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Distribution, Frequency, and Population Density of Nematodes in West Virginia Peach Orchards[1]

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Abstract: Nematode population densities were determined in soil and root samples collected from 205 peach (*Prunus persica* L.) orchard blocks between 25 March and 5 May 1986. Representative specimens from 75 blocks were identified to species; 28 species of plant-parasitic nematodes were identified. Predaceous nematodes (Mononchidae) were observed in 71% of the samples. The most common plant-parasitic genera were *Paratylenchus, Helicotylenchus, Pratylenchus,* and *Xiphinema,* occurring in 85, 84, 77, and 74% of the samples, respectively. Population densities of *Xiphinema, Pratylenchus, Meloidogyne, Hoplolaimus,* and *Criconemella* were at potentially damaging levels in 74, 19, 13, 10, and 2% of the samples, respectively. Potentially damaging nematode densities were observed in 78% of orchard blocks surveyed, with 35% having two or more nematodes with densities high enough to warrant concern. Nematode densities differed among soil types and tree rootstocks and were correlated with tree mortality rates.
Key words: *Criconemella, Helicotylenchus, Hoplolaimus, Meloidogyne,* distribution, peach, *Pratylenchus,* predaceous nematode, *Prunus persica,* soil texture, survey, *Xiphinema.*

Nematode samples have been collected from individual peach (*Prunus persica* L.) orchards in West Virginia for many years; however, comprehensive surveys have not been conducted. Existing data on nematode frequency and population density are fragmentary and difficult to evaluate and are of little value in estimating yield loss on a regional basis. Many growers either are unaware of nematode problems or are unnecessarily treating orchards with nematicides on a routine basis.

Nematode genera occurring in deciduous tree fruit orchards in other areas of North America include *Criconemella, Helicotylenchus, Hemicycliophora, Meloidogyne, Paratylenchus, Pratylenchus,* and *Xiphinema* (8–10,12,16,17). Action thresholds for control measures to prevent damage by several of these genera have been prepared (2); however, these thresholds may vary with time of year, rootstock, soil type, and geographic region (2,14).

This study was conducted to determine the identity, frequency, and population density of plant-parasitic nematodes in peach orchards in West Virginia. Distribution of nematodes was evaluated in relation to nematicide usage, peach cultivar, rootstock, soil type, orchard age, and tree mortality.

MATERIALS AND METHODS

Twenty commercial peach orchards identified for this survey were subdivided into blocks based on size, cultivar, and cropping history. Although orchard blocks surveyed were not selected in a strictly random manner, no effort was made to select problem orchards. Orchard blocks were mapped before sampling to assure uniformity of age, nematicide treatment, scion and rootstock cultivar, and previous cropping history. Five nectarine blocks were included in the survey, as were eight blocks planted to other crops where the grower anticipated planting peaches in the coming year. Blocks ranged from 0.1 to 2.5 ha in size, depending on the orchard layout.

A total of 205 orchard blocks, representing 282 ha in Berkeley, Jefferson, and Hampshire counties, West Virginia, were sampled between 25 March and 5 May 1986. Samples were composites of cores (2.5 cm d by 15 cm deep) collected from the herbicide-treated strip and within the drip line of 10–20 trees per block. Nematode densities in soil were determined by

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extracting nematodes from a 100-cm^3 subsample using the centrifugal-flotation method (1). Nematode densities in roots were determined by incubation of up to 1 g fibrous roots for 5 days in tap water on a rotary shaker (1). Data on orchard age, scion and rootstock cultivar, and nematicide usage were obtained from interviews with growers. Soil type was determined from USDA Soil Conservation Service soil survey maps (3,5,7). Tree mortality rates were estimated from number of dead and replanted trees in each block divided by the age of the block to give average annual tree mortality. Nematicide use data consisted of the number of applications in the previous 3 years.

Nematodes in all samples were counted and identified to genus. Tomato (*Lycopersicon esculentum* Mill. cv. Tiny Tim) was planted in soil from five samples containing juveniles of *Meloidogyne* spp., and perineal patterns of adult females were examined after 6 weeks. Species identifications of other genera were made from 75 representative samples containing moderate or high nematode densities. When mixed populations of species within a genus were found, the proportion of each species in the sample was estimated from randomly selected specimens.

Means, standard errors, and correlation coefficients for the various parameters were calculated from nontransformed data using the Statgraphics (STSC, Rockville, MD) statistical program.

TABLE 1. Density and frequency of nematode populations in peach orchards in West Virginia.

