Effect and Reproduction of *Rotylenchulus reniformis* on Sweet Potato Selections

C. A. CLARK and V. L. WRIGHT[1]

Abstract: Growth, yield, and quality of 10 sweet potato selections and reproduction of the reniform nematode, *Rotylenchulus reniformis,* were studied in fumigated and nonfumigated plots in a naturally infested field. Nematode reproduction on the different selections in the field was similar to that reported in the greenhouse but was not related to the effect of the nematode on yield of the different selections. Goldrush supported the least reproduction but was the most severely affected by the nematode, while Centennial supported the most reproduction but was the least affected. Although reniform nematode was not found within enlarged fleshy roots, sweet potatoes were more frequently cracked in nonfumigated plots even when nematode populations were relatively low. One selection, P-104, was resistant to cracking. Yield of all selections tested was significantly reduced when initial populations were moderate to high (1,500–10,000 nemas per 500 cm^3). Correlations were made between nematode population parameters and growth, yield, and cracking of the sweet potatoes. The initial populations and the reproduction ratio for the last part of the growing season gave the most significant negative correlations with yield for most selections. *Key words: Ipomoea batatas,* reniform nematode.

Journal of Nematology 15(2):198-203. 1983.

The reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira, has been reported in most of the Southeastern United States and many other subtropical and tropical areas of the world where sweet potatoes *Ipomoea batatas* (L.) Lam. are grown (3,4,10,11). Birchfield and Martin (2) and Martin (15) reported that *R. reniformis* markedly reduced sweet potato yields, and in 1979 Gapasin and Valdez (11) demonstrated that the nematode also reduced quality by causing cracks and distortions in the sweet potatoes. Resistance to the reniform nematode has been found in soybeans, *Glycine max* (L.) Merr., (14,21), and resistance and tolerance have been noted in Irish potatoes, *Solanum tuberosum* L., (18, 19). Martin et al. (16) compared larval populations of the nematode produced on different sweet potato selections in the

Received for publication, 3 March 1981.

[1]Associate Professor, Department of Plant Pathology and Crop Physiology, and Assistant Professor, Department of Experimental Statistics, respectively, Louisiana State University Agricultural Experiment Station, Baton Rouge, LA 70803.

We gratefully acknowledge the assistance of B. Watson, R. Thomas, D. Boniol, D. Mercante, R. Miller, G. Dill, and the advice of K. Koonce. Supported in part by USDA agreement No. 12-14-7001-1155.

greenhouse and found that while significant differences existed among selections, none was highly resistant.

This study was conducted to determine (i) whether the suitability of a sweet potato selection for reproduction of reniform nematode could be related to performance of the selection in infested fields, (ii) whether any of the common sweet potato cultivars have tolerance to the nematode, and (iii) the relationships between reniform nematode population levels, soil fumigation, and yield and quality of different sweet potato cultivars. A preliminary report has been published (8).

MATERIALS AND METHODS

Plots (1.3 × 4.0 m each) were located at the same site each year on an Olivier silt loam (pH 4.0–4.5) in Baton Rouge, Louisiana. The soil was naturally infested with a uniformly distributed population of *R. reniformis*. In 1978 sweet potato selections were randomized within four blocks but fumigated and nonfumigated plots were paired. In 1979 and 1980 all treatments were randomized within each of nine blocks. Plots were fumigated with a fumigun by injecting 86 liters a.i./ha of 1,3-dichloropropene to a depth of 25 cm in rows spaced 30 cm apart. Beds were immediately reformed to a height of 30–35 cm using disc hillers. In 1979 nematode populations surviving fumigation were high, thus granular ethoprop (3.4 kg a.i./ha of O-ethyl S,S-dipropyl phosphorodithioate) was also applied to the soil surface at layby (16 June). Ten terminal vine cuttings were planted in each plot and diphenamid (5.6 kg a.i./ha of N,N-dimethyl-α-phenylbenzeneacetamide) was applied over the top of the rows for weed control. Soil samples were collected from the root zone by taking five cores per plot to a depth of 20 cm. Vine growth was rated 4–6 weeks after planting.

In 1978 plots were fumigated on 6 April and planted and harvested 40 and 155 days later, respectively. Soil samples were collected from each plot on 27 March (initial population = Pi), 3 August (midseason = Pm), and 17 August (final = Pf). In 1979 plots were fumigated on 20 April and planted and harvested 27 and 140 days later, respectively. Soil samples were collected on 10 May (Pi), 17 July (Pm), and 21 August (Pf). In 1980 plots were fumigated on 23 April and planted and harvested 42 and 154 days later, respectively. Soil samples were collected on 26 May (Pi), 28 July (Pm), and 29 August (Pf).

