Vertical Distribution of Three Nematode Species in Relation to Certain Soil Properties[1]

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Abstract: Population densities of *Belonolaimus longicaudatus, Pratylenchus brachyurus,* and *Trichodorus christiei* were determined from soil samples taken weekly in Tifton, Georgia during a 14-month period (except for April and May) at 15-cm increments to a depth of 105 cm. *Belonolaimus longicaudatus* predominately inhabited the top 30 cm of soil that was 87-88% sand, 6-7% silt, and 5-7% clay. No specimens were found below 60 cm where the soil was 76-79% sand, 5-6% silt, and 15-19% clay. Highest population densities occurred during June through September when temperature in the top 30 cm of soil was 22-25 C and soil moisture was from 9 to 20% by volume. *Pratylenchus brachyurus* was found at all depths, but population densities were greatest 45-75 cm deep where the soil was 78-79% sand, 6% silt, and 15-16% clay. In the months monitored, highest population densities occurred during March, June, and December when the soil temperature 45-75 cm deep was 14-17 C and soil moisture was 22-42%. *Trichodorus christiei* was found at all depths, but population densities were highest 30 cm deep where the soil was 83% sand, 5% silt, and 12% clay. Highest population densities occurred during December through March when the soil temperature 30 cm deep was 11-17 C and soil moisture was 18-23%. *Key Words:* seasonal fluctuations, *Belonolaimus longicaudatus, Pratylenchus brachyurus, Trichodorus christiei.*

The vertical distribution of nematodes in soil is highly variable and may be influenced by many biotic and abiotic factors. Root distribution, height of water table, soil moisture, temperature, soil texture, rainfall, and depth of subsoil greatly influence vertical distribution patterns (6, 9, 8, 11, 12). There is some evidence that vertical distribution patterns are influenced by season (1, 5, 10, 11). Wallace (14) suggested that root distribution is the chief factor in the vertical distribution of plant-parasitic nematodes, and that physical factors play an important secondary role.

Highest population densities of most plant-parasitic nematodes are reported to occur in the upper 45 cm of soil, but specimens of some species have been found 400 cm deep (1). There appears to be some diversity in vertical distribution patterns among different species. *Trichodorus* species are reported to inhabit soil at greater depths than most nematodes (1). The relative ease with which *Belonolaimus longicaudatus* Rau is controlled with chemical drenches on turf indicates that this species resides in the top few cm of soil (2).

The correlation of textural characteristics of soil and the distribution of nematodes can be quite marked. Although most plant-parasitic nematodes survive well in coarse-textured soils (6, 15, 16), there are some exceptions (6, 10, 14). According to Wallace (16), the relation between nematode movement and soil texture is a function of the ratio of nematode size to pore and particle size. As the length and diameter of nematodes increase, the optimum pore and particle sizes for maximum movement also increase until pore diameter is too large to restrict lateral movement.

Soil moisture is necessary for many life activities of nematodes. Studies on the relationships between soil moisture and various nematode activities have usually indicated that 70-80% of old field capacity provides optimum conditions (14, 16). It has been suggested that seasonal fluctuations in nematode population densities largely result from variations in soil moisture (7, 11, 16).

There is much information on the influence of constant and fluctuating temperatures on nematodes (14, 15, 16). However, there are no reports of nematode reactions to temperature fluctuations as they occur in field soil. This study deals with the vertical distribution of *Belonolaimus longicaudatus, Pratylenchus brachyurus* (Godfrey) Filip. & Schuurm.-Stekh., and *Trichodorus christiei*

Received for publication 31 March 1975.

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Allen in soil, and with the possible influence of soil moisture, temperature, and texture. A preliminary report has been given (3).

