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Spatial-temporal Patterns of *Meloidogyne konaensis* on Coffee in Hawaii[1]

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Abstract: Population densities of *Meloidogyne konaensis* were determined in March and July of 1991 and 1992 on coffee cultivars Guatemalan and 502, and on four rootstocks (Purpuree, Congensis, Deweveri, and Kaffe) with Guatemalan or 502 as a scion. Three-dimensional spatial patterns were characterized on roots of Guatemalan and Deweveri. Population densities differed among rootstocks ($P < 0.05$) and times ($P < 0.01$). The greatest number of second-stage juveniles (J2) occurred on Guatemalan and fewest J2 on Purpuree and Deweveri rootstocks. More nematodes were found in March than in July of both years. The spatial distribution varied by positions and depths on Guatemalan. The highest nematode population density occurred at 60 cm from the base of the tree and 15–45 cm deep. Numbers of nematodes were relatively low at all positions and all depths on the Guatemalan–Deweveri combination.

Key words: coffee arabica, coffee, ecology, Kona coffee root-knot nematode, *Meloidogyne konaensis,* nematode, population distribution.

Meloidogyne konaensis Eisenback, Bernard, and Schmitt is a newly described nematode from coffee in Hawaii (6). This nematode infects and damages several coffee cultivars (13). The general relationships between initial population (Pi) densities of *M. konaensis* eggs and coffee growth have been determined (13); however, to improve predictive capabilities and understanding of the *M. konaensis*–coffee relationship, more data are needed on the temporal and spatial fluctuations of *M. konaensis* populations. Understanding *M. konaensis* population dynamics in the coffee agroecosystem should aid in the development of guidelines for the selection and timing of management inputs.

Root-knot nematodes are the most economically important plant-parasitic nematodes in the world (12), causing damage to a wide variety of crops, including coffee (*Coffea* L.) (4). Studies of the spatial and temporal distribution of *Meloidogyne* spp. were used to develop a simulation model for the development of these nematodes in grapes (7). Similar information could be used to improve sampling methods and experimental designs in coffee. The objectives of this study were to determine the temporal and spatial distribution and population fluctuations of *M. konaensis* in a naturally infested coffee field.

Materials and Methods

A coffee field located at the Kona Experiment Station, Kealakekua, Hawaii, was selected for this research. The field is at an elevation of 450 m, with annual soil temperatures ranging from 15–32 C (daily mean of 25 C). The field was planted in 1989 with eight combinations of two coffee scions (502 and Guatemalan) on four rootstocks (Purpuree, Congensis, Deweveri, and Kaffe), and cultivars 502 and Guatemalan for a total of 10 treatments. These rootstocks were selected for this study because of their resistance reaction in previous trials (P. Ito, pers. comm.). Five trees of each treatment, spaced 2 m apart, were planted in a single row in the center of each plot with 20 trees in most rows. Rows were spaced 3.5 m apart. Treatments were arranged in a randomized complete block design with four replications.

Temporal distribution: Temporal changes in population densities of *M. konaensis* were followed on all 10 cultivar, stock, and scion treatments from 1991 to 1992. The

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trees were 2 years old when this study was initiated and 3 years old when the tree shoots were cut off, leaving only a stump. New shoots began to grow within a few days. Ten soil cores (each 2.5-cm-d × 15 cm deep and two cores/tree) were collected and composited from the dripline of the coffee trees from each replication. Soil samples were collected in March and July of 1991 and 1992. Each sample was sieved through a screen with 3.75-mm openings. Nematodes were extracted from a 250-cm^3 subsample of each replication by a combination of elutriation (3) and centrifugal flotation (8).

Spatial distribution: The spatial distribution pattern of *M. konaensis* was determined on cultivar Guatemalan and on Guatemalan scion-Deweveri rootstock in 1992. Tree stocks were 3.5 years old when this study began, and new shoots had developed from the stumps. Samples were collected in November 1992 and in March, June, and September 1993. Soil cores (5-cm-d) were collected with a soil bucket auger from three horizontal positions (20, 40, and 60 cm from the trunk) and three vertical depths (0–15, 15–30, and 30–45 cm) from opposite sides of a tree, with three replicate trees from each treatment. From each sample, 250 cm^3 soil was placed into a plastic beaker and immersed in tap water for 24 hours before nematodes were extracted by elutriation (3) and centrifugal flotation (8).

