Infection and Morphological Development of *Meloidogyne incognita* in Roots of Susceptible and Resistant Sweet Potato Cultivars

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ABSTRACT

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Root systems of the sweet potato cultivars Centennial (susceptible), Jasper (intermediate-resistant), Jewel (resistant), and the breeding line W-51 (highly resistant) were examined at 4-day intervals to determine the frequency of developmental stages of *Meloidogyne incognita*. The initial rate of juvenile development in Jewel was equivalent to that in Centennial, but the number of juveniles in later developmental stages was reduced. Fewer juveniles entered the roots of Jasper than of Jewel or Centennial, but their subsequent development was similar to that in Centennial. Fewer juveniles entered roots of the breeding line W-51 than those of any of the cultivars, and none of the juveniles reached egg-laying maturity.

Additional key words: *Ipomoea batatas*, resistance, root-knot nematode

The root-knot nematode (*Meloidogyne incognita* (Kofoid & White) Chitwood) seriously reduces both yield and quality of the sweet potato (*Ipomoea batatas* (L.) Lam.). With the establishment of sweet potato breeding programs (7,8,10,16), the development of root-knot-resistant cultivars became an integral part of the root-knot control program.

Root-knot nematodes enter certain susceptible and resistant sweet potatoes in about equal numbers (5). Development of the nematode once it has entered the resistant cultivars is affected by plant genotype and the environment (22,23).

Preexisting factors such as nematode-repelling root exudates, which cause failure of the juvenile to penetrate the roots of certain cultivars (13); induced responses, which include plant hypersensitivity (4,5,9,13); and production of postinfection inhibitory chemicals (13) and failure of juveniles to establish a nutritive relationship once inside the plant (13) are factors that govern nematode resistance in sweet potatoes.

Recently developed sweet potato lines (6) show higher degrees of resistance than cultivars used in previous studies or in commercial sweet potato production. This study was conducted to compare the rate of development of *M. incognita* in three commercial cultivars with one such breeding line.

MATERIALS AND METHODS

The population of *M. incognita* used in this study was a population used in the Louisiana State University sweet potato breeding program. It was identified as *M. incognita* race 1 by the North Carolina Differential Host Test (21) and was maintained on tomatoes (*Lycopersicon esculentum* Mill. cv. Rutgers).

Inoculum was prepared by extracting *M. incognita* eggs from tomato roots 45 days after inoculation with 0.525% sodium hypochlorite for 4 min (12). A sand/soil mix (1:1, v/v) was uniformly infested with 2,500 eggs per 500 cm^3 in 11-cm-diameter clay pots, and one terminal vine cutting of the appropriate sweet potato selection was planted in each pot. Selections used were the cultivars Centennial (susceptible [20]), Jasper (intermediate-resistant [11]), and Jewel (resistant [6]) and the breeding line W-51 (highly-resistant [6]).

Plants were harvested at 4-day intervals for 30 days. *M. incognita* juveniles were extracted from the soil with a semiautomatic elutriator and centrifugal flotation (1,14). Root systems were washed in tap water to remove adhering soil and stained for 1 min in a lactophenol acid fuchsin solution. Roots were rinsed in tap water and destained for 1 min in clear lactophenol, then cut into 6-cm lengths and examined under a stereomicroscope at ×20–30 to determine the numbers of *M. incognita* growth stages as described by Christie (2). The experimental design consisted of a randomized complete block with uninoculated controls for each of the cultivars.

RESULTS

Second-stage *M. incognita* juveniles were first observed in sweet potato roots 8 days after inoculation (Fig. 1). Vermiform juveniles (Christie's class A) entered behind the root cap and established a parasitic relationship near the developing vascular system as previously described (15,21). There were no significant differences in number of class A larvae per root system among cultivars. Several fusiform (class B) juveniles were observed in the three cultivars, but none was observed in W-51.

Twelve days after inoculation, fusiform class B juveniles were observed in all cultivars. Significantly more class A and B juveniles as well as juveniles that had completed all molts and had begun to assume the shape of mature females (class C) were recorded in Jewel.

