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AN ECOLOGICAL STUDY OF A NEMATODE COMPLEX IN A FLORIDA CITRUS GROVE

by

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Many known and potential plant-parasitic nematode genera and species other than *Tylenchulus semipenetrans* Cobb and *Radopholus similis* (Cobb) Thorne are found singly or as mixed populations in Florida citrus groves (Bistline *et al.*, 1963; DuCharme and Suit, 1954; Feldmesser *et al.*, 1964; Malo, 1961; Suit and DuCharme, 1953; Tarjan, 1973). Some are pathogenic to citrus (Baines *et al.*, 1959; Brooks and Perry, 1967; Cohn and Orion, 1970; Feldmesser and Hannon, 1969; Inserra and Vovlas, 1974; O'Bannon *et al.*, 1976; Standifer and Perry, 1960; Stirling, 1976; Van Gundy, 1958), whereas others are associated in the rhizosphere (DuCharme, 1969).

Probably the most complete nematode survey of Florida citrus groves was that of Malo (1961), who identified 35 genera of stylet-bearing nematodes. The most frequently occurring were *Trichodorus* spp., *Tylenchulus semipenetrans*, *Xiphinema* spp., *Belonolaimus* sp., and *Hoplolaimus* sp. Genera less frequently encountered, but still relatively common in occurrence, were *Pratylenchus* spp., *Hemicycliophora* spp., *Helicotylenchus* sp., *Meloidogyne* spp., *Criconemoides* sp., and *Tylenchorhynchus* sp.

During several years of sampling citrus groves, we have encountered the same nematode species reported by Malo (1961), usually in mixed populations and in moderate-to-low population densities ($<100/200$ cm^3 soil).

The presence of most of these nematode genera in low numbers in the citrus rhizosphere suggests that (i) citrus is a relatively poor or nonhost, (ii) that nematodes may survive on the numerous weed species found in citrus groves, (iii) there are environmental factors within the rhizosphere that suppress nematode populations, or (iv) that dominance or competitiveness exists among mixed nematode populations, tending to suppress population levels.

The presence of ectoparasitic nematodes in citrus groves is rarely apparent in any symptoms in the trees aboveground. The role of the ectoparasitic nematodes in tree decline is difficult to assess and, so far, little is known about the tolerance of citrus to them. A citrus grove naturally infested with an ectoparasitic nematode complex, including *Belonolaimus longicaudatus* Rau, was pulled out and used to evaluate preplant fumigation. Increased tree growth and significantly higher fruit yields were observed for five crop seasons (Bistline *et al.*, 1967). *Pratylenchus brachyurus* (Godfrey) Filipjev *et* Schuurmans-Stekhoven, a migratory endoparasitic nematode, is widespread in Florida citrus (Feldmesser *et al.*, 1956); however, the population density in roots rarely exceeds 100 nematodes per g fresh root-weight, indicating that citrus is a poor host. Results from a chemical control experiment in a citrus grove naturally infested with *P. brachyurus* have shown that nematode control induced a tree response in young trees, whereas mature trees were less severely affected, as damage decreased with plant growth (O'Bannon *et al.*, 1974). This paper reports our findings on seasonal population variation of several nematode genera associated with citrus roots in a 50-year-old established citrus grove.

MATERIALS AND METHODS

Preliminary soil and root samples taken from around 'Valencia' orange [*Citrus sinensis* (L.) Osb.] trees on grapefruit (*C. paradisi* Macf.) rootstock growing in Eustis fine sand (sandy, siliceous, thermic psammentic paleudults), showed populations of *B. longicaudatus, Criconemoides curvatum* Raski, *Hoplolaimus galeatus* (Cobb) Thorne, *Trichodorus christiei* Allen, *T. semipenetrans*, and *Xiphinema americanum* Cobb. Soil samples taken from areas within the grove severely infested with a perennial grass revealed the presence of *Hemicriconemoides* sp., in addition to the other nematodes listed. All these species are migratory ectoparasites, except *T. semipenetrans*, which is a semi-endoparasite.

To study mixed nematode population variation, 10 trees were selected for sampling at monthly intervals. Because more than 50 species of broadleaf herbaceous and woody plants, vines, and grasses occur as weeds in citrus groves, they may also be hosts of some nematode genera associated with citrus. Therefore, soil around five of the trees was treated with herbicides to maintain sampling areas free of weeds for the duration of the study. The other five trees received regular grove maintenance, which included cultivation by disking at 3-month intervals. Composite soil and root samples were taken from four sides of the trees, at depths of 0-15, 15-30, and 45-60 cm under the drip line. Monthly samples were collected adjacent to the previous ones, proceeding around the tree perimeter for 13 months.

