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Nematode Community Structure in Dogwood, Maple, and Peach Nurseries in Tennessee[1]

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Abstract: Nursery blocks (48 dogwood, 27 maple, 17 peach) in 20 middle Tennessee nurseries were sampled for nematodes in March, July, and October 1981. Dogwoods and maples were grouped in three age classes: 1–2, 3–5, and 10+ years. Nematodes were extracted from soil samples, counted, and assigned to trophic groups as follows: plant parasites, microbivores, fungivores, predators, and omnivores (= Dorylaimida). Total nematode numbers per 200 cm^3 soil ranged from 52 to 9,166 (mean = 1,785 ± 1,420). Nematodes were more abundant in dogwood and maple than in peach blocks, and their numbers were significantly correlated with percentage of weed ground cover and number of weed species. Nematode numbers in dogwood sites were also correlated with dogwood age. Microbivores were the most abundant trophic group in all sites, followed by plant parasites, fungivores, omnivores, and predators. Nematode communities in nursery sites shared characteristics of both undisturbed and agricultural habitats. Degree and diversity of plant ground cover appeared to be the most important factors determining nematode community structure.
Key words: *Cornus florida, Acer rubrum, Prunus persica,* trophic groups.

The factor having the greatest influence on the distribution and density of soil-inhabiting nematodes is the presence of a food source, which is affected by a multitude of other factors. A positive relationship usually exists between the degree of vegetative cover in nonagricultural ecosystems and nematode abundance regardless of trophic classification (13). Intensively managed ecosystems tend to support a greater relative abundance of plant feeding nematodes than do nonagricultural ecosystems (3).

Soil-dwelling nematodes are often classified according to trophic groups for community analysis on the assumption that competitive interactions are minimal among groups with different food sources, and these classification schemes are based on known feeding habits or assumed ones according to the nematodes' morphological characters. Literature on nematode community structures based on trophic group comparisons was recently reviewed (3,13). Such studies have mostly been confined to nonagricultural habitats.

The purpose of this study was to characterize the nematode population in a relatively lightly managed agricultural habitat and to determine which of several plant and edaphic factors had the greatest effect on nematode community structure. Dogwood (*Cornus florida* L.), red maple (*Acer rubrum* L.), and peach (*Prunus persica* (L.) Batsch) nursery sites were chosen for study to represent ornamental, shade, and fruit trees; peach nursery trees are managed

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more intensively than are dogwood or maples. A preliminary report of this research has been published (8).

Materials and Methods

Ninety-two sites within 20 nurseries in five counties on the Cumberland Plateau of Tennessee were chosen for study. Sites selected were nursery blocks that had contained the same tree species for at least the previous 5 years and on which the trees would remain for the duration of the study. The sites comprised 48 dogwood and 27 maple, each with three age classes of trees, and 17 peach blocks (Table 1). The cultivar and fumigation history of peach sites for 5 years was collected.

Sampling areas of ca. 30 m^2 were marked near the center of each block of trees, and soil samples were taken in March, July, and October 1981. Each sample consisted of 20 soil cores (1,000 cm^3) collected from within the rows about the roots of the trees to a depth of 20–30 cm. Nematodes were extracted from 200 cm^3 subsamples by sugar flotation-centrifugation (4) with a 420-μm-pore sieve over a 38-μm-pore sieve. Recovered nematodes were assigned to trophic groups based on known feeding habits or morphological characters discernible with a stereomicroscope (60 ×) and counted. The classification scheme in this study used microbivores (bacterial feeders), fungivores, plant parasites (whether obligate or facultative), predators, and "omnivores" (for questionable cases, mostly dorylaims). Randomly chosen soil samples were replicated to determine the accuracy of nematode counts. Extraction efficiency, based on reprocessing of processed soil, was approximately 80% of the total nematodes recoverable by this method. Relative extraction efficiencies for different sizes or classes of nematodes were not determined.

The percentage of weed ground cover within sample sites was estimated in July. The number of weed species was also recorded. During the October sampling, extra soil cores were taken for soil analyses. Cores for determination of bulk density (g/cm^3) were measured on-site and stored in jars to be oven dried and weighed (2). Air-dried soil was passed through a 420-μm-pore sieve and ground with a ceramic mortar and pestle for the remaining soil

TABLE 1. Tree species and age classes of sites sampled for characterization of nematode communities in Tennessee nurseries.

Tree species	Tree age class (yr) 1–2	3–5	10+	Totals
Cornus florida	29	7	12	48
Acer rubrum	6	14	7	27
Prunus persica	17	0	0	17

analyses. Soil texture was determined by the Bouyoucos hydrometer method (1), and soil texture designation was assigned according to the U.S. system (2). Organic carbon content was determined by chromic acid titration (9,10); values were multiplied by 1.72 to convert to percentage of organic matter, with the assumption that soil organic matter is 58% carbon. Soil pH was determined for 10-gram samples mixed with 20 ml deionized distilled water. Duplicate soil samples were analyzed.