The rate of juvenile development in Jewel was faster than that in the other cultivars. Sixteen days after inoculation, females in Jewel began to develop the pyriform shape (class D) characteristic of *Meloidogyne* species, whereas class D individuals were not observed in the other cultivars. Centennial and Jewel had significantly more class A and B juveniles than Jasper and W-51. Jewel also had significantly more class C juveniles than the other cultivars. Males were observed coiled inside a few of the juvenile cuticles in Jasper and Jewel.

By 20 days after inoculation, class D juveniles were noted in about equal numbers in the three cultivars; however, class D juveniles were not observed in W-51. Females were gravid, but no eggs were detected outside of the body. The susceptible Centennial had more juveniles in each developmental class, but there were no significant differences among cultivars.

By 24 days after inoculation, females began to produce eggs (class E). Centennial and Jewel had more egg-laying females than Jasper, whereas none was observed in W-51. Jewel had the highest number of class A juveniles. Centennial and Jewel had significantly more class B and C juveniles. There were no significant differences among cultivars in developmental stage D.

By 28 days after inoculation, most *M. incognita* found in the roots were mature egg-laying females. More egg-laying females were found in Centennial than in Jasper or Jewel, and W-51 had none (Table 1). There were no significant differences in the number of juveniles in development stages A, B, and C among cultivars. Centennial and Jewel had more class D females than Jasper or W-51.

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More mature males were found in the roots of Jewel and Jasper than in Centennial or W-51. Males were first detected 24 days after inoculation, and their numbers were greater in each subsequent sample. Centennial had more galls, egg masses, and eggs than Jasper or Jewel, but W-51 had none.

The number of eggs recovered from soil samples decreased at each sampling date for each cultivar, whereas juvenile counts increased at some sampling dates. Individuals observed in roots at 28 days accounted for 85, 56, 66, and 26% of the total population recovered from soil and roots, which was 401, 171, 343, and 43 nematodes for Centennial, Jasper, Jewel, and W-51, respectively.

With the exception of W-51, root growth was less in the inoculated plants than in the control, but there were no significant differences in total root growth among the cultivars.

DISCUSSION

The different sweet potato cultivars affected development of *M. incognita* in different ways. Successive developmental stages of *M. incognita* occurred at about the same time in each of the sweet potato cultivars, and the life cycle of *M. incognita* in both susceptible and resistant cultivars was completed within 24–28 days as reported previously (17,19). The proportion of nematodes developing to maturity was reduced in Jewel, and no juveniles reached maturity in W-51. Few second-stage juveniles penetrated the roots of W-51, and subsequent development of those that had infected the roots was less than that of those that entered the other three cultivars.

More juveniles entered the resistant Jewel than the susceptible Centennial, and development was more rapid in Jewel than in Centennial for the first 20 days. After the 20-day evaluation, there were no differences in the rate of juvenile development between Jewel and Centennial, and the final proportion of females that reached maturity was slightly less in Jewel than in Centennial.

Few juveniles entered the root system of the cultivar Jasper, but the rate of development of the juveniles that did enter Jasper was similar to that of those that entered Centennial and Jewel. Although the total number of juveniles that reached maturity was lower in Jasper than in either Centennial or Jewel, the proportion of developing juveniles that reached maturity was higher in Jasper than in the other cultivars. The reaction of Jasper to *M. incognita* is similar to that reported in the resistant Nemagold sweet potato (13).

Root exudates may have reduced the number of juveniles entering the roots of W-51 and Jasper (13). The inability of the juveniles to reach maturity in W-51 may have resulted from the production of postinfection inhibitory chemicals. The fact that juveniles began initial molts suggests that a nutritive relationship was established initially. Numbers of larvae in the soil around W-51 roots declined throughout the experiment. If inhibitory chemicals were produced, they may have resulted in the death or delay in the maturation process of the juveniles rather than in the exodus of the juveniles from the roots as has been observed in other resistant sweet potato cultivars (13). This would explain why juveniles in various developmental stages, but no mature females, were found. The greatest proportion of juveniles observed was in the early developmental stages in contrast to the statement that resistance may affect the nematode at any stage of its life cycle (23).