Samples were placed in polyethylene bags and stored in a styrofoam box before processing, usually within 2 days of sampling. At the time of sampling, additional soil was collected in metal moisture containers for soil moisture determination by the oven-dry method. Soil temperature at two depths and rainfall measurements were continuously recorded throughout the experiment.

In the laboratory, roots were removed from the soil, washed in running tapwater, and immediately placed moist in jars for root incubation (Young, 1954). After 3 days, roots were flushed with water, an aliquot sample taken, and nematodes were counted. Roots were weighed moist, and the number of nematodes/g root was recorded. The soil fraction was thoroughly mixed, and a 200-cm^3 portion was processed by a centrifugal-flotation method (Caveness and Jensen, 1955) to extract the nematodes present. The nematodes in each sample were identified, counted and recorded. Counts were made of all life stages except for *T. semipenetrans* where only males and larvae were counted. Adults and larvae were not counted separately.

RESULTS

Data on fluctuations in nematode numbers are graphically presented for the 6 plant-parasitic nematode species for a 13-month period (Fig. 1 A-G).

No measurable differences were detected between nematode populations in plots with or without herbicides. Although it is possible that several genera could feed on weed hosts, comparative nematode

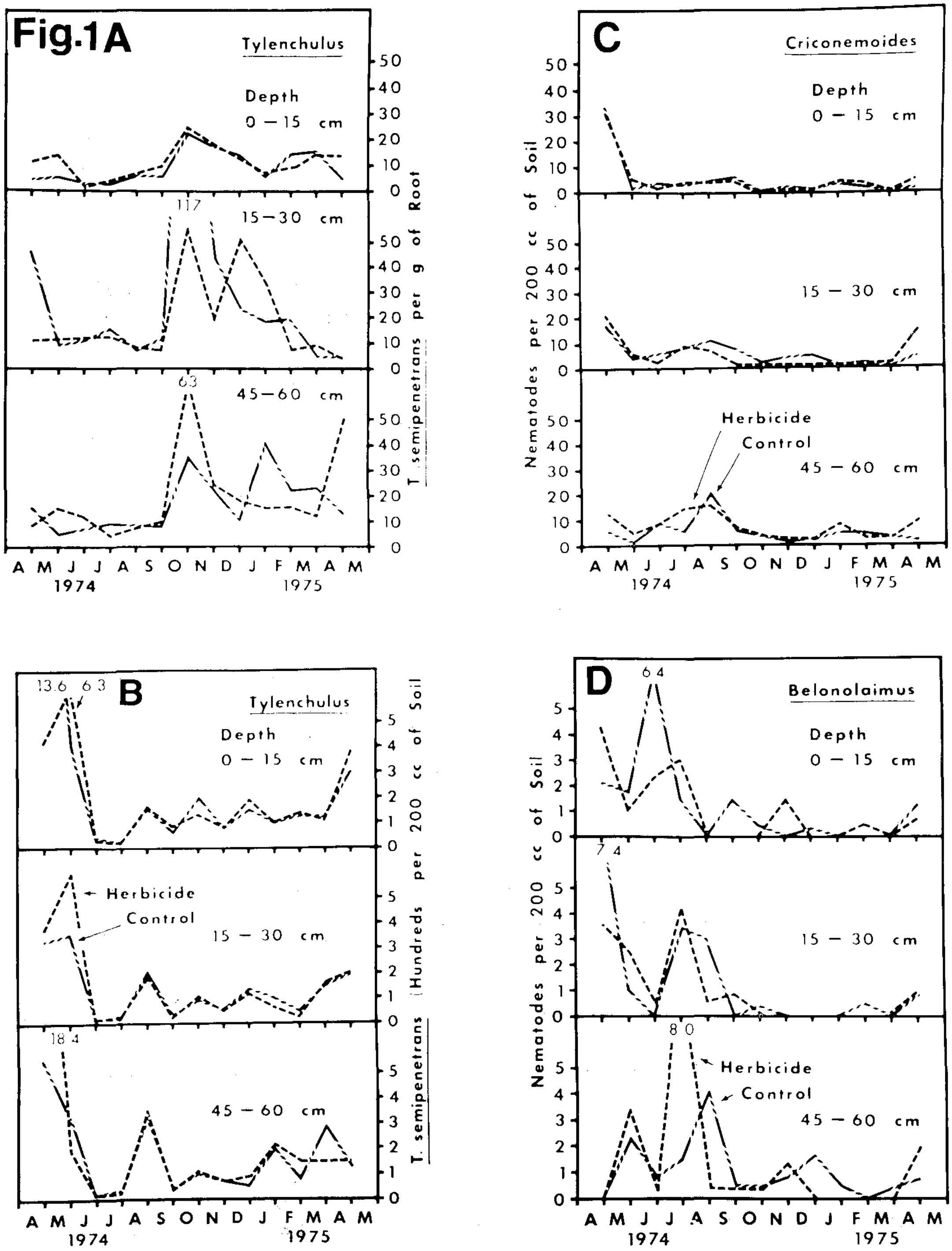
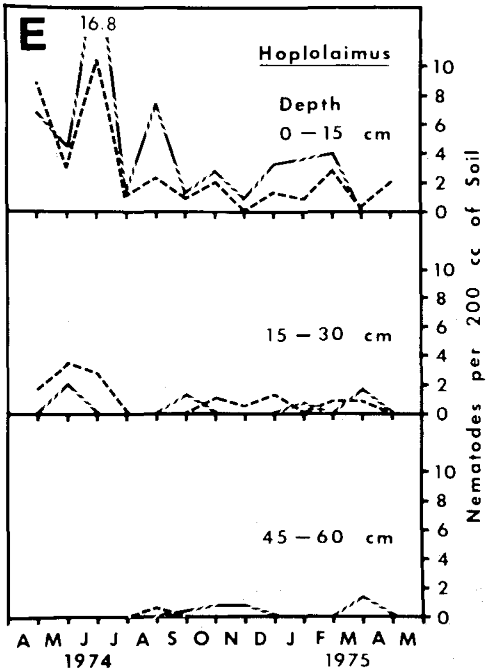
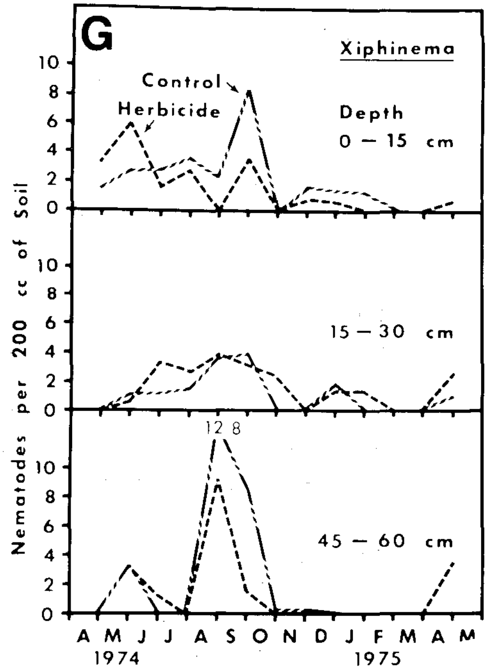
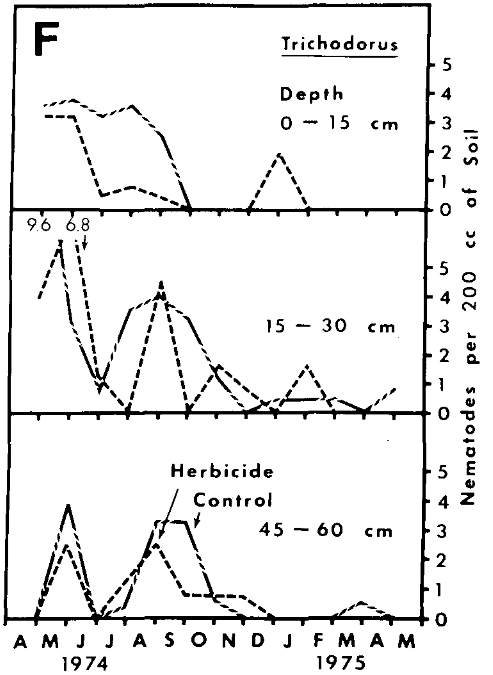


