Influence of Six Vegetable Cultivars on Reproduction of Meloidogyne javanica[1]

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Abstract: Replicated field and greenhouse experiments were used to evaluate the effect of tomato, cabbage, cucumber, carrot, *Amaranthus hybridus,* and pepper on growth and fecundity of *Meloidogyne* spp., particularly *M. javanica.* In the field tests, tomato, cucumber, and carrot favored population increases of *Meloidogyne* spp., while *Amaranthus,* pepper, and cabbage limited them. Some cropping sequences that included crops from the latter group had a suppressive effect on population growth. Thus, of the 36 cropping sequences that were investigated, the following kept the pests in check: tomato-pepper; tomato-*Amaranthus;* cabbage-pepper; *Amaranthus*-pepper; carrot-cabbage; pepper-pepper; pepper-*Amaranthus;* and *Amaranthus*-pepper. In the greenhouse tests, tomato, cucumber, and carrot had a high number of galls per 50 cm of root, large, conspicuous galls and egg masses, and a high number of larvae per egg mass. Thus, they were highly susceptible. Cabbage and *Amaranthus* were unsuitable hosts as reflected in the absence of galls or a low number per 50 cm of root, small size of galls and egg masses, and few progeny on the subsequent crop of pepper. The length of time required for eggs to hatch on different hosts varied considerably and is thought to be a significant factor in infection of hosts. *Key words:* rotations, pest management.

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Vegetable crop losses caused by plant-parasitic nematodes, particularly the root-knot nematodes, *Meloidogyne* spp., can be extensive (2,5,8) and are a function of pest population densities (3,6). One of the principal means of reducing these losses is growing unfavorable hosts which suppress nematode development and affect populations. Under present East African agricultural conditions, where vegetables are produced by small-scale farmers, crop rotation, or

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crop rotation in conjunction with other cultural control measures, is apparently the most practical method of nematode management. Local data to support a breeding program for resistance are lacking, and inexpensive nematicides are not readily available. However, efficient use of crop rotation depends on understanding the host-parasite relationship between the noxious nematode species and the host plants to be protected (1).

No data were available concerning the influence of various commonly grown East African vegetables on multiplication of root-knot nematodes, particularly *M. javanica,* the most prevalent pest in the region (10). Field and greenhouse experiments were conducted to gain this information.

MATERIALS AND METHODS

Field experiments: The treatment consisted of six crops (Table 1). In the first season, each treatment was replicated six times in a Latin square design. In the second season, treatments were applied in sequence to the same plots so that each crop grown in the first season had a chance to be followed by each of the six crops. In all, there were 36 treatment combinations.

Each plot measured 2.7 m × 1.5 m and was bordered by an interspace of 0.9 m. Of the four crop rows per plot, the two outer ones served as guard rows. The plots and the interspaces were kept weed free throughout the experimental period. To avoid cross transfer of soil from one plot to the other, only the initial cultivations were done by tractor; hand hoes were used for subsequent cultivations. The crops were managed according to current recommendations (4,11).

Soil samples (100 ml) for nematode examination were taken at five intervals after planting (Table 1). Root samples were taken only at harvest times. Nematodes extracted from soil with the Oostenbrink elutriator and those extracted from roots by the maceration-infiltration technique (7) were counted and identified as to genus under a stereo microscope.

Initial soil populations of root-knot nematodes were bioassayed at the start of each season. Composite soil samples, taken from each plot, were put in 15-cm plastic pots in the greenhouse and two indicator plants (*Citrullus vulgaris*) planted in each pot. The plants were examined for root-knot infection after 60 days. The degree of root-knot attack in both field and greenhouse plants was estimated, using a scale of 0–4, with 0 = no galls observed on the root system, 1 = 1–25% of root system infected, and 4 = 76–100% infected. The experiment was based at the National Horticulture Research Station, Thika, Kenya.

Table 1. Influence of host on soil populations of *Meloidogyne* species.*

Host	Nematode counts† at specified sampling dates (season I) in 1977				
	27 Jan	10 Feb	3 Mar	23 Mar	14 Apr
Tomato *Lycopersicon esculentum* Mill. cv. Moneymaker	8	19	304	1,346	777
Pepper *Capsicum frutescens* cv. Yolo Wonder	1	4	22	165	126
Cabbage *Brassica oleracea* var. *capitata* L. cv. Drumhead	17	16	61	213	195
Carrot *Daucus carota* L. var. *sativa* DC. cv. Chanteney	13	11	4	22	139
Cucumber *Cucumis sativus* L. cv. Ashley	9	11	115	269	322
Amaranthus *Amaranthus hybridus* L. var. *incurvatus*	4	9	29	75	3

*Populations of larvae and males.