Jewel may have exhibited two types of resistance to nematodes. Juveniles may have been unable to continue a nutritive relationship with the plant because of a hypersensitive plant reaction or nutrient deficiency (3,13). The presence of males in the roots, often in necrotic tissue, is characteristic of such a relationship. Resistance also may have been expressed by the production of postinfection inhibitory chemicals (13). This is supported by the decline in the rate of development noted after the 20-day evaluation. Before this sampling date, the number of juveniles in each developmental stage and their rate of development were higher than those in the susceptible Centennial.

Before a crop is grown on nematode-infested soil, two points should be considered: the extent to which the crop will be damaged and yield reduced and the amount of residual soil infestation that will carry over to infect the next crop (2). Use of resistance has been shown to increase yield as well as improve quality of sweet potatoes (18). However, Centennial, Jasper, and Jewel are good hosts for *M. incognita* in that they allowed an increase in population from the initial inoculum. The breeding line W-51 is at best a poor host for *M. incognita* because the final population was lower than the initial population placed on the plants (23). In the future,

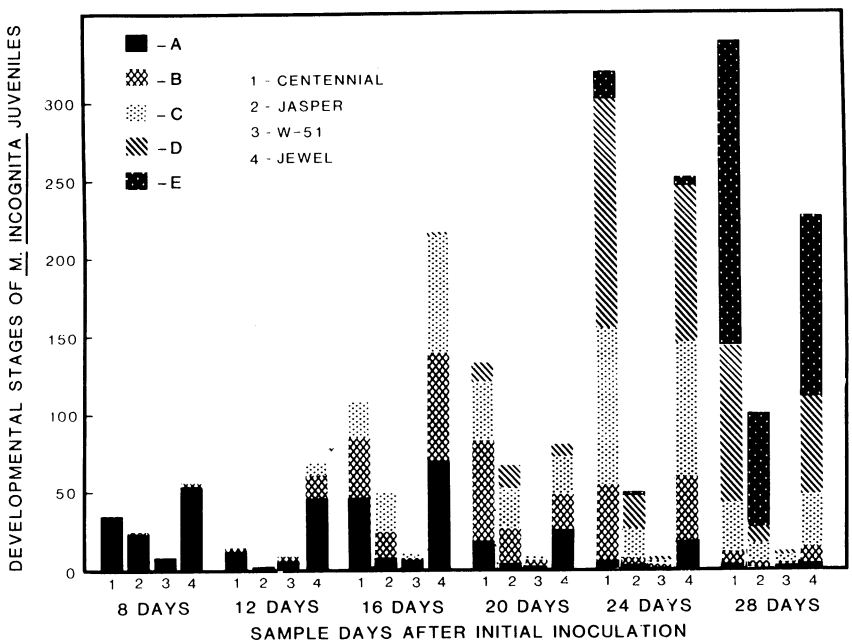

Fig. 1. Histogram of the number of individuals in each of Christie's developmental classes (2) for the selections Centennial (susceptible), Jasper (intermediate-resistant), Jewel (resistant), and W-51 (highly resistant) observed at 4-day intervals from 8 to 28 days after inoculation. Classes: A = vermiform juveniles, B = fusiform juveniles, C = juveniles that completed all molts and began to assume the shape of females, D = pyriform-shaped females, and E = mature females with egg masses.

Table 1. Number of mature females and males, galls, egg masses, and eggs produced by *Meloidogyne incognita* on sweet potato cultivars Centennial, Jasper, Jewel and the breeding line W-51 by 28 days after inoculation

	Number per plant				
Cultivar	**Females**	**Males**	**Galls**	**Egg masses**	**Eggs**
Centennial[a]	197 a[b]	0	98 a	111 a	13,900 a
Jasper	70 b	3	33 bc	50 ab	11,000 ab
Jewel	115 b	18	38 b	46 ab	4,300 bc
W-51	0 b	0	0 c	0 b	0 c

[a] Cultivar means represent the average of four replicates.
[b] Column means followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

sweet potato cultivars should be improved by increasing the level of resistance to *Meloidogyne* spp. to that exhibited by W-51.

