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Influence of Different Crops on the Dimensions of *Meloidogyne arenaria* Isolated from Fig

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ABSTRACT: A more striking effect of crops was observed on the dimensions of adult egg-laying females than on the pre-parasitic larvae and matured eggs of *Meloidogyne arenaria*. Generally, adult egg-laying females particularly from tomato, potato, and tobacco were larger with shorter neck length than those in barley, corn, lettuce, and carrot. The variations in the mean body length and width and neck length were highly significant in most of the crops. The size of matured eggs was also significantly affected by some crops. Those *M. arenaria* reared in carrots produced the smallest eggs (88.4 × 37.5 μm), while the largest eggs (104.3 × 39.9 μm) were produced by the nematodes in figs. Most of the crops had no apparent effect on the body width and stylet length of the larvae that hatched within 24 hours. It was only in the body length, tail length, and esophagus length to the end of the valve in the median bulb that most of the crops had significant influence. It was also shown that the age of pre-parasitic larvae had some effect on the body length but not on the body width, stylet, esophagus, and tail lengths.

Descriptions of root-knot nematode species are mainly based on morphological features and dimensions, as well as the proportions of parts of the nematode body at different stages of development. Systematic nematologists have attempted to emphasize dimensions and proportions of parts of the nematode in separating different species. This is particularly true in using larvae in species diagnosis. For instance, in his proposed key to larvae of *Meloidogyne* spp., Whitehead (1968) mainly used the dimensions of the larvae to separate and define the species of the nematodes. For example, larvae of *M. indica* could be distinguished from larvae of *M. artiellia* in that the former has a mean body length of 415 μm and 17-μm mean tail length whereas the latter has a mean body length of around 336 μm and 22-μm mean tail length. Following this key, however, Mulvey et al. (1975) claimed that larvae of *M. microtyla* which they described as a new species would easily key to *M. incognita*. This may be expected as the degree of variability of those dimensions within and among the species has not yet been established; neither are the factors of environment that influence such variations known and defined.

Goodey (1952) showed that host plants could exert considerable influence on the dimensions of *Ditylenchus destructor* Thorne. In root-knot nematodes, however, the extent of variation in their dimensions due to the influence of host crops and other environmental conditions has not yet been thoroughly investigated. In a previous paper (Davide, 1979), I obtained evidence that the dimensions of this fig isolate of *M. arenaria* not only vary at different stages of development but also vary with the two different host crops tested. It was observed that the adult egg-laying females were relatively bigger or broader in tomato plants than in cucumber plants and, in addition, they also have greater neck length and esophagus length to the end of median bulb.

This study, therefore, was primarily conducted to obtain further information on the effects of various crops on the dimensions of adult egg-laying females, matured eggs, and pre-parasitic larvae of this fig isolate of *M. arenaria*. The effect of age of larvae was also included in the study.

Materials and Methods

Measurements of larvae

Larvae that hatched in water within 24 hr from egg masses taken from adult females in galls of different crops were randomly picked up and mounted on ringed slides with a few drops of water. They were killed gently by heat. The larvae were immediately examined and measured under a calibrated microscope. Measurements of the body length and width, and stylet, esophagus, and tail lengths of 20 random samples of larvae were made from each crop. Since it was difficult to measure the esophagus length to its posterior end, the measurement was made only up to the end of the valve in the median bulb.

To determine the effect of age of larvae on their dimensions, egg masses from adult females in galls of tobacco plants were picked up and placed in hatching dishes with water. After 24 hr, all the larvae that had hatched were pipetted out and placed on a small dish. From these larvae 20 individuals were randomly picked up and mounted on ringed slides with a few drops of water, killed gently by heat, and measured immediately to represent the 24-hr-old treatment. The remaining larvae were then stored in the same dish in the laboratory for subsequent sampling at 48, 72, and 144 hr after hatching. Measurements also were made on the body length and width, and stylet, esophagus, and tail lengths using 20 random samples of larvae in each period of examination.

