RESEARCH NOTES

Interacting Effects of Soil Temperature and Type on Reproduction and Pathogenicity of Heterodera schachtii and Meloidogyne hapla on Sugarbeets[1]

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In central Washington, *Heterodera schachtii* Schmidt (the sugarbeet cyst nematode) is associated with sugarbeets (*Beta vulgaris* L.) growing in fine-textured soils, and *Meloidogyne hapla* Chitwood (the northern root-knot nematode) is associated with sugarbeets growing in coarse-textured soils. The optimum soil temperature for reproduction on sugarbeets is between 21 and 30 C for *H. schachtii* (2, 7, 8, 9, 11, 12) and between 24 and 30 C for *M. hapla* (unpublished). In 1975–77 temperatures 8–10 inches deep in several sugarbeet fields seldom exceeded 20 C during the growing season (March-October). Despite those relatively low soil temperatures, *H. schachtii* and *M. hapla* are important pathogens on sugarbeets in Washington. This study was undertaken to determine any relation between soil temperature and soil type on the reproduction and pathogenicity of *H. schachtii* and *M. hapla* on sugarbeets. Preliminary results have been reported (10).

H. schachtii was cultured on sugarbeets and *M. hapla* on tomato. Nematodes for inoculum were extracted by placing *H. schachtii* cysts and *M. hapla*–infected roots under mist for 24–48 hr. Inoculations were made by pipetting the desired number of nematodes into 50 ml of water and pouring the water around the plant roots. Sugarbeet seeds (U & I Hybrid 8) were planted in methyl-bromide-fumigated silt loam (28.2% sand, 45.4% coarse silt, 5.0% fine silt, 21% clay) or sandy loam (72.4% sand, 20.8% coarse silt, 1.8% fine silt, 5.0% clay) soil in 1-liter plastic containers. The containers were placed in temperature-controlled water tanks. Seeds were allowed to germinate and grow for 4 weeks at 24 C. Then the seedlings were thinned to one per pot and water-tank temperatures were readjusted to 16, 18, 21, and 24 C. Five-week-old seedlings were inoculated with 1,000 second-stage larvae of *H. schachtii* or *M. hapla*. Controls were plants receiving no nematodes. Pots in each temperature tank were arranged in a complete randomized block design, and each treatment was replicated eight times. Ambient temperature in the growth room was maintained at about 24 C. The light source was VHO cool white fluorescent bulbs at an intensity of 4.8×10^3 lumen/sq. meter situated 91 cm above the temperature tanks. Plants were watered as needed and fertilized with Hoagland's nutrient solution every 2 weeks. The experiment was terminated at 18 weeks. Fresh weight of shoots and roots was determined, and nematode counts were made from 850 cc soil and entire roots. Nematodes from soil were extracted by Jenkins' centrifugal-flotation technique (5). *H. schachtii* females and cysts attached to the roots were removed by washing. *M. hapla* second-stage larvae in roots were extracted by placing roots on screens under mist for 7 days.

H. schachtii reproduced best in the silt loam, and *M. hapla* reproduced best in the sandy loam (Table 1). Reproduction of *H. schachtii* was greater at 24 and 21 than at 18 and 16 C. Significantly more *M. hapla* second-stage larvae were recovered at 24 C than at either 21, 18, or 16 C. Nematode population increase with temperature was greater ($P = 0.01$) in silt loam for *H. schachtii* and in sandy loam for *M. hapla*. *H. schachtii* and *M. hapla* both reduced sugarbeet plant fresh weights at 24 C (Table 2) but not at the other temperatures tested. *H. schachtii* reduced top and root weights in both silt loam and sandy loam. *M. hapla*

Received for publication 17 August 1978.

[1] Scientific Paper No. SP 5156, Washington State University College of Agriculture Research Center, Project 1491.

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TABLE 1. Number of cysts[a] of *Heterodera schachtii* and larvae of *Meloidogyne hapla* 13 weeks after inoculation of sugarbeets growing in two soils at four temperatures. Inoculum: 1,000 second-stage larvae per pot.

Nematode and soil type	Soil temperature (°C)			
	16	18	21	24
H. schachtii				
Silt loam	130 a	680 a	4,200 a	4,900 a
Sandy loam	15 b	90 b	590 b	790 b
M. hapla				
Silt loam	1 b	40 b	1,000 b	2,700 b
Sandy loam	1,300 a	1,500 a	30,000 a	140,000 a

[a]Mean of 8 replicates. Values in each pair of figures in a column not followed by the same letter differ significantly at the 5% level (Duncan's multiple-range test).

reduced the weights of shoots, but not of roots in the sandy loam soil, and did not affect plant growth in silt loam. Sugarbeet plant growth, unaffected by soil temperature, was greater in silt loam than in sandy loam ($P = 0.01$).

The results with *M. hapla* support the observation that species of *Meloidogyne* damage sugarbeets more in coarse-textured soils (12). *H. schachtii* occurs in a wide range of soil types (3, 4, 12) but its activity is favored by coarse rather than fine-textured soils (1, 13, 14, 15). Even so, high population densities of *H. schachtii* have been recovered from sugarbeets growing in fine-textured soils (4). Caveness suggests that the occurrence of *H. schachtii* in fine-textured soils may be related to soil structure (4). Studies by Wallace indicate that the emergence of *H. schachtii* larvae from cysts is related to soil structure rather than soil type (13). He suggests that soil aeration is the single most important factor associated with soil structure. Soil structures that favor plant growth also favor activity of *H. schachtii* (14). This statement supports the results we obtained. Both sugarbeet growth and *H. schachtii* reproduction were better in silt loam than in sandy loam. Reduction in sugarbeet growth by these nematode pathogens would probably not have been limited to the highest temperature tested if younger seedlings had been inoculated (6). Heavy root galls induced by *M. hapla* may account for the maintenance of root weight by infected plants.

TABLE 2. Fresh weights of sugarbeet plants grown 18 weeks at 24 C in two soils with and without inoculation with two nematode species.[a]

Soil type and nematode	Shoot weight[b] (g)	Root weight[b] (g)
Silt loam		
0	29.7 a	26.2 a
Meloidogyne hapla	31.2 a	26.6 a
Heterodera schachtii	23.5 b	14.1 b
Sandy loam		
0	25.6 a	25.3 a
M. hapla	19.6 b	24.3 a
H. schachtii	17.2 b	11.2 b

[a]Five-week-old seedlings were inoculated with 1,000 second-stage larvae per pot.
[b]Mean of 8 replicates. Values in each column not followed by the same letter differ significantly at the 5% level (Duncan's multiple-range test).

In central Washington the common occurrence of *H. schachtii* with fine-textured soils and *M. hapla* with coarse-textured soils may be due in part to suboptimal soil temperatures for nematode development. In areas where soil temperatures are commonly optimal for nematode development the effect of soil type may be less pronounced. Our study showed that nematode reproduction increased as soil temperatures approached optimum, regardless of soil type. The combination of suboptimal soil temperatures and soil type probably limits the distribution of *H. schachtii* and *M. hapla* on sugarbeets in central Washington.

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