MATERIALS AND METHODS

The study was made in Tifton, Georgia in a field of Tifton sandy loam that had a history of severe plant damage caused by *B. longicaudatus.* Routine soil samples, taken 15 cm deep, contained an average of 60-100 specimens of *B. longicaudatus* and 1-4 specimens of *P. brachyurus* and *T. christiei*/150 cm^3 of soil. The field had been in cultivation for over 40 years and was seeded with millet (*Panicum ramosum* L.) the season before initiation of the study. During the study, the field was planted with soybean (Glycine max (L.) Merr. cv 'Custer'). The crops were planted (mid-April) and allowed to grow and mature (October) without harvest.

Four, 3 x 3 m areas were selected within the field for measurements of soil moisture, temperature, texture, and determination of nematode population densities. All measurements were made at 15-cm increments to a depth of 105 cm. Measurements were made from December through December, except for April and May.

Soil temperature was measured weekly with a YSI® temperature recorder. Temperature sensing probes were buried at the desired depths under the drill row in each plot and remained there during the study. Soil temperature measurements were averaged monthly.

Soil moisture was measured weekly with a Troxler® nuclear soil moisture meter. Measurements were made by suspending the sensing element of the moisture meter to the desired depth inside an aluminum irrigation pipe (3-cm diam) that had been buried vertically under the drill row in each plot. Soil moisture measurements were averaged monthly.

Soil samples for nematode assay were taken weekly with an "orchard bucket" sampling device. An orchard bucket is a 15 x 7.5 cm cylinder which has cutting edges on one end and is mounted at the other end to a 1.25-cm galvanized pipe which can be varied in length. This device removed a 15 x 7.5 cm soil core that represented a sample. During each sampling period, samples, each representing a different sampling depth, were taken at 15-cm increments to a depth of 105 cm from each of four plots. Soil samples were taken under the drill row. Each sampling period was represented by a new sampling hole in each plot. The orchard bucket was equipped with a top cover to prevent contamination by falling soil. To further reduce contamination, the top and bottom 1.5 cm of soil from each sample were discarded. The soil samples were processed by wet sieving through 850- and 38-μm sieves.

Soil samples similarly taken were used to determine soil texture at different soil depths. The hydrometer method of mechanical analysis was used, except that Colgon (registered TN of Merck and Company) was used as a dispersing agent instead of sodium hydroxide and sodium oxalate.

RESULTS

Sand and clay content varied with depth of soil. With an increase in depth, there was a decrease in percentage of sand and a corresponding increase in percentage of clay (Table 1 av. of 4 replications). Silt content remained relatively constant. The soil did not form aggregates.

Soil temperature varied with depth of sample and time of year. The greatest variation in soil temperature (10-25 C) occurred in the top 15 cm of soil. As depth increased, variation in soil temperature decreased. There was never more than 5 C difference in soil temperature with depth. Variation with depth was greater in winter than in summer. In the winter, soil temperature increased as depth increased and in the summer, it decreased as depth increased (data not given).

TABLE 1. Percentage sand, silt and clay at different depths in Tifton sand loam soil.

Depth (cm)	Sand	Silt	Clay
0-15	88	7	5
15-30	87	6	7
30-45	83	5	12
45-60	79	6	15
60-75	78	6	16
75-90	77	5	18
90-105	76	5	19

Soil moisture varied with season and depth. Soil moisture was lowest in the top 30 cm of soil and highest at a depth of 105 cm. Although soil moisture varied from month to month in the top 30 cm of soil, it generally varied more in summer than in winter. During the summer, soil moisture 105 cm deep was sometimes more than double that at 15 cm deep (data not given).

Occurrence and population densities of the three nematode species varied with depth of soil. *Belonolaimus longicaudatus* was found only to a depth of 60 cm (Fig. 1). Population densities of this nematode were greater in the upper 30 cm of soil which was 87-88% sand, 6-7% silt, and 5-7% clay; below 30 cm a significant reduction in density occurred. *Pratylenchus brachyurus* was found at all depths (Fig. 1), but average densities were greater 45-75 cm deep where the soil was 78-79% sand, 6% silt, and 15-16% clay; above and below this depth a significant reduction in density occurred. *Trichodorus christiei* was found at all depths, (Fig. 1), but average densities were greater 30 cm deep where the soil was 83% sand, 5% silt, and 12% clay; above and below this depth significant reduction in density occurred.