Measurements of adult females

Adult females that had already laid eggs in egg sacs were used in this study, as it has been shown in another study (Davide, 1979) that at this stage they have already attained the maximum size. They were dissected from gall samples (1 g) taken from each crop 2 months after inoculation. The galls were first fixed in FAA for at least 48 hr, washed in tap water, and stained in boiling acid–fuchsin lactophenol for 2 minutes. They were then kept in vials with clear lactophenol for at least 5 days before the adult egg-laying females were dissected and mounted on ringed slides with a few drops of clear lactophenol. To prevent breakage or distortion of the nematode body, no coverslips were placed over them. From each crop, 20 random samples of adult egg-laying females were examined and measured under a calibrated microscope. Measurements were made only on the body length and width and neck length, as the other parts of the body were not clearly seen on the stained specimens.

Measurements of matured eggs

From the stained galls of different crops, egg masses were removed from adult females. They were placed on ringed slides with a few drops of clear lactophenol. From each crop, 20 random samples of matured eggs were taken and measured for their lengths and widths.

In this study no measurement was made on the males because they were not found in most of the crops.

Table 1. Effects of different crops on the dimensions of about 24-hr-old larvae of *M. arenaria* isolated from fig.

	Larval measurement* (μm)				
Crops	Body length	Body width	Stylet length	Esophagus length†	Tail length
Barley	418.95 b	14.28 a	14.53 ab	65.16 bc	45.5 a
Bean (Dwarf)	410.9 a	14.16 a	14.35 a	61.68 ab	48.7 b
Cauliflower	438.6 c	14.61 a	14.61 ab	68.78 d	52.5 c
Corn	407.4 a	14.96 ab	14.44 a	61.43 a	45.1 a
Cucumber	409.8 a	14.97 ab	14.88 ab	66.01 c	51.92 c
Fig (Weeping)	408.8 a	14.70 ab	14.70 ab	62.38 ab	50.4 bc
Lettuce	406.0 a	15.23 b	14.53 ab	62.29 ab	49.48 b
Potato	410.2 a	14.70 ab	14.53 ab	63.29 b	51.19 bcd
Radish	438.5 c	14.61 a	14.44 a	67.03 c	50.58 bc
Spinach	428.4 bc	14.53 a	14.70 ab	64.05 bc	48.83 b
Soybean	423.8 b	15.45 b	15.25 b	66.24 c	50.23 bc
Tobacco	410.0 a	15.17 b	15.00 b	62.56 ab	51.89 c
Tomato	445.2 c	15.49 b	15.14 b	66.50 c	54.43 d
Turnip	434.3 bc	14.82 ab	14.70 ab	67.11 cd	51.89 c
Watermelon	420.0 ab	15.23 b	15.05 b	65.27 c	49.52 b
Wheat	428.6 b	14.88 a	14.56 ab	62.74 ab	48.91 b

* Data are means of 20 random samples of the nematode larvae. Means followed by the same letter within each column are not significantly different at $P = 0.05$.

† Measured to the end of the median valve.

Results

Measurements of 24-hr-old larvae from different crops

As shown in the results summarized in Table 1, it is evident that the 16 different crops tested had some significant effects on the dimensions of the larvae that hatched within 24 hr. Statistical analysis of the data using Student's t-test indicated that a great number of the crops gave a highly significant difference in the mean body length, esophagus length to the end of the median valve, and tail length. However, only very few of the crops had any significant influence on the body width and stylet length.

Effect of age of larvae

It is evident from the results presented in Table 2 that the age of larvae had significant influence only on the body length. It did not affect the body width, or stylet, tail, and esophagus lengths. The mean length of 48-hr-old larvae was about 8 μm greater than that of 24-hr-old larvae, while those 72 and 144 hr old were longer by 17 and 30 μm, respectively. This indicates that there was a continuous lengthwise growth of the larvae in water suspension when kept for several days after hatching.

Measurements of adult egg-laying females and matured eggs

As shown in the data of Table 3, different crops had pronounced effects on the dimensions of adult egg-laying females. Statistical comparison of individual means indicated that a great majority of the crops had significant influence on the body length and width and neck length. However, for matured eggs there were more crops showing significant influence on the length than on the width.

