

The Interrelationship of *Heterodera schachtii* and *Ditylenchus dipsaci* on Sugarbeet¹

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Abstract: *Heterodera schachtii* significantly ($P = 0.05$) reduced sugarbeet root growth below that of uninoculated controls at 20, 24, and 28 C, and *Ditylenchus dipsaci* significantly ($P = 0.05$) reduced root growth below that of uninoculated controls at 16, 20, 24, and 28 C. A combination of *H. schachtii* and *D. dipsaci* significantly ($P = 0.05$) reduced root growth below that of single inoculations of *H. schachtii* at all temperatures and *D. dipsaci* at 20, 24, and 28 C. Single inoculations of *H. schachtii* and *D. dipsaci* significantly ($P = 0.05$) reduced top growth of sugarbeet below that of uninoculated controls at 20, 24, and 28 C, and 16, 20, 24, and 28 C, respectively. A combination of the two nematodes significantly ($P = 0.05$) reduced top growth below that of single inoculations of *H. schachtii* at all temperatures. However, a combination of the two nematodes failed to significantly ($P = 0.05$) reduce top growth below that of single inoculations of *D. dipsaci* at any temperature. Inoculations of either *H. schachtii* or *D. dipsaci* did not affect penetration of the other nematode, and *D. dipsaci* did not affect development and reproduction of *H. schachtii*. *D. dipsaci* did not reproduce on sugarbeet. *Key words:* sugarbeet cyst nematode, alfalfa stem nematode, temperature, penetration, concomitant.

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The association of more than one species of nematode with the decline of a plant is not unusual. The presence of one nematode may enhance or retard the development of another nematode on the same host, and the effect may be reversed with the same two species of nematodes in a different host plant (1,2,3,5,9,10).

The sugarbeet cyst nematode *Heterodera*

schachtii Schm, is found in all major sugarbeet (*Beta vulgaris* L.) production areas of the western United States. The alfalfa stem nematode *Ditylenchus dipsaci* (Kuhn) Filipjev is often found associated with sugarbeet in areas where alfalfa (*Medicago sativa* L.) and sugarbeet are grown in rotation.

In Europe *D. dipsaci* has been found parasitizing sugarbeet for more than 75 years (4), and the same symptomatology has been duplicated in the United States by an alfalfa strain of the nematode (8). There have also been reports from growers and

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extension specialists of poor sugarbeet stands in fields previously planted to alfalfa.

This study was made to determine 1) the interaction of *H. schachtii* and *D. dipsaci* on the growth of sugarbeet and 2) what effect *D. dipsaci* has on penetration, development, and reproduction of *H. schachtii* on sugarbeet.

MATERIALS AND METHODS

Nematode penetration: Pregerminated sugarbeet 'TASCO AH14' seeds were planted in sandy loam soil in a temperature gradient (2–28 C) growth container and inoculated with 300 *H. schachtii* juveniles (J2) and 100 *D. dipsaci* juveniles and adults, singly and in combination in a greenhouse study. Plants, four replicates per 2 C increments, were harvested after 28 days and the number of each species of nematodes per plant determined.

Effect of temperature on nematode interactions: Pregerminated TASCO AH14 seed, one/10-cm container, were inoculated with single and combined nematode species at inoculum densities of 25, 50, 100, and 200 *D. dipsaci* (adults and juveniles) and 100, 500, 1,000, and 2,000 *H. schachtii* (J2). The stem nematode inoculum was obtained from a field population of infected alfalfa, and sugarbeet cyst nematode inoculum was obtained from greenhouse cultured sugarbeet. Treatments, including uninoculated controls, were replicated 10 times and grown in growth chambers at 16, 20, 24, and 28 C. After 50 days growth, plants were harvested and the mortality percentage, top and root weights, and *H. schachtii* development and reproduction were determined.