Seasonal variation in population densities was exhibited by all three nematode species. The highest densities of *B. longicaudatus* occurred during June through September (Fig. 2) when the soil temperature in the upper 30 cm (area of highest density) was 22-25 C and soil moisture was 9-20% by volume. In the months monitored, population densities of *P. brachyurus* were highest during March, June, and December (Fig. 2) when soil temperature 45-75 cm deep was 14-17 C and soil moisture was 22-42% by volume. Highest densities of *T. christiei* occurred during December through March (Fig. 2) when soil temperature 30 cm deep was 11-17 C and soil moisture was 18-23% by volume.

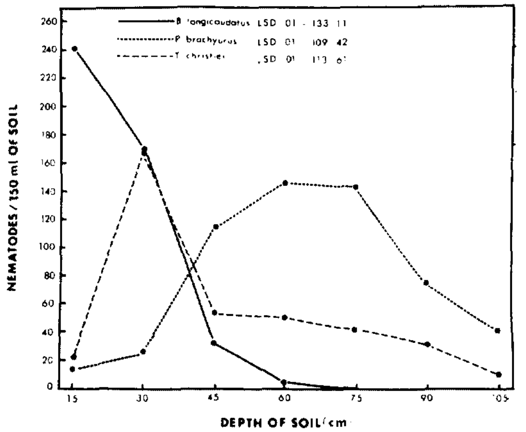

FIG. 1. Average number of nematodes recovered from different depths of soil during a 13-month sampling period (sampled at weekly intervals December through December, except April and May).

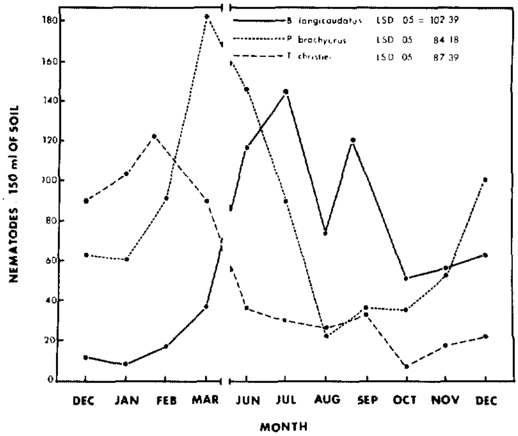

FIG. 2. Average number of nematodes recovered from the upper 105 cm of soil during different months.

Significant variation in population densities depended upon nematode species and depth of soil. At any one time, only one species predominated at a given depth (Fig. 3). Significant variation in densities of *B. longicaudatus* occurred at all depths where the nematode was found. The numbers of *P. brachyurus* varied significantly in soil at only the 45 and 60 cm depths. *Trichodorus christiei* exhibited significant variation in density at only the 15 and 30 cm depths.

DISCUSSION

Wallace (15) suggested that root distribution is the major determinant of the vertical distribution patterns of plant nematodes in soil. According to Caldwell et al. (4), the tap roots of soybean may reach a depth of 200 cm, with lateral roots reaching a depth of 180 cm. However, most of the root system is concentrated in the upper 15 cm of soil. Thus, according to root distribution, each species had an equal chance to inhabit soil at all depths sampled. This relationship was not the