Nematodes were extracted from 250-cm^3 aliquots of each sample with a semiautomatic elutriator. After an elutriation time of 4 min at full air and water pressure, the material retained on the 38-μm sieves was further processed by a centrifugal flotation technique to extract larvae (5,13). Material retained on the 425-μm sieves was extracted as previously described (6,7) to estimate egg populations in the Pm and Pf samples. Samples were then placed in calibrated dishes for identification and counting. Raw data was converted to nematodes per 500 cm^3.

Data were analyzed by aid of the 1979 release of SAS computer procedures (SAS Institute, Cary, North Carolina). The General Linear Models procedure using factorials for cultivar and fumigation treatments was utilized.

RESULTS

Soil moisture and Pi varied considerably from year to year. There was adequate soil moisture for good sweet potato growth in 1978, but in 1979 severe drought conditions persisted during the beginning and middle of the growing season, and in 1980 moderate drought occurred at midseason. In 1978 reniform populations were relatively low (Pi = 660 larvae per 500 cm^3 of soil in nonfumigated [N] plots, and Pf = 1,446 and 3,237 nematodes per 500 cm^3 of soil in fumigated [F] and N plots, respectively) and were thus not included in Table 1. In 1979 Pi was very high (F = 2,896 and N = 9,219). In 1980 Pi was intermediate (F = 94 and N = 1,525). Statistically significant differences ($P < 0.01$) occurred between F and N at Pi, Pm, and Pf. In 1979 and 1980 significant differences also occurred among selections at Pm and Pf, but there was not a significant interaction between fumigation and selection at either sampling date in either year (Table 1). The highest populations occurred at midseason in N plots in 1979 and 1980; the population declined markedly from Pm to Pf. Egg populations

Table 1. Midseason and final populations of reniform nematode in a naturally infested field.

Year	Selection	Total reniform nematodes (larvae + eggs) per 500 cm³ soil*			
		Pm		Pf	
		Fumigated	Nonfumigated	Fumigated	Nonfumigated
1979	Centennial	8,229 a	15,754 b	2,254 a	4,010 a
	Goldrush	6,238 a	5,231 a	3,694 a	3,667 a
	Heartogold	9,243 a	10,790 ab	2,494 a	7,282 bc
	Jasper	8,435 a	14,576 b	2,790 a	3,842 a
	Jewel	4,399 a	8,681 a	4,168 a	8,443 c
	Porto Rico	4,575 a	6,397 a	2,695 a	4,798 ab
	L1-207	6,813 a	8,289 a	2,021 a	5,505 ab
	Travis	4,876 a	5,052 a	1,670 a	3,962 a

Variables	ANOVA F = values (probability levels) Pm	Pf
selections	4.38 ($p < 0.0001$)	2.96 ($p = 0.003$)
fumigation	7.51 ($p = 0.007$)	34.29 ($p < 0.0001$)
selections × fumigation	1.60 ($p = 0.12$)	1.44 ($p = 0.18$)

Year	Selection	Pm Fumigated	Pm Nonfumigated	Pf Fumigated	Pf Nonfumigated
1980	Centennial	13,191 a	32,036 b	4,322 a	7,508 a
	Goldrush	2,690 a	15,518 a	3,547 a	8,473 a
	Heartogold	6,622 a	33,938 b	7,591 a	13,847 bc
	Jasper	5,780 a	27,227 b	2,892 a	8,658 a
	Jewel	12,409 a	26,217 b	6,348 a	7,876 a
	Porto Rico	4,987 a	27,636 b	4,018 a	7,662 a
	L1-207	10,370 a	30,364 b	5,751 a	16,636 c
	Travis	4,560 a	15,991 a	2,174 a	6,617 a
	P-104	4,553 a	13,218 a	4,011 a	9,207 ab

Variables	ANOVA F = values (probability levels) Pm	Pf
selections	5.62 ($p < 0.0001$)	4.34 ($p < 0.001$)
fumigation	137.83 ($p < 0.007$)	46.72 ($p < 0.0001$)
selections × fumigation	1.87 ($p = 0.07$)	1.36 ($p = 0.22$)

*Numbers followed by the same letter in the same column are not significantly different (DMRT P = 0.05).

were 43% for Pm and 19% for Pf of the total populations for the average of all three years.