Table 2. Effects of age on the dimensions of pre-parasitic larvae of *M. arenaria* isolated from fig.

Larval age (hr)	Larval measurement* (μm)				
	Body length	Body width	Stylet length	Esophagus length†	Tail length
24	410.0 a‡	15.17	15.0	62.6	51.9
48	417.9 ab	14.96	14.9	61.3	51.9
72	426.6 b	14.61	15.0	64.2	52.8
144	440.2 c	14.61	14.7	62.8	52.7

* Data are means of 20 random samples of the nematode larvae.
† Measured to the end of the median valve.
‡ Means followed by the same letter are not significantly different at $P = 0.05$.

Discussion

The influence of the different crops on the dimensions of the nematodes was more striking on the adult egg-laying females than on the pre-parasitic larvae. This may be due to the fact that these adult females have been in direct contact with the host plants since the time they entered, have been nourished, and have developed to maturity inside the gall tissues, whereas the pre-parasitic larvae have not yet made any direct contact with the plants. It seems, however, that nutrition or the availability of nutrients in the host plants is the main factor that determines the growth and increase in size of the nematode body. It was generally observed that those nematodes in less susceptible crops like barley, corn, and radish were relatively smaller than those in more susceptible crops such as potato, tomato, cucumber, tobacco, and others.

Table 3. Effects of different crops on the dimensions of adult females and eggs of *M. arenaria* isolated from fig.*

Crop	Adult egg-laying female (μm)			Matured eggs (μm)	
	Body length	Body width	Neck length	Length	Width
Barley	468.3 a	283.1 b	211.8 cd	91.0 ab	36.3 a
Bean (Bread)	710.5 de	434.0 deg	193.6 bc	97.8 c	37.4 ab
Bean (Dwarf)	608.3 bc	411.6 de	149.5 ab	91.6 b	39.1 bc
Carrot	602.7 bc	194.8 a	231.0 bcd	88.4 ab	37.5 ab
Cauliflower	602.7 bc	365.7 cd	154.0 ab	92.9 b	40.0 c
Corn	574.0 b	360.7 cd	162.7 a	90.6 ab	39.9 c
Cucumber (Explorer)	691.6 cde	386.1 d	223.3 cd	97.4 c	39.9 c
Cucumber (Long Green)	741.6 e	348.9 cd	241.2 d	99.7 c	38.6 bc
Fig (Weeping)	663.0 cd	335.0 c	212.0 cd	104.3 d	39.9 c
Lettuce	647.2 cd	384.7 d	239.1 cd	90.4 ab	39.1 bc
Potato	725.5 de	438.2 c	191.1 bc	88.4 ab	
Radish	579.6 b	324.8 bc	163.1 ab	98.0 c	38.1 b
Spinach	709.4 de	429.1 c	201.9 c	97.3 c	38.5 bc
Tobacco	692.6 de	526.7 f	143.5 a	90.0 ab	39.3 c
Tomato	711.5 de	479.5 g	194.6 b	94.7 bc	39.5 c
Turnip	684.6 d	441.5 eg	170.5 b	94.9 bc	38.4 bc
Watermelon	700.2 de	386.7 d	243.5 d	90.0 ab	38.4 bc
Wheat	637.0 c	360.3 cd	186.9 b	92.2 b	38.8 bc

* Data are means of 20 random samples of adult egg-laying females and matured eggs of the nematode. Means followed by the same letter within each column are not significantly different at $P = 0.05$.

From the taxonomic point of view, this wide variation in body length and width of adult females as influenced by the host crops would certainly affect the usefulness of these parts in species diagnosis. I fully support the view of Esser et al. (1976) that body length of adult females as well as alpha measurements be rejected as criteria in species diagnosis.

Therefore, in considering the dimensions and body ratios as criteria in specific descriptions of root-knot nematodes, it may be important to specify the host plants and other environmental conditions to which the nematodes were subjected prior to their diagnosis. This is, in effect, emphasizing Goodey's (1952) statement that systematic nematologists should adopt what is essentially an ecological attitude in studying nematode behavior and the reaction of their host, as well as their appearance.

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