Data analysis: All data were subjected to analysis of variance. Population data for temporal distribution were analyzed by rootstocks, cultivars, scions, times, and interactions using a repeated-times-measurement analysis. Means were compared by Waller-Duncan k ratio *t*-test. Population patterns for spatial distribution were analyzed by position, depth, cultivar, and rootstock. Nematode count data were $\log_{10}(N + 1)$ transformed where N = number of J2 of *M. konaensis*. Antilogs were used for graphic presentations.

Results

Temporal distribution: The temporal pattern of *M. konaensis* J2 in the upper 15 cm of soil in the coffee field varied among rootstocks and times, but not ($P < 0.05$) between scions 502 and Guatemalan. The population density of J2 in the soil was more abundant initially (when trees were 2 years old) on Guatemalan and 502 than on any of the rootstock–scion combinations (Fig. 1). The mean numbers of J2 were different among cultivars and rootstocks ($P \leq 0.05$). The nematode population density increased from March to July in 1991 on Kaffe stock, Guatemalan–Congensis, and 502–Deweveri, but decreased or changed only slightly on all other scion–stock combinations or cultivars. Population densities peaked in March 1992 in all treatments except Deweveri–502, then declined to barely detectable levels by July 1992 (following the removal of shoots in March 1992).

Rootstock influenced the population density of the nematode ($P < 0.05$). The greatest nematode population (570 J2/250 cm^3 soil in March 1992) was found on cultivar Guatemalan and the lowest number occurred on the Purpuree stock. Deweveri stock was also effective in suppressing numbers of this nematode (Fig. 1). Nematode numbers were not different between scions and interactions within stocks and scions ($P < 0.05$).

Spatial distribution: The spatial population distribution of *M. konaensis* J2 was related to horizontal and vertical distance from the base of the coffee tree (Fig. 2). The J2 population densities and frequencies of occurrence were greater at 60 cm than at 20 or 40 cm from the trunk ($P \leq 0.05$). More nematodes occurred at depths of 15–45 cm than at 0–15 cm ($P \leq 0.01$) on cultivar Guatemalan. The depth and distance interactions were not significant for population density of J2. The population densities were also not different ($P < 0.05$) among positions and depths on Guatemalan–Deweveri (Fig. 2). The means of dry root weights from the samples were different ($P < 0.05$) among depths and distances (data not shown). More roots were present at 60 cm from the trunk and at 15–45 cm depth than at 20 and 40 cm from the trunk and at the 0–15 cm depth. Root weights