Yields of the sweet potatoes were highest in 1978 and lowest in 1979. Yields in 1978 did not differ significantly between fumigated and nonfumigated plots, and therefore those data are not included. Yields for 1979 and 1980 are shown in Figure 1. Significant differences occurred among selections for all three years and between F and N for 1979 and 1980. In 1979 and 1980 highly significant ($P < 0.01$) differences in total yield were found for varieties and fumigation. The interaction between varieties and fumigation was significant ($P <$ 0.01) in 1979 but not in 1980 (P = 0.88). The greatest percent gain in yield of fumigated over nonfumigated plots occurred with the cultivar Goldrush, while the smallest percent gain occurred with Centennial and Jewel. In addition, fumigation increased the proportion of U.S. #1 sweet potatoes by a greater amount with Goldrush than with Centennial or Jewel.

Quality was affected not only by the size of individual sweet potatoes but also by the occurrence of cracks (Fig. 2). Most of the cracks appeared to have been initiated early in development, since they were very deep and had healed by forming callus and periderm over the exposed surfaces. In 1978 a significantly higher incidence of cracked sweet potatoes occurred in the N than the F plots and significant differences were found among selections (Table 2). Differences among selections were also significant in 1979 and 1980; the difference between

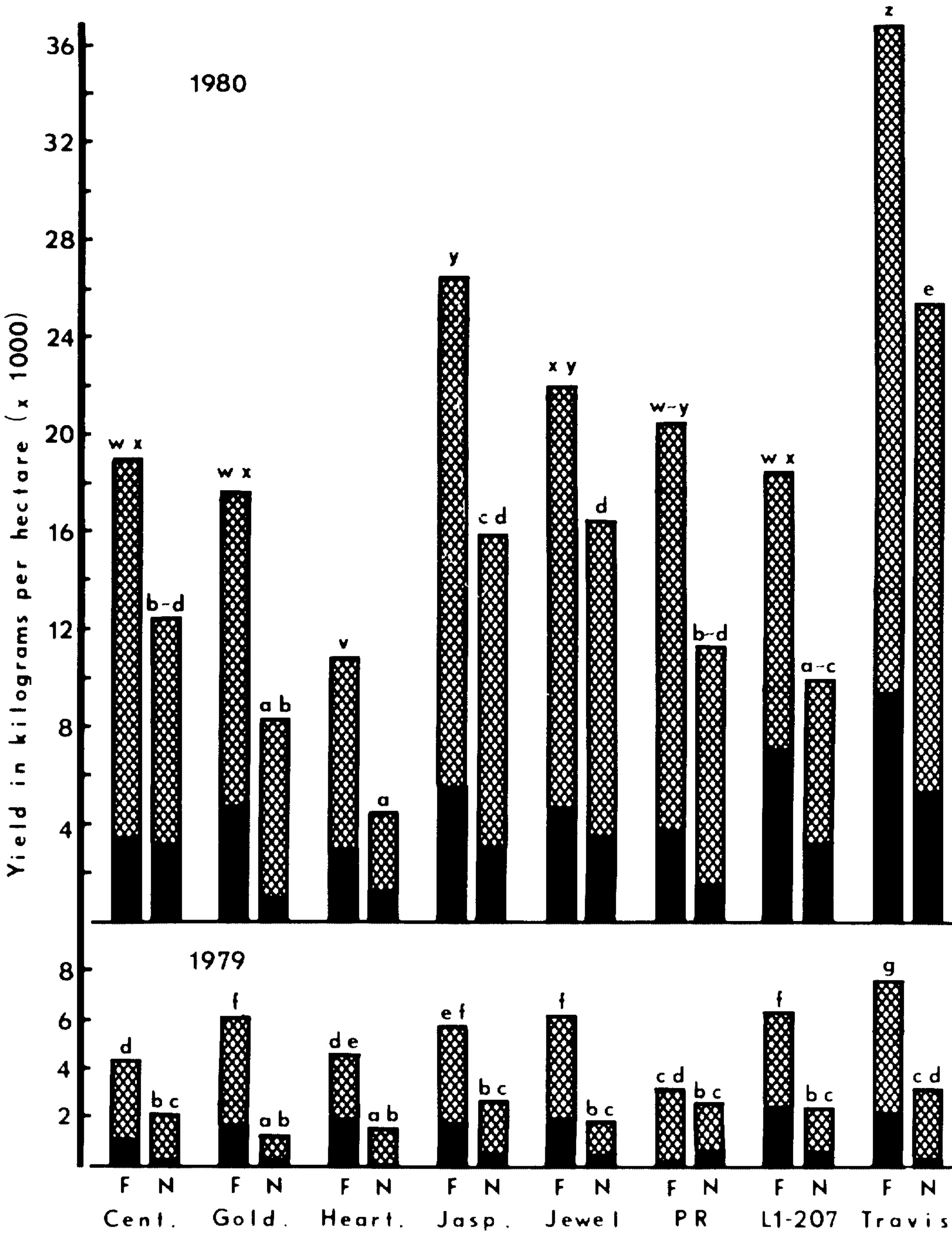

Fig. 1. Yields of sweet potato selections in fumigated and nonfumigated plots in a field naturally infested with the reniform nematode, *Rotylenchulus reniformis,* for 1979 and 1980. Solid portions of bars represent yield of U.S. #1 sweet potatoes and the full bars represent total yields. Total yields for bars for a year with letters in common are not significantly different ($P = 0.05$). For 1980 the letters v-z or a-e compare selections in fumigated or nonfumigated plots, respectively. In 1979 the selection × fumigation interaction was significant and all plots are compared together.

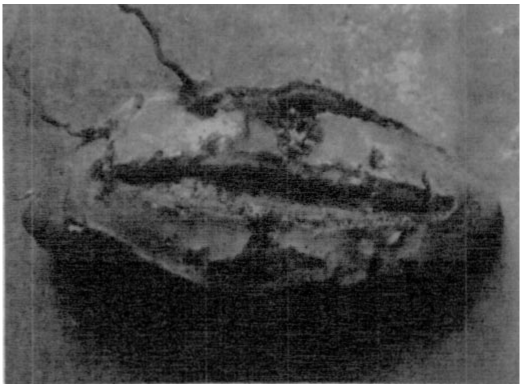