Fig. 1 - Nematode population fluctuations at 3 depths in a citrus grove: A. *Tylenchulus semipenetrans* from roots, B. T. *semipenetrans* from soil, C. *Criconemoides curvatum*, D. *Belonolaimus longicaudatus*, E. *Hoplolaimus galeatus*, F. *Trichodorus christiei*, G. *Xiphinema americanum*.







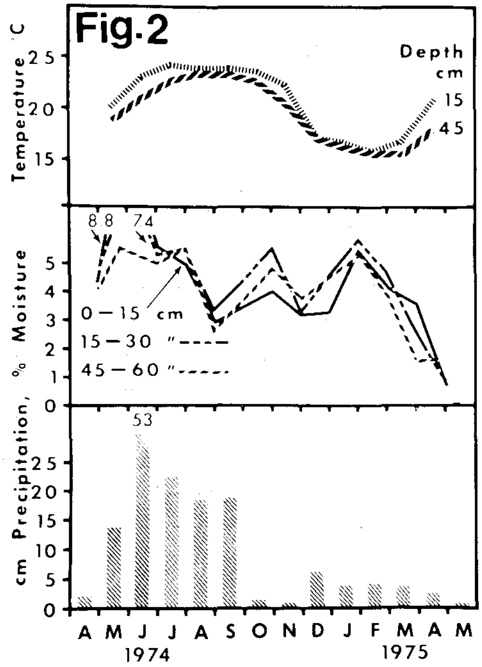


Fig. 2 - Rainfall, soil moisture, and temperature record during the sampling period.

numbers between herbicide and control plots from the deepest sampling, generally below the root zone of most annuals present, precluded weed roots as an only source of nutrition.