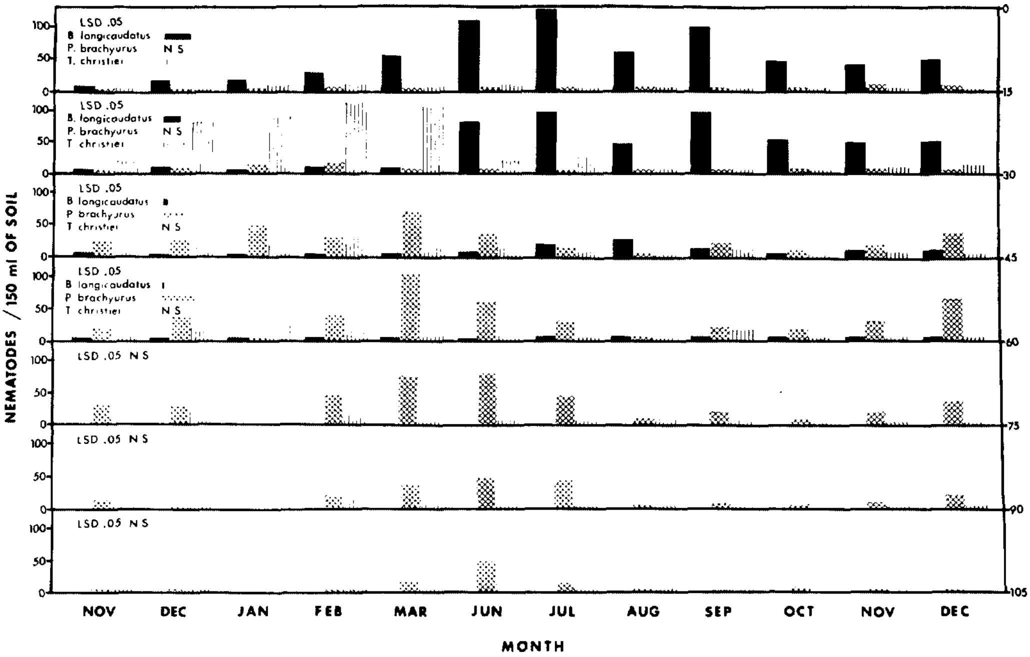

FIG. 3. Average number of nematodes recovered from different depths of soil during different months.

case with the three species in my studies. Population densities of each species maximized at different soil depths, where soil texture differed, and at different times of the year when temperature and moisture was different. According to my data, soil texture, temperature, and moisture apparently exert a marked influence on verticle distribution of these nematodes.

The suggestion of Robbins and Barker (13) and Miller (7) that *B. longicaudatus* does not survive in soil of less than 80% sand content was supported in my study by the lack of recovery of *B. longicaudatus* below a depth of 60 cm where the soil is less than 80% sand. My results also coincide with Wallace's (14, 15, 16) conclusion on the relation between nematode movement and soil texture: as length and diam of nematode increase, the optimum pore and particle size for maximum movement also increase until pore diam is too large to restrict lateral movement. Accordingly, *P. brachyurus* and *T. christiei* could inhabit and survive in soil with less than 80% sand content. Because of its width, *T. christiei* would require a larger pore diameter than would *P. brachyurus*. My data show that *T. christiei* density maximized at a soil depth with 83% sand content and *P. brachyurus* maximized at depths with 78-79% sand.

Seasonal population fluctuation was exhibited by all three species. Densities of *B. longicaudatus* were highest during the growth of the host plant, as would be expected of an ectoparasite. The decline in soil population density of *P. brachyurus* during the growing season is probably caused by the nematode leaving the soil and entering the roots. The increase of *P. brachyurus* during the winter probably occurred as they were released from rotting roots. Although *T. christiei* is reported as being parasitic on soybean (4), it declined after soybeans were planted, an indication that it was not parasitic on the cultivar used in this study. This decline could also account for *T. christiei* density not maximizing at depths of greatest root growth.

In a study of this nature, it is difficult to separate nematode response to temperature, moisture, and host plant because growth and decline of the host are associated with suitable moisture and a seasonal rise and decline in temperature. However, the maximizing of densities of each species at different temperatures suggested that temperature was a factor in vertical distribution. Because of abundant rainfall during this study, low soil moisture apparently was not a factor; however, excessive soil moisture during the winter may have limited nematode survival at lower depths. Daily fluctuations in temperature and moisture in the upper few cm of soil probably caused daily fluctuations in nematode population densities, but such measurements were not made in this study.

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