Nematode genus	Mean density†	Relative frequency of occurrence‡
Xiphinema	8.0 ± 1.1	74
Pratylenchus	8.4 ± 0.7	77
Meloidogyne	7.5 ± 2.2	31
Hoplolaimus	3.1 ± 0.6	29
Criconemella	6.9 ± 1.8	30
Helicotylenchus	75.7 ± 12.6	84
Paratylenchus	44.9 ± 6.3	85
Hemicycliophora	0.9 ± 0.5	6
Monochidae	3.5 ± 0.3	71

† Mean ± standard error of nematodes per 100 cm^3 soil in 205 samples.
‡ Percentage of samples in which the genus was found.

RESULTS

Plant-parasitic nematodes were observed in 204 of the 205 soil samples. *Helicotylenchus* and *Paratylenchus* were the most frequently encountered genera of plant parasites; they also occurred in the highest densities (Table 1). *Xiphinema* spp. occurred in 74% of the samples. Because of the potential of *Xiphinema* spp. to act as virus vectors (4,15), action thresholds are set at the detection limit of 1 nematode/100 cm^3, resulting in *Xiphinema* being the most frequently encountered nematode problem. *Pratylenchus* spp. also occurred commonly, but only 19% of the samples had levels high enough ($\geq$ 15/100 cm^3) to indicate a potential nematode problem (2). *Meloidogyne* spp., *Hoplolaimus* spp., and ring nematodes (*Criconemella xenoplax* (Raski) Luc & Raski, *C. curvata* (Raski) Luc & Raski, and other unidentified species) occurred less frequently, and only 13, 10, and 2%, respectively, of the samples had densities of these genera high enough (10, 10, and 100/100 cm^3) to indicate a potential nematode problem (2).

Quinisulcius capitatus (Allen) Siddiqi, *Rotylenchus buxophilus* Golden, and *Tylenchorhynchus agri* Ferris were found in only one sample each (Table 2). The only species of *Meloidogyne* identified from the tomato bioassay was *M. hapla* Chitwood. All *Hoplolaimus* spp. examined were identified as *H. galeatus* (Cobb) Thorne. *Criconemella, Helicotylenchus, Hemicycliophora, Paratylenchus, Pratylenchus,* and *Xiphinema* were each represented by two or more species, often in mixed populations (Table 2). Predaceous nematodes (Mononchidae, primarily *Clarkus papillatus* (Bastian) Jairajpuri, *Mylonchulus obliquus* (Cobb) Andrássy, and an unidentified species of *Iotonchus*) were found in 71% of the samples. *Pratylenchus* spp. were recovered from some root samples, but at low densities (3.8 ± 0.9/g).

Significant ($P \leq 0.05$) correlations were detected among orchard age, nematicide treatments, tree mortality rate, and nematode densities (Table 3). The population

TABLE 2. Relative frequency of 28 species of plant-parasitic nematodes identified in 75 samples from peach orchards in West Virginia.

Nematode species	Relative frequency of occurrence†
Criconemella curvata (Raski, 1952) Luc & Raski, 1981	7
C. xenoplax (Raski, 1952) Luc & Raski, 1981	9
Helicotylenchus digonicus Perry, 1959	15
H. dihystera (Cobb, 1893) Sher, 1961	41
H. platyurus Perry, 1959	35
H. pseudorobustus (Steiner, 1914) Golden, 1956	21
Hemicycliophora vidua Raski, 1958	3
H. vivida Wu, 1966	3
Hoplolaimus galeatus (Cobb, 1913) Thorne, 1935	16
Meloidogyne hapla Chitwood, 1949	5
Paratylenchus ciccaronei Raski, 1975	5
P. hamatus Thorne & Allen, 1950	3
P. nannus Cobb, 1923	37
P. projectus Jenkins, 1956	5
P. tenuicaudatus Wu, 1961‡	1
Pratylenchus crenatus Loof, 1960	39
P. neglectus (Rensch, 1924) Filipjev & Schuurmans Stekhoven, 1941	15
P. penetrans (Cobb, 1917) Filipjev & Schuurmans Stekhoven, 1941	31
P. pratensis (de Man, 1880) Filipjev, 1936	3
P. scribneri Steiner, 1943	3
P. thornei Sher & Allen, 1953	9
P. vulnus Allen & Jensen, 1951‡	1
Quinisulcius capitatus (Allen, 1955) Siddiqi, 1971	<1
Rotylenchus buxophilus Golden, 1956	<1
Tylenchorhynchus agri Ferris, 1963	<1
Xiphinema americanum Cobb, 1917	59
X. californicum Lamberti & Bleve-Zacheo, 1979	1
X. rivesi Dalmasso, 1969	52

† Percentage of 75 samples in which the species was present. Sums of relative frequencies within genera sometimes exceed 100% because samples with mixed populations were counted more than once.

‡ Identification tentative.

density of mononchids was positively correlated with that of *M. hapla* or *Xiphinema* spp. but was negatively correlated with that of *H. galeatus*.