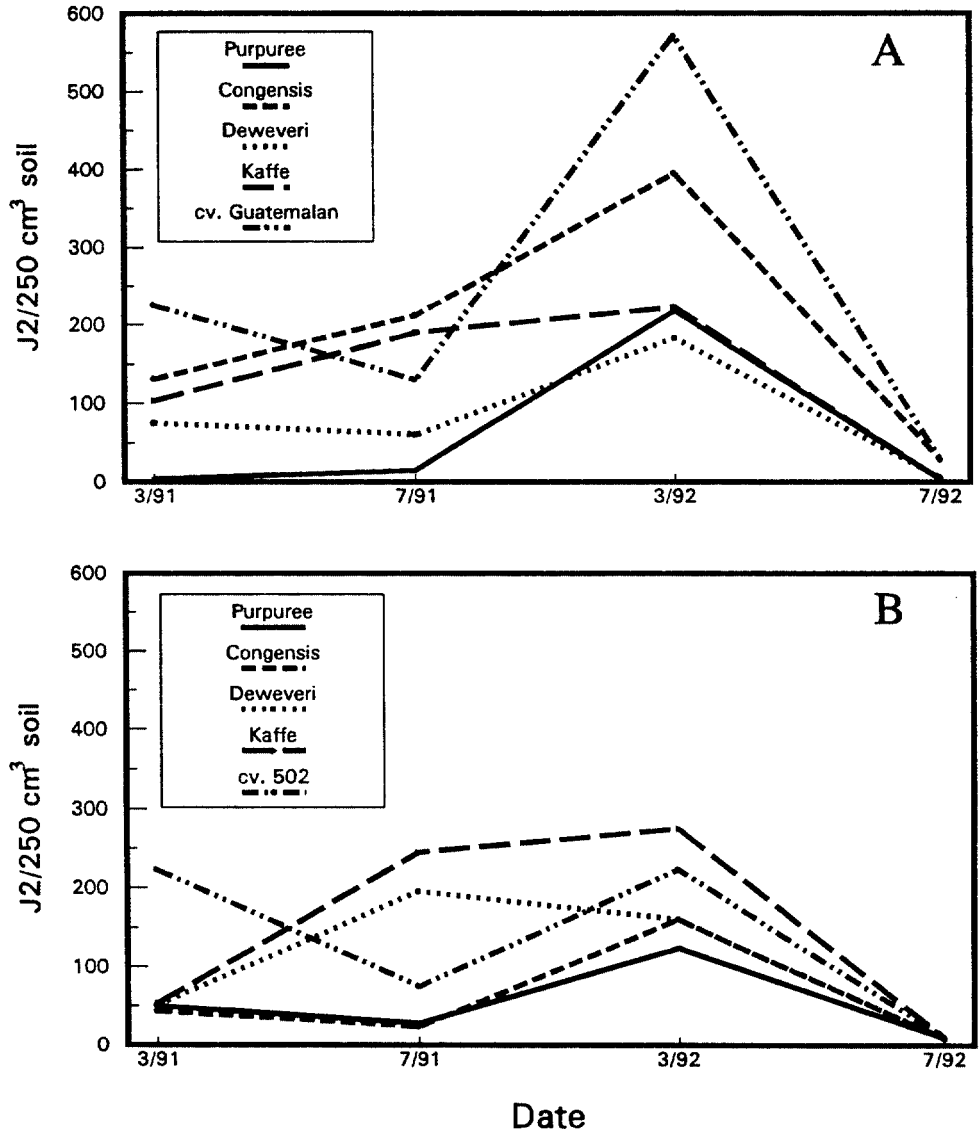

FIG. 1. Population changes of *Meloidogyne konaensis* on cultivars 502, Guatemalan, and 502 and Guatemalan scions on four rootstocks. A) Guatemalan scion and B) 502 scion. Data are means of four replications.

were three times higher in March than in June, September, and November.

DISCUSSION

Nematode population density and distribution in the soil can be influenced by many factors, such as initial population density (1); plant species (9,11); crop management strategies (5); soil structure, depths, and season (10); and environmental conditions (2). *Meloidogyne konaensis* appears to survive and reproduce best below 15 cm deep in the soil and at a distance of 60 cm from the trunk. This area corresponded to the dripline of the tree. The area with more roots, especially more new roots, would be most favorable for new infection and reproduction of the nematode. The soil moisture and temperature are more stable at this depth and may be the reason for the higher nematode population density.

The coffee cultivar Guatemalan is susceptible to several species of *Meloidogyne* and was the best host for this nematode's