Fig. 2. A sweet potato of the cultivar Goldrush showing cracking characteristic of that which occurred in nonfumigated plots in a field naturally infested with the reniform nematode, *Rotylenchulus reniformis*.

fumigated and nonfumigated was significant in 1980 but not in 1979.

Nematode populations were compared to the different growth and yield parameters by individual selection for 1979 and 1980. Pi was positively correlated with Pm and Pf in 1980 for each selection, but in 1979 it differed among selections and was not significant. The selections Goldrush, Heartogold, Jasper, and L1-207 had a significant negative correlation between Pi and total yield. Porto Rico had a negative correlation between Pm, but not Pi, and yield in 1980. Other correlations between nematode populations and yield were not significant. When the ratios of Pm/Pi, Pf/Pi, or Pf/Pm were compared to yield parameters for all selections combined, Pf/Pm was negatively correlated ($r = -0.29$) in 1980, while in 1979 Pm/Pi was positively correlated ($r = 0.24$) with yield. Pm/Pi was negatively correlated with percent cracked in 1979 but not 1980.

DISCUSSION

Reproduction of *R. reniformis* on different sweet potato selections was similar in the field to that in previous greenhouse studies (16, Clark unpublished data). A high proportion of the total population (19–43%) was in the egg stage, indicating the importance of enumerating both larvae and eggs of the reniform nematode when assessing field populations. The rate of reproduction was apparently dependent on initial population levels. In 1979 when Pi was high, the populations did not increase greatly during the season. In all three years

Table 2. Frequency of cracking of sweet potato selections grown in a field infested with the reniform nematode, *Rotylenchulus reniformis*.

	Percentage of sweet potatoes cracked					
	1978		1979		1980**	
Selection	Fumigated*	Non-fumigated*	Fumigated*	Non-fumigated*	Fumigated	Non-fumigated
Centennial	2 a	9 ab	16 a	7 a	34 de	28 cde
Goldrush	1 a	13 ab	13 a	23 ab	27 cde	50 g
Heartogold	7 a	13 ab	16 a	50 c	28 cde	23 cd
Jasper	0 a	15 b	14 a	22 ab	28 cde	36 def
Jewel	5 a	13 ab	9 a	14 a	33 de	34 de
Porto Rico	4 a	11 ab	37 b	37 bc	39 efg	47 fg
L1-207	1 a	2 a	4 a	9 a	10 ab	17 bc
Travis	1 a	14 b	16 a	16 ab	23 cd	28 cde
P-104	...	...	...	...	1 a	1 a