†Each figure is the sum of six composite samples (100 ml soil/sample), each made up of five subsamples.

Greenhouse studies: M. javanica, found to be the most important pest in the preliminary field studies, and the six vegetable cultivars used in the field trials were used in these studies. Eleven-day-old seedlings in 20-cm plastic pots filled with steam-sterilized soil were inoculated with 0, 10, 1,000, and 10,000 second-stage juveniles of *M. javanica.* Inoculations were made by pipetting standardized nematode suspensions into shallow depressions made in the soil around the base of each seedling. The depressions were then filled with soil and a little water added. Each treatment was replicated five times; the noninoculated seedlings served as controls.

Measurements of infection and reproduction were made 49 days after inoculation. The severity of root infection was determined by taking root-knot indices as described earlier. The number of galls on ten 5-cm pieces of root was also determined. The number of juveniles per egg mass was estimated in the following manner. Varying numbers of light-brown, intact egg masses were removed from host roots with fine forceps. Groups of 10 or fewer egg masses from the same host were placed in separate watch glasses, cleaned with sterile water, and then placed in an incubator maintained at 25 C. Hatched juveniles were withdrawn with a dropper from the watch glass every 24 hours, counted, and discarded. Clean distilled water was then added to the remaining eggs and they were returned to the incubator. This procedure was repeated daily until hatching ceased; however, observations were continued for 7 days as a further check on a possible temporary stop to hatching. No egg masses or galls were found on pepper.

RESULTS

Field experiments: Population densities of *Meloidogyne* species increased in the rhizosphere with the growth of host plants until about harvest time when a decline was observed (Table 1). There were differences in the occurrence and population densities of these nematodes on different crops (Tables 1, 2). Tomato supported the highest nematode population densities both in soil and roots. Cabbage and cucumber also had a favorable influence on population growth. Although carrots exhibited low infection, they generally had small root systems and their swollen root parts were infected inconspicuously.

During the second season, a lengthy

Table 2. The numbers of individuals of *Meloidogyne* spp.* and the root-knot indices associated with six vegetable crops, Thika, Kenya, January–September 1977.

Data recorded†	Season‡	Crop§					
		To.	Pe.	Ca.	Cuc.	Cab.	Am.
%Occurrence in rhizosphere soil	I	80.0	70.0	56.7	63.3	73.3	56.7
	II	46.7	43.3	36.7	33.3	43.3	50.0
Mean nematode count per soil sample	I	81.8	10.6	6.3	24.2	16.7	4.0
	II	3.7	1.9	2.1	8.9	3.8	5.1
Popu'ation in roots	I	47,121	1,249	687	1,286	1,291	804
	II	9,036	213	54	632	83	19
Mean root knot index+	I	1.7	1.3	0.7	1.1	1.3	0.9
(i) greehouse field	I	4.0	0.9	3.9	3.9	2.0	2.1
(ii) greenhouse field	II	1.1	1.6	2.0	2.0	1.3	1.9
	II	3.8	0.6	3.8	3.9	2.2	2.0

*Mixed populations of *Meloidogyne* spp.

†Based on 36 samples per vegetable per season.

‡Season I January–May; II May–September.

§To = tomato, cv. Moneymaker; Ca = carrot, cv. Chanteney; Cab = cabbage, cv. Drumhead; Pe = pepper, cv. Yolo Wonder; Cuc = cucumber, cv. Ashley; Am = Amaranthus.

||Population of juveniles and a few males.

+Scale: 0 = no galls; 1 = 1–25%; 2 = 26–50%; 3 = 51–75%; 4 = 76–100% of the root system infected.

drought adversely affected stands and subsequently plant growth and nematode reproduction. Nevertheless, the level of infection on preferred hosts was high. Highest mean counts of root-knot larvae and males from the rhizosphere were taken from cucumber, *Amaranthus,* and cabbage. However, highest root infections were found in tomato and cucumber; *Amaranthus* had the lowest infection level. Estimates of root-knot indices for the two seasons indicate that mixed populations of *Meloidogyne* spp. were unable to build up on pepper, cabbage, and *Amaranthus.*

Of the 36 different cropping sequences studied, rotations of tomato-*Amaranthus,* tomato-pepper, carrot-cabbage, pepper-pepper, cabbage-pepper, *Amaranthus*-cabbage, pepper-*Amaranthus,* and *Amaranthus*-pepper were most effective in suppressing nematode population increases.