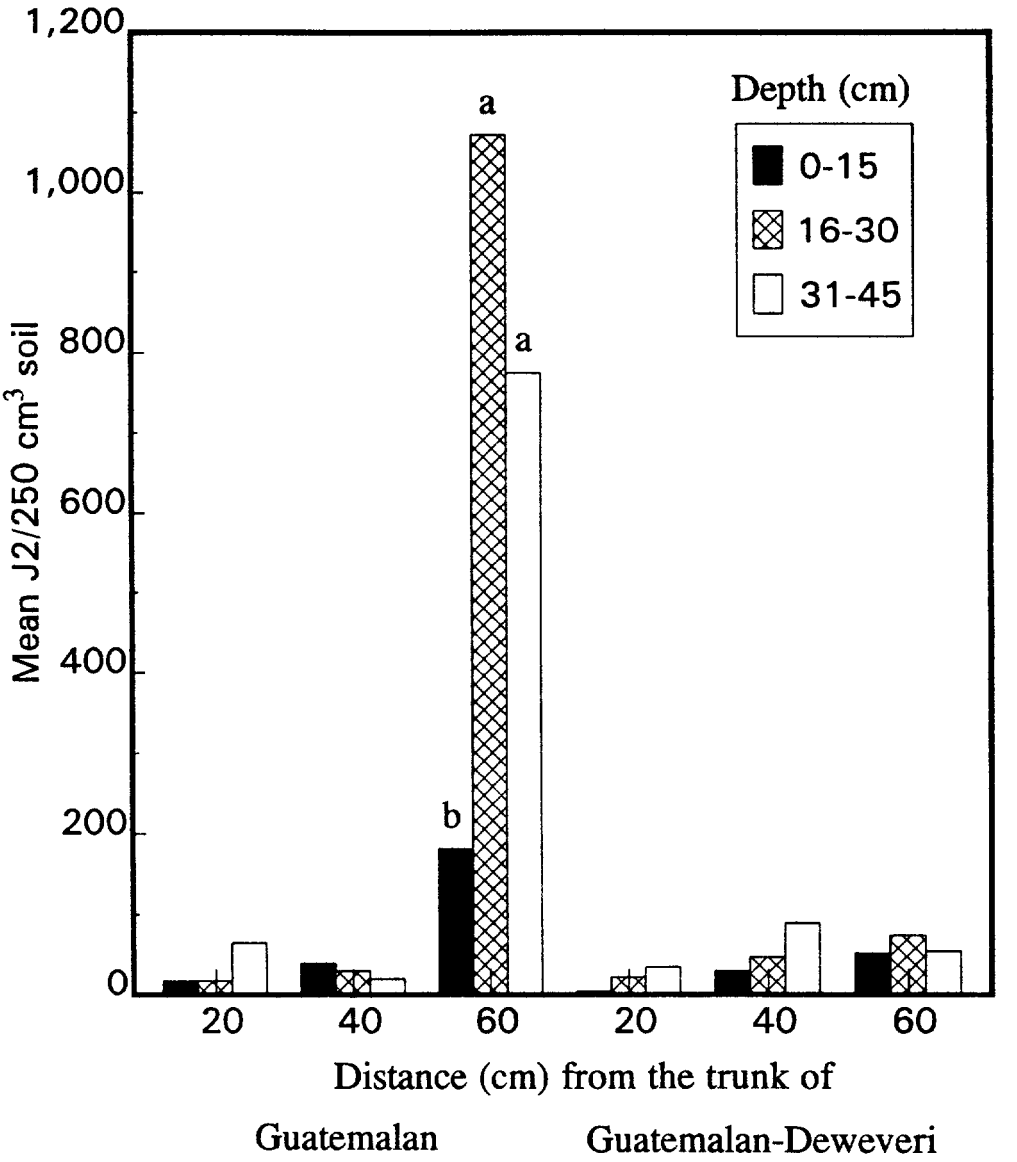

FIG. 2. Population density of *Meloidogyne konaensis* at different positions and depths on Guatemalan and Guatemalan–Deweveri coffee. Data are means of 12 observations (2 sides × 3 replications × 2 times). Bars with the same letter are not significantly different ($P < 0.05$).

reproduction. Rootstocks had different responses to *M. konaensis* in this study. Lower mean numbers of J2 in treatments 502–Purpuree, Guatemalan–Purpuree, Guatemalan–Deweveri, and 502–Congensis than those of the other treatments implies that these rootstock–scion combinations are poor for reproduction of *M. konaensis*. Rootstock Purpuree on both scions and Deweveri on Guatemalan scion, because they suppressed reproduction of *M. konaensis* most, should be evaluated further.

Soil temperature and moisture were important factors influencing changes in population densities of *M. konaensis* throughout the 2 years of this study. Soil temperatures averaged 30 C from July to October 1991 and 22 C from November 1991 to March 1992. The soil was dry from July to October 1991 and was relatively

moist from November 1991 to March 1992. According to the life history of this nematode (13), lowest mortality and highest percentage hatching occurs at 24 C. Thus, conditions were favorable for this nematode's reproduction, accounting for the highest level in March 1992. Roots in soil samples were more abundant from November to March, indicating better conditions for plant growth. This additional source of food probably enhanced the nematode population level. The sharp decline in July 1992 populations was likely due to dry, hot conditions and removal of the tree's shoots. All of these factors would reduce or even stop root growth and be unfavorable to the nematode, thereby reducing the population densities during this period.

The knowledge about the distribution and fluctuation in *M. konaensis* populations has enabled us to modify sampling procedures for this nematode on coffee. It should also be useful in determining placement of nematicides.

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