	ANOVA F — values (probability levels)		
Variables	1978	1979	1980
selections	3.68 ($P = 0.002$)	3.95 ($P < 0.0002$)	18.19 ($P < 0.0001$)
fumigation	35.88 ($P < 0.0001$)	3.31 ($P = 0.07$)	5.21 ($P = 0.024$)
selections × fumigation	1.49 ($P = 0.18$)	1.47 ($P = 0.16$)	2.25 ($P = 0.028$)

*Percentages for selections in the same fumigation treatment (column) followed by the same letter are not significantly different (DMRT, $P = 0.05$).

**Percentages for 1980 followed by the same letter are not significantly different (DMRT, $P = 0.05$). The selection × fumigation interaction was significant.

reproduction was greater when initial populations were reduced by fumigation.

Nematode populations and the proportion in the egg stage declined between the midseason and final sampling dates, especially when Pi and Pm were high. Late in the season sweet potatoes cease production of new absorbing roots (9), and root senescence or nematode induced necrosis (15) may result in reduction in available feeding sites. Such phenomena might account for the decline of reniform populations on sweet potato late in the season. On soybean and cotton, reniform nematode populations remained high through the last part of the growing season and winter (3).

The effect of reniform nematodes on growth and yield of the different sweet potato selections studied was not related to their suitability for reproduction of the nematode. In fact, Goldrush which supported the least reproduction was the most severely affected in the field, while Centennial which supported the greatest reproduction was the least severely affected. This relationship is similar to that reported for the reniform nematode on Irish potato (18). The sensitivity of Goldrush to the reniform nematode may result in a greatly reduced root system with fewer feeding sites and a corresponding decrease in the reproduction of the nematode.

Sweet potatoes are known to crack in response to several factors including root-knot nematode (*Meloidogyne* spp.), sudden rapid growth, or sudden exposure to cool temperatures at harvest. These were not significant factors in the present study, yet high incidences of cracking were observed and significantly more occurred in the nonfumigated plots in two of the three years. Development of reniform nematode on sweet potato differs from that of root-knot in that it apparently does not develop on the fleshy storage roots after they have enlarged beyond a diameter of approximately 5–10 mm (1). Until the report of Gapasin and Valdez (11), it was presumed that because the nematode did not feed on enlarged fleshy roots, it did not cause cracking (15). This report also suggests that reniform nematode causes cracking of sweet potatoes under field conditions. This has been confirmed in artificially infested field plots (20). The nature of the cracks was qualitatively different from that associated with other causes. Reniform nematode-induced cracks were deeper, the exposed surfaces were healed over by formation of callus and periderm, and no larvae or adults were found on or within cracked sweet potatoes. Selection P-104 was resistant to cracking.

Sweet potato yields were most negatively correlated with initial population densities for most selections and with reniform nematode reproduction late in the season (Pf/Pm). This is in general agreement with the observations of Birchfield and Martin (2). Nematode reproduction early in the 1979 season was positively correlated with yield parameters. High Pi levels greatly reduced early vegetative growth which in turn may have reduced the ability of the plants to support reproduction of the nematode.

Growth of the sweet potato plant has been divided into three phases: (i) initial growth of vines and absorbing roots only; (ii) an intermediate phase consisting of growth of the vines, absorbing roots, and initial development of the fleshy roots; and (iii) a final phase consisting of rapid development of the fleshy roots (9). The reniform nematode is known to have a "root pruning" effect on sweet potatoes (15), and thus the negative correlation between Pi and yield is probably a direct result of a reduction in the absorbing root system in the initial and intermediate phases of growth of the sweet potato. However, such an effect would not explain the negative correlation between Pf/Pm and yield. The nematode may impair function of the existing absorbing root system late in the season, or it may interfere with translocation of photosynthate to the developing fleshy roots. A "metabolic sink" effect has been demonstrated for root-knot nematode in which the nematode induces an enhanced accumulation of photosynthates at its feeding sites (17). Such an effect, although never demonstrated for *R. reniformis,* might mean that the nematode would actually compete with the fleshy roots for photosynthate produced in the vines in the final phase of growth. A mechanism of this nature might also explain one way in which reniform nematode could reduce the sucrose content of cantaloupe (12).