The most frequently grown scion cultivars were Loring (22% of the blocks sampled), Redskin (16%), Redhaven (12%), Cresthaven (9%), Sunhigh (7%), Glohaven (7%), and Blake (5%). Fifteen other cultivars made up the remainder of the blocks. No differences in nematode densities or tree mortality were observed among scion cultivars.

The rootstock was identified positively in 96 blocks; Halford, Lovell, and Siberian C occurred in 18, 65, and 16% of blocks, respectively. Rootstocks in Hampshire county were almost entirely Halford, and differences in soil type and nematode populations there biased comparisons among rootstocks. Therefore, rootstock comparisons were based on sites in Berkeley and Jefferson counties only. Siberian C tended to have a higher tree mortality rate than Halford or Lovell; however, differences were not statistically significant (Table 4). Densities of *M. hapla* were higher ($P \leq 0.05$) on Siberian C than on other rootstocks. Highest densities of *H. galeatus* and *Pratylenchus* spp. were found on Halford. Lovell was associated with higher population densities of *Pratylenchus* spp. than was Siberian C and with lower population densities of *H. galeatus* than was Halford.

Soil analyses were not conducted, but field observations confirmed the descriptions obtained from soil survey maps. Samples were grouped into three classes based on soil texture (Table 5). *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven, *P. crenatus* Loof, and *P. neglectus* (Rensch) Filipjev & Schuurmans Stekhoven were associated with most soil types surveyed. Highest densities of *P. penetrans* and *P. crenatus* were found in silty clay loam and silty clay soils, whereas highest densities of *P. neglectus* were found in silt loam and loam soils (Table 5). *Xiphinema americanum* Cobb was widely distributed in all soils encountered, but its highest population densities were in rocky loam soils, especially in Hampshire county (data not shown). Although in lower densities than *X. americanum*, *X. rivesi* Dalmasso occurred frequently in loam and silt loam soils but was rare in Hampshire County. Mixed populations of both *Pratylenchus* spp. and *Xiphinema* spp. were found in many orchards in Jefferson and Berkeley counties.

TABLE 3. Significant ($P \leq 0.05$) correlation coefficients among densities of nematode genera and cultural factors.

	Orchard age	No. of nematicide applications	Tree mortality rate	*Meloidogyne*	*Helicotylenchus*	*Xiphinema*	*Hoplolaimus*
Orchard age	1.00						
Nematicide applications	—	1.00					
Tree mortality rate	−0.27	0.31	1.00				
Meloidogyne	—	—	—	1.00			
Helicotylenchus	0.20	—	−0.18	0.16	1.00		
Xiphinema	0.29	—	—	—	—	1.00	
Hoplolaimus	—	—	—	—	—	—	1.00
Pratylenchus	—	−0.17	0.17	—	—	—	0.35
Criconemella	0.30	—	—	—	—	0.29	0.15
Paratylenchus	−0.21	0.33	0.17	—	—	—	—
Hemicycliophora	0.36	0.22	—	—	0.19	—	—
Mononchidae	0.20	−0.19	—	0.26	—	0.43	−0.15

Correlations based on 180 samples; dashes (—) indicate correlation not significant ($P \leq 0.05$). Samples are omitted from blocks where tree mortality or nematicide data were unavailable.

DISCUSSION

Overall, 78% of the blocks sampled had nematode populations high enough to indicate a potential for damage, according to published thresholds (2), and 35% had high populations of two or more pathogenic nematode genera. The detection of *Xiphinema* spp. in 74% of the orchard blocks contributes the largest portion of this risk. Since a single nematode can transmit a lethal virus disease (4,15), the potential for damage may also exist in blocks with *Xiphinema* spp. densities below the detection limit. Alternatively, the presence of populations of *Xiphinema* spp. which fail to transmit tomato ringspot virus (6) would suggest that a much lower potential for damage may exist.

Pratylenchus spp. also occurred in potentially damaging numbers in many blocks. Furthermore, *Pratylenchus* spp. densities could increase over time, indicating a potential for damage even in blocks currently exhibiting low densities. Alternatively, since only *P. penetrans* has been demonstrated to be pathogenic on peach (11), the presence of other *Pratylenchus* spp. would suggest that the potential for damage could be overestimated.

These considerations illustrate the difficulty in obtaining disease loss estimates in perennial crops such as peach. Long-term monitoring and site-specific nematode management programs are essential for growers in this area.

The diversity of the plant-parasitic nematode fauna and the frequent occurrence of high nematode population densities found in this survey were unexpected. In general, growers with high nematode densities tend to apply nematicides regularly, but the nematicides are apparently not adequately reducing nematode densities.