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LITERATURE CITED

1. Byrd, D. W., Jr., Barker, K. R., Ferris, H., Nusbaum, C. J., Griffin, W. E., Small, R. H., and Stone, C. A. 1976. Two semiautomatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.
2. Christie, J. R. 1946. Host-parasite relationships of the root-knot nematode, *Heterodera marioni*. II. Some effects of the host on the parasite. Phytopathology 36:340-352.
3. Christie, J. R. 1949. Host-parasite relationships of the root-knot nematodes *Meloidogyne* spp. III. The nature of resistance in plants to root-knot. Proc. Helminthol. Soc. Wash. 16:104-108.
4. Cordner, H. B., Struble, F. B., and Morrison, L. 1954. Breeding sweetpotatoes for resistance to the root-knot nematode. Plant Dis. Rep. (Suppl.) 227:92-93.
5. Dean, J. L., and Struble, F. B. 1953. Resistance and susceptibility to root-knot nematodes in tomato and sweet potato. (Abstr.) Phytopathology 43:290.
6. Dukes, P. D., Jones, A., Cuthbert, F. P., Jr., and Hamilton, M. G. 1978. W-51 root-knot resistant sweet potato germplasm. HortScience 13:201-202.
7. Edmond, J. B., and Ammerman, G. R. 1971. Sweet Potatoes: Production, Processing, Marketing. Avi, Westport, CT. 334 pp.
8. Gentile, A. G., Kimble, K. A., and Hanna, G. C. 1962. Reactions of sweetpotato breeding lines to *Meloidogyne* spp. when inoculated by an improved method. Phytopathology 52:1225-1226.
9. Giamalva, M. J., Martin, W. J., and Hernandez, T. P. 1963. Sweetpotato varietal reaction to species and races of root-knot nematodes. Phytopathology 53:1187-1189.
10. Harmon, S. A., Hammett, H. L., Hernandez, T., and Pope, D. T. 1970. Progress in the breeding and development of new varieties. Pages 8-17 in: Thirty Years of Cooperative Sweet Potato Research 1939-1969. South. Coop. Ser. Bull. 159.
11. Hernandez, T. P., Hernandez, T. P., Constantin, R. J., and Martin, W. J. 1974. Jasper, a soil rot resistant sweet potato variety. La. Agric. Exp. Stn. Circ. 100.
12. Hussey, R. S., and Barker, K. R. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Dis. Rep. 57:1025-1028.
13. Jatala, P., and Russell, C. C. 1972. Nature of sweet potato resistance to *Meloidogyne incognita* and the effects of temperature on parasitism. J. Nematol. 4:1-7.
14. Jenkins, W. R. 1964. A rapid centrifugal flotation technique for separating nematodes from soil. Plant Dis. Rep. 48:692.
15. Krusberg, L. R., and Nielsen, L. W. 1958. Pathogenesis of root-knot nematodes to the Porto Rico variety of sweet-potato. Phytopathology 48:30-39.
16. Kushman, L. J., and Machmer, J. H. 1947. The relative susceptibility of 41 sweet potato varieties, introductions, and seedlings to the root-knot nematode, *Heterodera marioni* (Cornu) Goodey. Proc. Helminthol. Soc. Wash. 14:20-23.
17. Lamberti, F., and Taylor, C. E. 1979. Root-Knot Nematodes (*Meloidogyne* species). Systematics, Biology and Control. Academic Press, London. 477 pp.
18. Lawrence, G. W. 1984. The role of sweet potato resistance in the population dynamics and development of *Meloidogyne incognita*. Ph.D. dissertation. Louisiana State University. 105 pp.
19. Martin, W. J. 1962. Controlling root-knot nematodes in sweet potatoes. La. Agric. 6:6-7.
20. Miller, J. C., Hernandez, T. P., Hernandez, T. P., and Martin, W. J. 1960. Centennial, a new sweet potato variety. La. Agric. Exp. Stn. Circ. 63.
21. Taylor, A. L., and Sasser, J. N. 1978. Biology, Identification, and Control of Root-Knot Nematodes (*Meloidogyne* species). North Carolina State University Graphics. 111 pp.
22. Thorne, G. 1961. Principles of Nematology. McGraw Hill, New York. 553 pp.
23. Wallace, H. R. 1973. Nematode Ecology and Plant Disease. Edward Arnold, London. 228 pp.