Analysis of variance and product moment correlation were used to determine relationships among nematodes, plants, and edaphic factors measured. Analyses involving tree age classes included data from only the dogwood and maple sites (Table 1). Correlations involving weed data included July data only, as weed data were not collected in March or October. Analysis of variance of the numbers and percentages of nematodes in each of the five trophic groups was conducted with the data collected from sites in nurseries in which both dogwood and maple trees of at least two ages were sampled (n = 12) and with data collected from nurseries in which all three tree species 1–2 years of age were sampled (n = 4).

Results

Nematode density data and mean counts for each of the five trophic groups by tree species and sample date are summarized in Table 2. Correlation coefficients reported herein were significant at $P < 0.05$.

Total nematodes: Total nematodes for all sites over all sampling dates ranged from 52 to 9,166 per 200 cm^3 soil, with a grand mean of 1,785 (standard deviation = 1,420). In March, the mean total for peach sites was significantly lower than those for maple and dogwood sites. In July, totals

TABLE 2. Nematodes per 200 cm^3 soil in five trophic groups in dogwood, maple, and peach nursery sites in Tennessee on three sampling dates.

Tree	Sample date	Microbivores	Plant parasites	Fungivores	Omnivores	Predators	Total nematodes Mean	Range	SD
Dogwood	March	1,020 a*	434 a	253 a	77 a	20 a	1,803 a	162–7,212	1,285
	July	643 a	635 a	162 a	71 a	9 a	1,519 a	76–9,166	1,678
	October	1,134 a	473 a	174 a	71 b	9 a	1,862 b	66–5,216	1,358
	LSD (0.05)	300	253	83	34	7	531		
Maple	March	976 a	577 a	227 a	91 a	42 b	1,912 a	272–5,194	1,295
	July	488 a	633 a	125 a	58 a	8 a	1,312 a	138–3,112	752
	October	1,352 a	880 b	166 a	116 a	19 b	2,532 a	158–5,928	1,248
	LSD (0.05)	345	261	80	43	17	549		
Peach	March	597 b	270 a	182 a	47 b	10 a	1,107 b	52–4,178	1,004
	July	626 a	290 a	144 a	35 b	7 a	1,101 a	226–3,178	787
	October	2,123 b	401 a	430 b	35 c	9 a	2,998 a	226–6,884	2,059
	LSD (0.05)	650	248	224	29	2	950		

* Means within columns and for the same sample date followed by the same letter are not significantly different (LSD at $P = 0.05$).

were lower than in March for all three tree species, but differences among the July means were not significant. In October, nematode totals were higher for all tree species, and the mean for dogwood sites was significantly lower than those for maple and peach sites.

Nematode totals were correlated significantly with three of the variables measured. Correlation coefficients with totals in all sites were +0.37 with percentage of weed ground cover and +0.46 with number of weed species. A positive correlation was found between nematode totals and tree age in dogwood sites ($r = +0.36$).

Microbivores: In most sites, microbivorous nematode numbers exceeded those of other groups. Both mean numbers and their percentage constituency of total nematodes were lower in July than in March in dogwood and maple sites. The highest means of both numbers and percentages of microbivores were found in October for all tree species. Microbivores accounted for 71% of the total in peach sites in October which was more than three times higher than in March or July.

Positive correlations were found between numbers of microbivores and percentage of weed cover in dogwood ($r = +0.31$) and maple ($r = +0.38$) sites, while negative correlations existed between percentage of microbivores and percentage of weed cover ($r = -0.25$ for dogwood and -0.29 for maple sites). There were no correlations between weed factors and microbivores in peach sites. A negative correlation was also found between percentage of microbivores and dogwood tree age (Fig. 1).

Plant parasites: Mean densities and percentages of plant parasitic nematodes were higher in July than in March for all sites. Plant parasites were the only group for which the mean percentage of the total count was higher in July than in March for

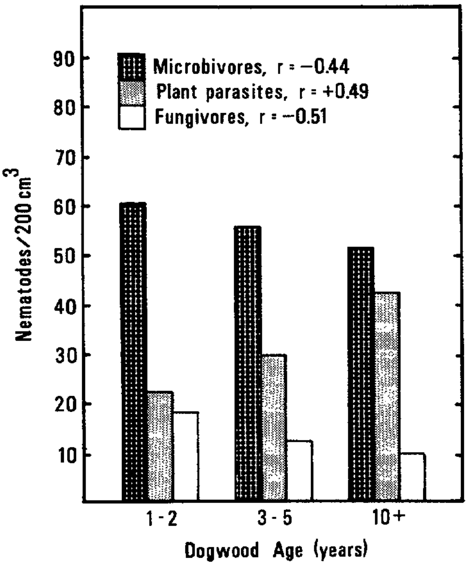

FIG. 1. Relationships among soil populations of three nematode trophic groups and dogwood tree age in sites of three age classes in Tennessee nurseries.