Data presented in this study cannot be used to accurately estimate thresholds; however, two observations should be noted. First, cracking occurred in 1978 when Pi was low and no effect on yield was noted; when Pi was high in 1979 and 1980, incidence of cracking was high in both F and N plots. This suggests that the population level necessary for cracking may be very low and is probably less than that for yield reduction. Second, in 1979 and 1980 the yields were low in both F and N. The reniform nematode populations surviving fumigation in this natural infestation may be sufficient to reduce yield. Thus, it may be necessary to use both resistance or tolerance and chemicals to adequately control reniform nematode on sweet potato. Unfortunately, none of the sweet potato selections yet tested is sufficiently resistant or tolerant to offset effects of the reniform nematode under field conditions.

LITERATURE CITED

1. Birchfield, W. 1972. Differences in host-cell response to the reniform nematode. Phytopathology 62:747 (Abstr.).

2. Birchfield, W., and W. J. Martin. 1965. Effects of reniform nematode populations on sweet potato yields. Phytopathology 55:497 (Abstr.).

3. Bird, G. W., J. L. Crawford, and N. E. McGlohon. 1973. Distribution, frequency of occurrence, and population dynamics of Rotylenchulus reniformis in Georgia. Plant Dis. Rept. 57:399-401.

4. Braithwaite, C. W. D. 1977. The response of sweet potato to nematode infection. Newsletter Internat. Soc. Trop. Root Crops No. 10:32-38.

5. Byrd, D. W., Jr., K. R. Barker, H. Ferris, C. J. Nusbaum, W. E. Griffin, R. H. Small, and C. Stone. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. J. Nematol. 8:206-212.

6. Byrd, D. W., Jr., H. Ferris, and C. J. Nusbaum. 1972. A method for estimating numbers of eggs of Meloidogyne spp. in soil J. Nematol. 4:266-269.

7. Clark, C. A., and R. J. Thomas. 1979. Extraction of reniform nematode eggs for inoculum or estimation of field populations. Phytopathology 69: 526 (Abstr.).

8. Clark, C. A., V. L. Wright, and R. L. Miller. 1980. Reaction of some sweet potato selections to the reniform nematode, Rotylenchulus reniformis. J. Nematol. 12:218 (Abstr.).

9. Edmond, J. B., and G. R. Ammerman. 1971. Sweet potatoes: Production, processing, marketing. AVI Publishing Co. Inc. Westport, Connecticut.

10. Fassuliotus, G., and G. J. Rau. 1967. The reniform nematode in South Carolina. Plant Dis. Rept. 51:557.

11. Gapasin, R. M., and R. B. Valdez. 1979. Pathogenicity of Meloidogyne spp. and Rotylenchulus reniformis on sweet potato. Ann. Trop. Res. 1:20-26.

12. Heald, C. M. 1980. Effect of reniform nematode on cantaloup yields. Plant Disease 64:282-283.

13. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Rept. 48:692.

14. Lim, B. K., and M. B. Castillo. 1979. Screening soybeans for resistance to reniform nematode disease in the Philippines. J. Nematol. 11:275-282.

15. Martin. W. J. 1960. The reniform nematode may be a serious pest of the sweet potato. Plant Dis. Rept. 44:216.

16. Martin, W. J., W. Birchfield, and T. P. Hernandez. 1966. Sweet potato varietal reaction to the reniform nematode. Plant Dis. Rept. 50:500-502.

17. McClure, M. A. 1977. Meloidogyne incognita: A metabolic sink. J. Nematol. 9:88-90.

18. Rebois, R. V., B. J. Eldridge, and R. E. Webb. 1978. Rotylenchulus reniformis parasitism of potatoes and its effect on yields. Plant Dis. Rept. 62:520-523.

19. Rebois, R. V., R. E. Webb, and B. J. Eldridge. 1977. Reniform nematode, Rotylenchulus reniformis, resistance in potatoes, Solanum tuberosum. Proc. Am. Phytopathol. Soc. 4:218 (Abstr.).

20. Thomas, R. J., and C. A. Clark. 1983. Population dynamics and their concomitant effects on sweet potato of Meloidogyne incognita and Rotylenchulus reniformis. J. Nematol. 15:204-211.

21. Williams, C., D. F. Gilman, D. S. Fontenot, and W. Birchfield. 1979. A rapid technique for screening soybeans for reniform nematode resistance. Plant Dis. Rept. 63:827-829.