Florida citrus trees have two major growth flushes a year, spring (April-May) and late summer (August-September). All nematode species increased in numbers with the spring new root flush (Fig. 1 A-G). *Belonolaimus longicaudatus* and *X. americanum* populations peak followed the spring root flush (Fig. 1 D, G) and coincided with summer rains (Fig. 2). *Criconemoides curvatum*, T. *christiei*, *X. americanum*, and *T. semipenetrans* populations increased again with the late summer root flush, indicating that population increases and apparent seasonal variation of these nematodes are influenced by new root growth. This was previously observed with *T. semipenetrans* (O'Bannon *et al.*, 1972). This nematode feeds only in cortical tissue which is most abundant during the two major growth flushes. All nematode populations were generally low during the winter months (January-March). Supplemental irrigation of the groves maintained adequate soil moisture during the normally low-rainfall months, January-May, and reduced the adverse effects on nematode population density caused by the winter drought. However, soil temperatures ranged between 15 and 18 °C which combined with reduced root activity probably accounts for lower populations during this season.

In Florida, 38% of the root systems of older trees on rough lemon rootstocks growing in deep, well-drained sands, are in the top 76 cm of soil (Ford, 1954). Some nematodes, especially *R. similis*, are sensitive to soil depths; the highest populations of *R. similis* occur from 60 to 150 cm deep (Suit *et al.*, 1954).

In the upper 0-15 cm root zone, soil temperature and moisture are the most variable, and extremes can be beyond the limits for the host-parasite relationship. In our observations, *B. longicaudatus*, *C. curvatum* and *X. americanum* populations were not influenced by depth, whereas *H. galeatus* populations were most frequent at 0-15 cm and negligible between 45-60 cm. *Trichodorus christiei* and *T. semipenetrans* populations generally showed higher concentrations below 15 cm, suggesting that these nematodes are more sensitive to fluctuations of temperature and moisture found near the surface.

DISCUSSION

The presence or absence of weeds did not influence nematode fecundity (Fig. 1) as population levels were generally similar in either treatment. Environmental factors, such as moisture and temperature, appeared to have a minimal effect on nematode populations; however, lower mean winter temperatures did limit root growth and nematode activity. We consider that nematode populations increased in direct proportion to an increased food supply, which was greatest during the two major root flushes.

Only small populations of all the nematode genera were encountered during most of the year. Of the several factors that might influence population densities, our observations indicate that competition among different types of nematodes accounts for the low numbers recorded. Specific symptoms of tree injury due to nematodes were not evident in this grove because the rate of nematode population increase was lower than the tolerance limits of infected trees.

SUMMARY

Seasonal population fluctuations of *Belonolaimus longicaudatus*, *Criconemoides curvatum*, *Hoplolaimus galeatus*, *Trichodorus christiei*, *Tylenchulus semipenetrans*, and *Xiphinema americanum* were studied in an old established citrus grove in central Florida during 1974-1975.

Population levels of all nematode species increased in the spring (April-May) with new root growth. Lowest population density occurred during the winter season (January-March). No noticeable density differences were detected between nematode populations from tree areas treated with herbicide compared to no herbicide. Highest numbers of *H. galeatus* were detected in the topsoil, above 15 cm, whereas *T. christiei* and *T. semipenetrans* were more numerous in the subsoil, below 15 cm. No influence of depth on population numbers was observed with *B. longicaudatus*, *C. curvatum*, and *X. americanum*.

RIASSUNTO

Studio ecologico di un complesso di nematodi in un agrumeto della Florida.

Sono state studiate, nel 1974-1975, le fluttuazioni stagionali delle popolazioni dei nematodi *Belonolaimus longicaudatus*, *Criconemoides curvatum*, *Hoplolaimus galeatus*, *Trichodorus christiei*, *Tylenchulus semipenetrans* e *Xiphinema americanum* in un agrumeto della Florida centrale. I livelli di popolazione di tutte le succitate specie sono aumentati in primavera (aprile-maggio) con la produzione di nuove radici. Le densità più basse sono state osservate in inverno (gennaio-marzo), mentre non sono apparse sensibili differenze nelle cariche tra campioni raccolti in prossimità di piante trattate o non con erbicidi.

Le cariche più alte di *H. galeatus* sono state osservate nei primi 15 cm di profondità del terreno, mentre *T. christiei* e *T. semipenetrans* erano più numerosi al di sotto dei 15 cm. La profondità non sembra avere alcuna influenza sulle densità di popolazione degli altri nematodi.

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