TABLE 4. Tree mortality rate and densities of nematode genera on three peach rootstocks in Berkeley and Jefferson counties, West Virginia.

Rootstock	Tree mortality rate†	Nematodes per 100 cm^3 soil: *Meloidogyne*	*Pratylenchus*	*Xiphinema*	*Hoplolaimus*
Halford	1.6 ± 0.8	1 ± 13	13 ± 3	4.7 ± 3.4	8.4 ± 2.0
Lovell	1.6 ± 0.3	3 ± 5	9 ± 1	5.6 ± 1.1	0.7 ± 0.7
Siberian C	2.8 ± 0.6	50 ± 10	4 ± 2	5.8 ± 2.4	0.1 ± 1.4

Data are means ± standard error of 7, 60, and 14 orchard blocks with Halford, Lovell and Siberian C, respectively.
† Percentage of dead trees per year of orchard age.

TABLE 5. Mean population densities of *Pratylenchus* spp. and *Xiphinema* spp. associated with three soil texture groups in West Virginia.

	Nematodes per 100 cm³ soil		
	Silt loams†	Rocky loams‡	Silty clay loams§
P. penetrans	1.8 ± 1.0	3.7 ± 1.4	7.4 ± 2.7
P. crenatus	4.5 ± 1.3	3.6 ± 1.2	9.3 ± 4.4
P. neglectus	5.5 ± 2.2	1.1 ± 0.8	0.4 ± 0.4
X. americanum	6.4 ± 2.6	19.3 ± 4.9	7.8 ± 5.5
X. rivesi	5.3 ± 0.5	2.0 ± 0.5	2.4 ± 1.6

Data are means ± standard error of nematode density per 100 cm³ soil for each species averaged across all samples in that soil type containing the genus in numbers sufficient for species identification.

† Silt loam and loam soils common in Jefferson and Berkeley counties. Of 77 samples collected from these soils, 23 contained *Pratylenchus* spp. and 21 contained *Xiphinema* spp. in numbers sufficient for species identification.

‡ Rocky, gravelly, shaly, cherty, or channery loam, silt loam, and fine sandy loam soils common to Jefferson, Berkeley, and Hampshire counties. These soils are characterized by a high proportion of coarse materials. Of 116 samples collected from these soils, 34 contained *Pratylenchus* spp. and 37 contained *Xiphinema* spp. in numbers sufficient for species identification.

§ Silty clay and silty clay loam soils found in Jefferson and Berkeley counties. These soils are characterized by a high clay content, occasionally with rocky or cherty materials. Of 12 samples collected from these soils, 6 contained *Pratylenchus* spp. and 5 contained *Xiphinema* spp. in numbers sufficient for species identification.

Growers appear to have targeted their problem orchards for nematicide treatment; however, once virus problems (such as peach stem pitting) become established, orchards do not appear to respond to nematicide treatments. Nematicide treatments would have a greater chance of success if applied as preventative measures rather than after tree mortality rates increase. These observations suggest a lack of success in nematode management programs in West Virginia orchards.

The negative correlation between orchard age and tree mortality rates is unexplained. It may be due to underestimation of mortality in older orchards or it could be an artifact produced by early removal of orchards with high mortality rates. The lack of correlation between population density of *Xiphinema* spp. and tree mortality rates is also noteworthy. It may be due to irregularities in the distribution of tomato ringspot virus, the causal agent of peach stem pitting, or it could reflect the population changes of the nematode over time, thus pointing out the difficulty of relating existing nematode population densities to those occurring at the time tree mortality was incited.

Interpretation of correlations among nematode densities is difficult without a more quantitative understanding of the competitive interactions and predator–prey relationships that may exist among these nematodes. Furthermore, these relationships may vary with rootstock and among nematode species in the same genus.

West Virginia peach orchards occur on many soil types, ranging from soils derived from relatively acid sandstone and shale on ridge tops in Hampshire county to the limestone-derived soils in valley orchards of Berkeley and Jefferson counties. Differences in nematode distribution between these sites, especially pronounced when species within a genus are compared, may be due to soil type or climatic factors.

Many findings in this survey were consistent with results from surveys of peach and other orchard crops in North America (9,10,12,16,17). *Paratylenchus* spp., *Xiphinema* spp., and *Pratylenchus* spp. are common inhabitants of orchard soils. However, contrary to other reports (8,13), *Criconemella* spp. were not found frequently or in high densities, whereas *Helicotylenchus* spp. were observed frequently.

Surveys are useful for determining the relative importance of various nematode problems on a regional basis, and yield loss estimates can be improved by a clear understanding of nematode distribution. This survey has identified *Xiphinema* spp., *Pratylenchus* spp., *Meloidogyne hapla*, and *Hoplolaimus galeatus* as the most important nematode parasites in West Virginia peach orchards.

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