Greenhouse studies: Except in pepper where there was no attack, the level of infection of *M. javanica* in all crops, as assessed by root-knot indices and the number of galls per 50 cm of root, increased with increase in inoculum density (Table 3). Most of the galls were found on primary

Table 3. Effect of host and *Meloidogyne javanica* inoculum levels on root-knot index and gall frequency*

Host	Innoculum level eggs/plant	Root-knot index†	No. of galls per 50 cm of roots	Hatching period (days)‡	Mean no. of juveniles/ egg mass§
Tomato	0	0.0		31	778
cv. Moneymaker	10	0.7	4.2		
	100	2.1	87.6		
	1,000	3.5	81.4		
	10,000	4.0	293		
Cabbage	0	0.0			
cv. Drumhead	10	2.1	35.8	10	43
	100	ND	ND		
	1,000	3.4	48.6		
	10,000	3.0	74.0		
Cucumber	0	0.0	0.0		
cv. Ashley	10	1.0	0.8	106	393
	100	1.4	25.2		
	1,000	2.3	39.4		
	10,000	4.0	165.0		
Carrot	0	0.0	0.0		
cv. Chanteney	10	0.8	2.5	89	325
	100	1.4	31.6		
	1,000	3.0	73.6		
	10,000	3.4	109.2		
Amaranthus	0	0.0	0.0		
	10	0.0	0.0		
	100	1.0	2.3	69	157
	1,000	1.8	38.8		
	10,000	3.7	69.6		
Pepper	0	0.0			
cv. Yolo Wonder	10	0.0			
	100	0.0			
	1,000	0.0			
	10,000	0.0			

*Data on hatching period and number of larvae per egg mass relate to representative specimens from all inoculations.

†Scale: 0 = no galls; 1 = 1–25%; 2 = 26–50%; 3 = 51–75%; 4 = 76–100% of the root system infected.

‡Length of time required for all viable eggs to hatch.

§The following number of egg masses were used: tomato, 50; cabbage, 11; cucumber, 36; carrot, 32; and Amaranthus, 21.

and secondary roots, a possible indication that there was no second-generation attack on most vegetables during the period of investigation. Root systems of tomato showed the highest infection level and those of *Amaranthus,* the least number of galls.

There was variation in the sizes of galls. Galls in tomato, cucumber, and carrot were large and conspicuous and had large egg masses, indicating good reproduction. Those in *Amaranthus* and cabbage were tiny and inconspicuous and had egg masses that were small. Egg masses in cabbage were difficult to find, and the majority of those found did not contain eggs.

Hatching (incubation) period: Some hatching occurred immediately in distilled water, but there was a kind of rhythm: one big hatch was often followed by a small hatch on the following day or two. According to a Kruskal-Wallis test, there was also variation ($P = .05$) in juvenile counts among hosts and in the length of time eggs from different hosts took to hatch. However, on *Amaranthus* and cucumber, and on carrot and tomato, results did not differ significantly.

There was no relationship between clutch size and incubation period ($r = 0.03$). Eggs incubated the least amount of time on tomato and the longest on carrot ($P = 0.01$). Except for cabbage, in which case variability could not be assessed, the other cultivars were intermediate in their effects.

DISCUSSION

Results from field studies indicate that host plants had a dominant influence on the survival and multiplication of root-knot nematodes, particularly under conditions of adequate soil moisture. More nematodes were found on tomato, cucumber, and carrot than on *Amaranthus,* pepper, and cabbage. 'Moneymaker' tomato was comparatively the most susceptible host; population increases of root-knot nematodes on this crop were rapid and persistently high. Root infection as assessed by plant galling was extensive, indicating the high susceptibility of this crop; in contrast, *Amaranthus* supported a low rate of nematode reproduction, demonstrating high resistance. Cropping sequences that included pepper, cabbage, and *Amaranthus* generally had a suppressive effect on root-knot nematodes.

Greenhouse studies indicate that except for pepper, which is not a host of *M. javanica,* the other vegetables differed in their ability to support the growth and reproduction of *M. javanica:* tomato, cucumber and carrot are suitable hosts; cabbage and *Amaranthus,* poor hosts.

It is not clear what factors were responsible for the variations in hatching time of eggs from different hosts. It is possible that the prehatch physiological development of juveniles, accumulation of inhibitors in egg masses as hatching proceeds, clutch size, or temperature were responsible, either singly or in combination, for these variations (9,12). The extensive incubation period of eggs from some hosts presents a potential danger of continuous infection or infection of crops over a long time. Rapid hatching could lead to rapid spread of the pest when weather conditions are suitable; slow hatching could complicate planning of control measures for this nematode.

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