) on Gwagwa (2,246 egg/g of root) than on SoSat-C88 (1,252 eggs/g of root). Averaged across progenies, egg production on the four cultivars was less ($P \leq 0.001$) than on HGM-100, but was not different from TifGrain 102.

Discreet resistant and susceptible phenotypes (i.e., no intermediate phenotypes) were identified only in S₁ progeny of Zongo (Fig. 2). Reproduction on Z-85, -87, and -79 were different ($P < 0.05$) from TifGrain 102, and reproduction on the remaining progeny were different from HGM 100. Distinct phenotypic classes of S₁ progeny of the other cultivars were less clear. P3Kollo progenies with reproduction greater than P-25 and less than P-11 were classified as susceptible because they did not differ from HGM-100, but they also were not different from the resistant control TifGrain 102. Gwagwa progeny G-113 and SoSat-C88 progeny S-50 did not differ ($P < 0.05$) from either HGM 100 or TifGrain 102.

The discreet phenotypic classes identified in Zongo allowed an estimate of the number of genes conferring resistance by χ^2 tests. Within the limits of the assumptions identified earlier, the 27R:3S phenotypic segregation in Zongo was consistent with the segregation of two dominant genes ($\chi^2 = 0.399$, $0.50 < P < 0.75$). Estimates for the other cultivars tend to support a one- or two-gene hypothesis; however, phenotypic classes defined by comparison to the resistant and susceptible controls were overlapping. Estimates for P3Kollo are particularly problematic, given the distribution of nematode reproduction for the progeny. This distribution is likely the result of multiple genes with minor effects on nematode reproduction, or major genes that are associated with large environmental variances.

Experiment 3. Nematode reproduction on the S₂ progeny in experiment 3 tended to confirm the results from the S₁ progeny in experiment 2. With a few exceptions, progeny rated as resistant or susceptible in experiment 2 were confirmed as such in experiment 3 (Table 2). Among the 52 progeny lines tested, 7 (P-7, P-12, P-14, Z-67, G-113, G-117, and S-51) exhibited contradictory reactions between experiments 2 and 3. Most of the contradictory results could be explained by segregation within the S₁ progeny for resistance to *M. incognita*. Although the average egg production on P-14, G-113, and G-117 was relatively high in the S₁ (Fig. 2; Table 2), the plant selected for advance to the S₂ exhibited a resistant reaction (i.e., low egg production). In contrast, the average egg production on P-12 and Z-67 was relatively low in the S₁, but the plant selected for advance to the S₂ exhibited a susceptible

Table 2. Reproduction of *Meloidogyne incognita* race 3 on S₁ and S₂ progeny of four pearl millet cultivars from West Africa evaluated in the greenhouse

Cultivar	Progeny selection	Nematode reproduction ^a			S ₂ class ^b
		S ₁ (% HGM-100)	S ₂ (% HGM-100)	S ₂ (eggs/g of root)	
HGM-100	...	...	...	9,502	...
P3Kollo	P-15	0.9	0.4	43	R
P3Kollo	P-17	1.8	0.5	50	R
P3Kollo	P-2	1.2	0.8	79	R
P3Kollo	P-18	7.5	1.0	95	R
P3Kollo	P-3	5.2	1.7	164	R
P3Kollo	P-23	0.3	1.9	185	R
P3Kollo	P-27	3.5	6.6	625	R
P3Kollo	P-13	1.1	8.8	832	R
P3Kollo	P-14	64.4	12.1	1,153	R
P3Kollo	P-28	7.5	12.8	1,212	R
P3Kollo	P-7	82.6	51.0	4,868	R
P3Kollo	P-29	88.8	56.2	5,344	S
P3Kollo	P-12	4.6	83.4	7,922	S
Zongo	Z-69	0.5	0.1	12	R
Zongo	Z-68	0.7	0.2	21	R
Zongo	Z-82	1.2	0.5	52	R
Zongo	Z-66	0.6	0.6	57	R
Zongo	Z-77	0.3	0.9	88	R
Zongo	Z-80	1.9	1.0	99	R
Zongo	Z-78	1.1	1.8	174	R
Zongo	Z-73	0.7	2.3	215	R
Zongo	Z-90	2.3	3.0	280	R
Zongo	Z-67	1.4	48.5	5,756	S
Zongo	Z-87	74.4	71.0	6,750	S
Zongo	Z-85	65.4	72.1	6,853	S
Zongo	Z-79	105.6	118.0	11,215	S
Gwagwa	G-102	1.6	0.3	27	R
Gwagwa	G-116	1.1	0.8	80	R
Gwagwa	G-103	0.9	1.8	172	R
Gwagwa	G-107	1.2	2.0	193	R
Gwagwa	G-117	116.2	7.4	700	R
Gwagwa	G-100	2.9	13.9	1,325	R
Gwagwa	G-114	3.3	17.1	1,626	R
Gwagwa	G-120	9.7	17.7	1,680	R
Gwagwa	G-113	61.1	22.9	2,174	R
Gwagwa	G-118	9.6	28.8	2,735	R
Gwagwa	G-94	1.8	31.4	2,982	R
Gwagwa	G-96	5.6	32.2	3,062	R
Gwagwa	G-115	107.0	188.0	17,866	S
SoSat-C88	S-57	1.7	0.4	34	R
SoSat-C88	S-31	0.8	0.5	50	R
SoSat-C88	S-39	2.8	1.2	111	R
SoSat-C88	S-45	1.8	3.0	285	R
SoSat-C88	S-36	0.5	5.2	496	R
SoSat-C88	S-58	0.5	6.8	641	R
SoSat-C88	S-52	2.5	12.7	1,205	R
SoSat-C88	S-46	1.5	17.3	1,645	R
SoSat-C88	S-55	3.7	19.4	1,845	R
SoSat-C88	S-48	37.6	31.8	3,026	R
SoSat-C88	S-51	3.5	71.6	6,800	S
SoSat-C88	S-59	77.4	145.0	13,775	S
SoSat-C88	S-50	53.7	148.5	14,111	S
TifGrain 102	...	12.1	7.0	665	...
LSD ($P = 0.05$) ^c	...	...	...	4,592	...