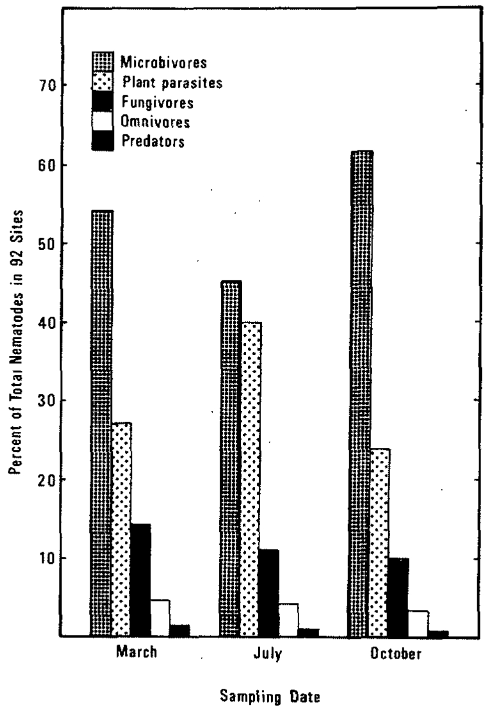

FIG. 2. Relative population sizes of nematode trophic groups in soil samples collected from Tennessee tree nurseries on three sampling dates.

all three tree species (Fig. 2). The percentage of plant parasites in October was lower than in March in dogwood and maple, and only slightly higher than in March in peach sites.

Tree age was positively correlated with numbers ($r = +0.38$) and percentages ($r = +0.39$) of plant parasites in dogwood and maple sites combined (Fig. 1 contains data for dogwood sites). Positive correlations of numbers of plant parasites with percentage of weed cover ($r = +0.41$) and number of weed species ($r = +0.45$) were found for dogwood sites, but not for maple or peach sites.

Fungivores: Fungivore counts were highest in March in dogwood and maple sites. The mean percentage of fungivores in peach sites in March was higher than the mean percentage of plant parasites (data not given). Also contrary to the results for dogwood and maple sites, numbers of fungivores in peach sites were highest in October. A negative correlation ($r = -0.51$) was found between percentage of fungivores and tree age only in dogwood sites (Fig. 1).

TABLE 3. Influence of nursery, tree species, trophic group classification, and tree age on nematode density in dogwood and maple sites in Tennessee.

Source of variation	*F* ratios†		
	March	July	October
Nursery	2.86	2.31	2.01
Tree species	2.18	6.14	5.88
Trophic group	55.11*	23.06*	74.14*
Tree species × trophic group	0.77	0.40	2.74
Tree age	11.83*	22.09*	12.08*

* Significant at $P = 0.01$.

† March, CV = 107.23, $R^2 = 0.503$; July, CV = 160.37, $R^2 = 0.367$; October, CV = 104.88, $R^2 = 0.560$.

Omnivores: Numbers of omnivores were highest in dogwood and peach sites in March and in maple sites in October. The mean percentages were higher in July than in March in dogwood and maple sites, but lower in peach sites. In October, these percentages were higher than March levels in dogwood and maple sites, but much lower in peach sites.

Tree age was positively correlated with both numbers ($r = +0.45$) and percentages ($r = +0.32$) of omnivores. Numbers of omnivores were also positively correlated with percentage of weed cover ($r = +0.36$) and number of weed species ($r = +0.42$) in all sites. Very weak positive correlations were found between numbers of omnivores and percentage of sand ($r = +0.14$) and bulk density ($r = +0.14$) in all sites.

Predators: Predaceous nematodes consistently occurred in the lowest numbers among the five trophic groups. Predator counts and percentages were lower in July than in March and higher in October than in July; the highest numbers occurred in March in all sites. A weak positive correlation ($r = +0.19$) was found between numbers of predators and percentage of soil organic matter.

Community structure: For the purposes of the analysis of variance, tree age was treated as a continuous variable, rather than as a discrete class, and analyses were segregated by sample date. Tree age (Table 4) was positively correlated with both percentage of weed ground cover ($r = +0.60$) and number of weed species ($r = +0.71$). Total nematode density was significantly affected by densities in each trophic group

TABLE 4. Percentage of weed ground cover and number of weed species in Tennessee nursery sites in July classified by tree and age class.

