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Distribution of *Heterodera carotae* and *Meloidogyne hapla* in Michigan Carrot Production

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Abstract: During 1986 and 1988, selected farms in all of the major carrot-growing counties of Michigan were surveyed to determine the extent of infestation by *Heterodera carotae* and *Meloidogyne hapla*. Both species were found in all eight counties surveyed, but not on all farms. *Heterodera carotae* was recovered from 67.4% of the fields surveyed. *Meloidogyne hapla* was detected in 24.8% of the samples and from 69.8% of the fields. In most cases, *H. carotae* and *M. hapla* occurred in the same field.

Key words: carrot, carrot cyst nematode, *Daucus carota, Heterodera carotae, Meloidogyne hapla,* nematode, northern root-knot nematode.

Meloidogyne hapla Chitwood, the northern root-knot nematode, has long been recognized as an economic pest of carrot production (6–8). The presence of *M. hapla* in Michigan has been well documented (1). Reduction of marketable carrot yields in excess of 25% can occur as a result of *M. hapla* (John Neider, pers. comm.).

Heterodera carotae Jones, the carrot cyst nematode, was first detected in Michigan in 1979 during a survey of organic soil carrot–onion rotations. This find was first reported in 1985 (2). To date, Michigan remains the only area in North or South America to report *H. carotae* (5). The discovery of a second important nematode pest of carrots in the Michigan carrot production areas led to this survey to determine the extent of the range of these two species within the carrot production regions of Michigan.

Materials and Methods

Surveys were conducted during the 1986 and 1988 growing seasons. All sampling was done late in the season during the months of July and August, within 2 weeks of harvest. Fields to be sampled were identified through the Cooperative Extension Service and direct grower contacts. Only fields identified as having a nematode problem affecting carrot production were sampled. This bias was introduced to limit the number of fields sampled in which no plant-parasitic nematodes would be found. Preference was also given to fields planted to carrots in the year of the survey.

Each field chosen for sampling was divided into subsections (sites) of 8 ha. A modified timed sampling method, weighted to damaged carrots, was used to determine the intensity of sampling in each field. Fifteen minutes was allocated for sampling each site, beginning as the scout entered the site. As the scout moved randomly through the site, each carrot encountered that exhibited root system symptoms of nematode infection was placed in a plastic bag, along with associated rhizosphere soil. A carrot plant was dug for examination if the shoot system was shorter than the surrounding plants, if the tops were discolored (red or yellow), or if the stand was thinner than in the surrounding areas. Only carrots showing root system deformation were retained as potentially nematode-infected carrot samples. Root system deformation included forked roots, stubby roots, or excessive lateral root formation (4). The time factor entered into the sampling process when no carrots exhibiting shoot or root system symptoms were encountered. This decision was made every 5 minutes, during the 15-minute sampling period. At the end of any 5-minute period if no damaged carrots were found, then a sample was taken randomly. Thus, the minimum number of

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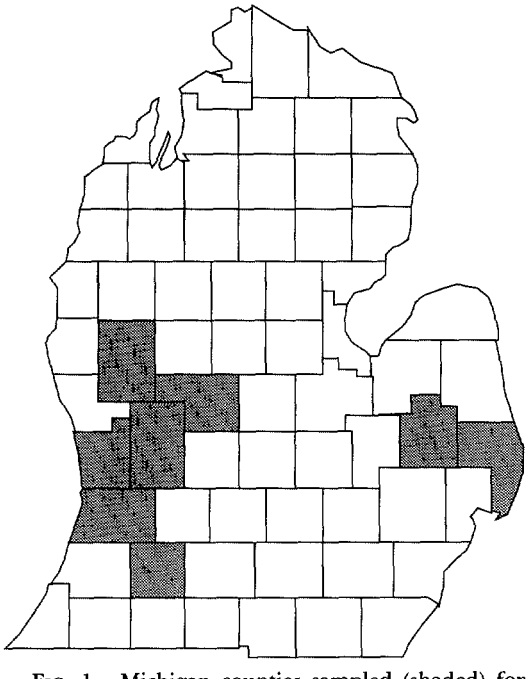

FIG. 1. Michigan counties sampled (shaded) for *Heterodera carotae* and *Meloidogyne hapla*.

samples per site was set at three by this default.

All soil samples were stored at 10 C until processed by modified sugar flotation-centrifugation (3). Additionally, each root system was examined for the presence of root-knot and cyst nematodes and rated for root deformation. After processing, the remaining soil was used in a bioassay by planting a single carrot (cv. Chancellor) in a one-liter pot containing the remaining soil. These pots were placed in the greenhouse and the carrots allowed to grow for 4 months. At the end of this time, carrots were removed from the pots and visually evaluated for the presence of *M. hapla* and *H. carotae*. Results presented are combined data from the sugar flotation-centrifugation and bioassay procedures.

RESULTS

During the 2 years of this survey, 592 samples were taken from 514 ha in 43 fields belonging to 11 carrot growers in 8 counties in Michigan (Fig. 1). These samples represented 15% of the acreage planted to carrots in 1986–1988, as well as 13% of the growers.

At least one field in each county sampled was found to have both *Heterodera carotae* and *Meloidogyne hapla*. Each grower had at least one field infested with *M. hapla*. There was only one farm where *H. carotae* was not detected. With the exception of one farm, *H. carotae* was always detected concomitantly with *M. hapla*.

Heterodera carotae was recovered from 29.7% of the samples and 67.4% of the fields (Table 1). *Meloidogyne hapla* was detected in 24.8% of the samples and 69.7% of the fields (Table 1). *Meloidogyne hapla* and *H. carotae* were not recovered from 57.7% of the samples and 18.6% of the fields.

DISCUSSION

Heterodera carotae is widely distributed through the carrot growing regions of Michigan. The survey confirmed that all regions also had fields infested with *M. hapla*, and 82.7% of all fields inhabited by *H. carotae* were also inhabited by *M. hapla*. All of the fields that were exceptions to this trend were on a single farm where field corn had been the exclusive crop grown

TABLE 1. Frequency of occurrence of *Heterodera carotae* and *Meloidogyne hapla* in the Michigan carrot nematode survey, 1986–1988.

	Heterodera carotae alone		*Meloidogyne hapla* alone		*H. carotae* and *M. hapla* both		No detection	
Year	Samples	Fields	Samples	Fields	Samples	Fields	Samples	Fields
1986	42	0	71	5	47	18	168	3
1988	61	5	3	1	26	6	174	5
Total	103	5	74	6	73	24	342	8
%	17.4	11.6	12.5	14.0	12.3	55.8	57.8	18.6

for 3 or more years previously. This rotation was unique among the fields sampled. *Heterodera carotae* was recovered from 80.0% of the fields infested with *M. hapla.* These fields were distributed among all growers and regions surveyed. Most of the fields sampled had organic (muck) soil. A limited number of fields with mineral (sandy) soil were sampled, but none of these fields were found to be infested with *H. carotae.* These mineral soil sites had a greater level of infestation by *M. hapla,* however.

In conclusion, the degree of co-occurrence of *H. carotae* and *M. hapla* within the carrot-growing regions of Michigan is very high. The widespread geographic occurrence of *H. carotae* suggests that either this species has been passively spread at a relatively rapid rate, or has been present in Michigan for an extended period of time. The lack of aggregation of *H. carotae* by region or grower suggests the latter.

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