^a Data for selected S₁ and corresponding S₂ progenies are expressed relative to nematode reproduction on the susceptible hybrid HGM-100. S₁ progenies were evaluated in experiment 2 and S₂ progenies were evaluated in experiment 3. Hybrid TifGrain 102 was included as the resistant control in each evaluation. Data are the mean of five replications.

^b S₂ phenotype classification: R = resistant S₂ progeny, S = susceptible S₂ progeny. Susceptible phenotypes had nematode reproduction similar to or greater than ($P \leq 0.05$) that of HGM-100.

^c LSD = least significant difference.

ble reaction (i.e., high egg production). The reason for the contradictory results in the remaining two progeny lines was not apparent. Average nematode reproduction was relatively high on P-7 S₁ and S₂ (Table 1). However, because egg production on P-7 S₂ was less than on HGM-100 ($P < 0.05$), it was classified as resistant. Within SoSat-C88, the contradictory reactions for S-51 (Table 2) could not be explained by examining the individual plant data from experiment 2. The discrepancy with S-51 may have been due to environmental conditions in the pots that inhibited nematode survival and root infection, or to misidentification of the seed source.

Heritability of nematode reproduction (standardized as the ratio of the value to HGM-100) as determined by regression of S₂ progeny means on S₁ parent means was calculated to be 0.54. Realized heritability determined by comparison of lines selected for either high or low reproduction was calculated to be 0.87.

DISCUSSION

Each of the 17 African pearl millet cultivars was considered to be more resistant than the susceptible control HGM-100 when evaluated as bulk cultivars in experiment 1. Among the African cultivars, there was a range of responses from highly to moderately resistant, but no pattern was discerned between resistance and country of origin. Some relationships exist among some of these cultivars. SoSank was derived from a cross between SoSat-C88 and Ankoutess. Haïni Kiré was the source of HKP-GMS and was a parent of 3/4HK-B78. Related cultivars did not differ in nematode reproduction when evaluated in S₀ bulks.

A prior study of the diversity and relationships among several African pearl millet lines based upon morphological traits, downy mildew resistance, and yield and yield components found that pearl millet cultivars from Niger clustered together, whereas Iniari, Mansouri, and Ugandi formed a different cluster (10). In our studies, P3Kollo from Niger was more susceptible than most of the other pearl millet from Niger, while Ugandi was more resistant than Mansouri. Neither geographic origin nor relationships determined from the prior study (10) were a good predictor of resistance in our limited samples.

It was possible to select several unrelated cultivars differing in geographic region of importance that also showed a range of nematode reproduction. SoSat-C88 is a recent improved cultivar that is widely grown in Mali, Burkina Faso, Niger, and Nigeria. Gwagwa is a local cultivar grown in Nigeria. Zongo is a local cultivar grown in east Niger. P3Kollo is an older improved cultivar developed by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) that has been grown in Niger.

The data from experiment 2 indicate that the bulk analysis of cultivars in experiment 1 gave a reasonable assessment of the relative level of resistance within cultivars. Zongo was confirmed to be more resistant than P3Kollo, and SoSat-C88 was confirmed to be more resistant than Gwagwa. More detailed evaluation of individual plant selections clearly demonstrated that heterogeneity for resistance to root-knot nematode existed within the four diverse cultivars. Although only four cultivars were chosen for the more detailed evaluation in experiments 2 and 3, they represented the range of observed resistance responses in experiment 1. It is likely that further analysis would reveal similar segregation of resistance and susceptibility among progeny of the other cultivars. The phenotypic class ratios observed in Zongo progeny suggests two dominant genes for resistance. The distributions observed in the other three cultivars require additional research to determine inheritance of resistance.

African pearl millet consists of open-pollinated cultivars that are genetically heterogeneous; therefore, allele frequencies are responsive to selection pressure. Previously evaluated landraces of pearl millet from Burkina Faso were heterogeneous for resistance to foliar diseases (16,17). Resistance to leaf blight (caused by *Pyricularia grisea*) was much more common than resistance to rust (caused by *Puccinia substriata* var. *indica*). Those data suggest that resistance to leaf blight confers some reproductive advantage and is maintained in the populations, whereas little selection pressure exists to maintain rust resistance in the African production setting. Although the importance of both diseases frequently is discounted in West African production settings (9), leaf blight is very common in West Africa, whereas rust is rarely observed (15). Resistance to *M. incognita* was readily identified in the four West African cultivars evaluated, leading us to hypothesize that this nematode exerts a significant selection pressure on pearl millet in West Africa. This scenario could have implications in production of pearl millet as well as in crops grown in rotation or in intercropping systems.

All pearl millet currently grown in Africa consists of open-pollinated cultivars, but research efforts are increasingly working toward the goal of hybrid production (1). When homogeneous hybrid cultivars are available, nematode resistance will be a valuable contribution to yield stability. If any of these pearl millet cultivars are to be used as sources of nematode resistance in the United States or West Africa, it will be necessary to identify specific resistant progeny selections as parents for breeding or hybrid production. Heritability estimates were moderate to high, indicating that data from these controlled studies are

a good predictor of progeny performance, and good progress is expected in selecting for resistance to *M. incognita*.

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