Tree	Age class (yr)	Percentage of weed ground cover	Number of weed species
Dogwood	1–2	19 b*	2 a*
	3–5	42 c	3 a
	10+	73 d	10 b
Maple	1–2	27 b	3 a
	3–5	44 c	5 a
	10+	61 cd	8 b
Peach	1–2	11 a	2 a

* Means within columns followed by the same letter are not significantly different (LSD at $P = 0.05$).

TABLE 5. Least squares means of nematode trophic group densities per 200 cm^3 soil in dogwood and maple sites more than 3 years old in Tennessee nurseries.

Trophic group	March	July	October
Microbivores	939	593	1,282
Plant parasites	500	642	684
Fungivores	232	163	190
Omnivores	87	77	106
Predators	39	28	26
LSD (0.05)	65	80	80

and by tree age, but not by nursery, tree species, or a species × group interaction (Table 3). The same pattern was found in analysis of trophic group percentages (data not given). Differences in least squares means of trophic group densities were significant among microbivores, plant parasites (except in July), and fungivores, but not between omnivores and predators (Table 5).

When all sites of the 1–2 year age class were considered together, no significant differences were found in trophic group densities or in percentages among the three tree species. However, ranking of the groups by both absolute and relative densities was the same for dogwood and maple sites (Table 5), except that plant parasite counts exceeded those for microbivores in July.

DISCUSSION

Despite the extreme variability in nematode numbers, a pattern of community structure in nurseries was discernible. The relative ranking of microbivores > plant parasites > fungivores > omnivores > predators was generally consistent. As with the seasonal variations in natural or lightly managed habitats (3,13), total nematode densities exhibited two peaks, one in spring (March) and one in fall (October); however, this pattern reflects the predominance of microbivorous nematodes. The monocultural aspect of the nurseries, their major characteristic in common with agricultural habitats, was reflected by the comparatively low total nematodes, ranging from 2,600 to 458,300/m^2 (av. 89,260/m^2). This aspect is further reflected by the high position of the plant parasites and the low position of the omnivores relative to the others. Johnson et al. (5) surveyed 18 Indiana hardwood stands and found that one site, which had been cut over and allowed to grow back to an even-aged stand of black locust, differed from the others in having a high percentage of tylenchid nematodes and a low percentage of Dorylaimida. Tylenchids correspond in some degree to "plant parasites" and Dorylaimida to "omnivores." Johnson et al. (5) considered the dorylaimids indicators of ecological change, as the less disturbed sites had greater numbers and more diverse dorylaimid fauna. Conversely, Wasilewska (12) found a decrease in omnivores with plant succession in forested sand dunes. In the Tennessee nursery sites sampled, the numbers and percentages of omnivores were low, but the positive correlations between tree age and both absolute and relative density of omnivores support the hypothesis that omnivores increase with time from the time of major soil disturbance (in this case, planting). The very low means for omnivore densities in peach sites further support this hypothesis; the low omnivore means for dogwood and maple sites were due to the large percentage (47%) of sites with 1–2-year-old trees included in those means.

Another indication of fewer soil disturbances in older blocks of trees was found in the strong positive correlations between tree age and percentage of weed cover and number of weed species. Because of these relationships, the tree age classification can be viewed as an index of the complexity of the flora in the nursery sites. Tree species in itself was not an important factor influencing nematode community structure in the nurseries; the tree species and age factors were confounded for the peach sites as peach trees grown in these nurseries remain in the field only 1–2 years. Peach trees are cultivated more often than are dogwoods and maples. Few differences in nematode communities existed between dogwood and maple sites, and the differences between these and peach sites are attributable to the differences in site management.

Johnson et al. (6) found that when all nematode orders found in 18 hardwood sites were combined for analysis of site similarity by community ordination, the resulting positions of sites on the main ordination axis could not be correlated with any of several separate edaphic variables they measured. Similarly, in the Tennessee nurseries, no strong relationship existed between the edaphic characteristics of site and nematode community structure. In general, the soils sampled were similar (in all of the characteristics measured) and did not prove useful in characterizing the nematode population.

Wasilewska (11) suggested that reciprocal interactions occurred among trophic groups, because the percentages of these groups were similar in several habitats but the absolute densities were highly variable. In the present study, positive correlations were found for total nematodes with percentage of weed cover and number of weed species. The negative correlations of percentage of weed cover and number of weed species with percentages of microbivores, despite the positive correlations with densities, could reflect a reciprocal interaction connected indirectly to the degree and diversity of ground cover. Kimpinski and Welch (7) studied nematode communities in Manitoba soils and attributed differences in nematode numbers, regardless of trophic group, to differences in the amount of plant material, as have other authors (13). The nematode population found in the nurseries shares characteristics of undisturbed and agricultural habitats, as described by Ferris and Ferris (3), and the degree and diversity of plant material are the major factors affecting its structure.

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