***D. dipsaci* effect on *H. schachtii* development and reproduction:** Pregerminated TASCO AH14 seed in 10-cm containers (four seeds/container) were inoculated with 100 *D. dipsaci* and grown in temperature controlled chambers at 16, 20, 24, and 28 C. At periods of 0, 21, and 42 days after stem nematode inoculations, plants of each inoculum density were inoculated with 1,000 *H. schachtii* (J2). Treatments, including single inoculations of *D. dipsaci* and *H. schachtii* and uninoculated control, were replicated five times. Fifty days after the final inoculation period, plant root and top weights, plant mortality, and *H.*

schachtii development and reproduction were determined.

RESULTS AND DISCUSSION

Nematode penetration: Combined inoculation of pregerminated seed had no effect on penetration of sugarbeet by either *H. schachtii* or *D. dipsaci* (Fig. 1). Maximum infection of sugarbeet by *D. dipsaci* occurred at 10–28 C, while maximum infection by *H. schachtii* occurred at 28 C. This agrees with previous results (6,7) for penetration of both species of nematodes. There was no antagonism between nematode species, and combined inoculations did not help or hinder penetration of the other nematode. Both nematode species were specific for the area of plant penetration; *D. dipsaci* were found only in epicotyl tissue, while *H. schachtii* were found only in the hypocotyl and root tissue.

Effect of temperature on nematode interactions: Plant root growth was significantly suppressed ($P = 0.05$) at the lower temperatures (16 and 20 C) by *D. dipsaci*

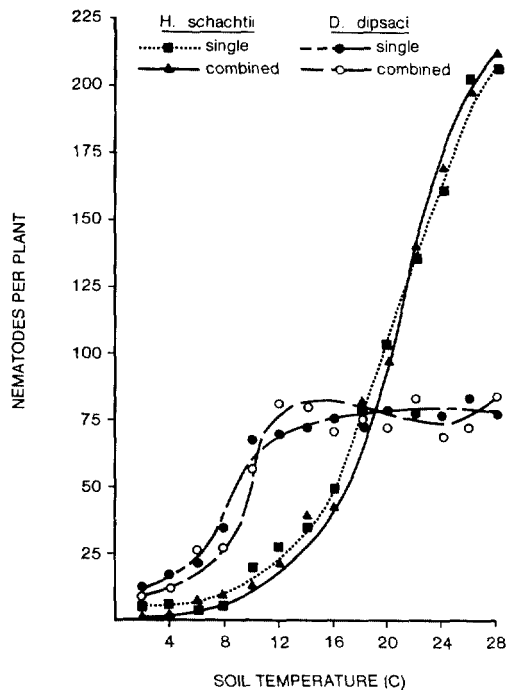


Fig. 1. Effect of soil temperature on penetration of sugarbeet (*Beta vulgaris* cv. TASCO AH 14) seedlings by single and combined inoculations of *Heterodera schachtii* and *Ditylenchus dipsaci*. LSD ($P = 0.05$) = 13.

and at the higher temperatures (24 and 28 C) by *H. schachtii* (Fig. 2). There was, however, for both species, a direct relationship between the root growth suppression and the inoculum density. Root weight suppression from a combination of *D. dipsaci* and *H. schachtii* compared closely to that of single inoculations of *D. dipsaci* at 16 C and *H. schachtii* at 24 and 28 C, indicating that *D. dipsaci* is more virulent at the lower temperatures and *H. schachtii* is more virulent at the higher temperatures. The greatest reduction in root growth from combined inoculations of the two nematode species was observed at 20 C, which was not the temperature at which *H. schachtii* was the most virulent. Soil temperature of inoculum densities affected plant top growth the way it affected root growth except

that *D. dipsaci* in single and combined inoculations caused the greatest reduction of top growth at 24 C (Fig. 3).

Sugarbeet reaction to *D. dipsaci* was similar to that previously described (8); initially, cotyledons were malformed and distorted with bloated petioles. The primary leaves were distorted and swollen, and the stem tissue showed varying degrees of swelling, it being most pronounced at 28 C. Blindness (destruction of the apical meristematic tissue) was common and soon resulted in the death of the sugarbeet plant.

The effect of soil temperature and inoculum density on plant mortality followed the same trend as root and top growth suppression; the highest mortality percentage attributed to *D. dipsaci* was at 16 C; while that for *H. schachtii* occurred at 28 C (Fig.

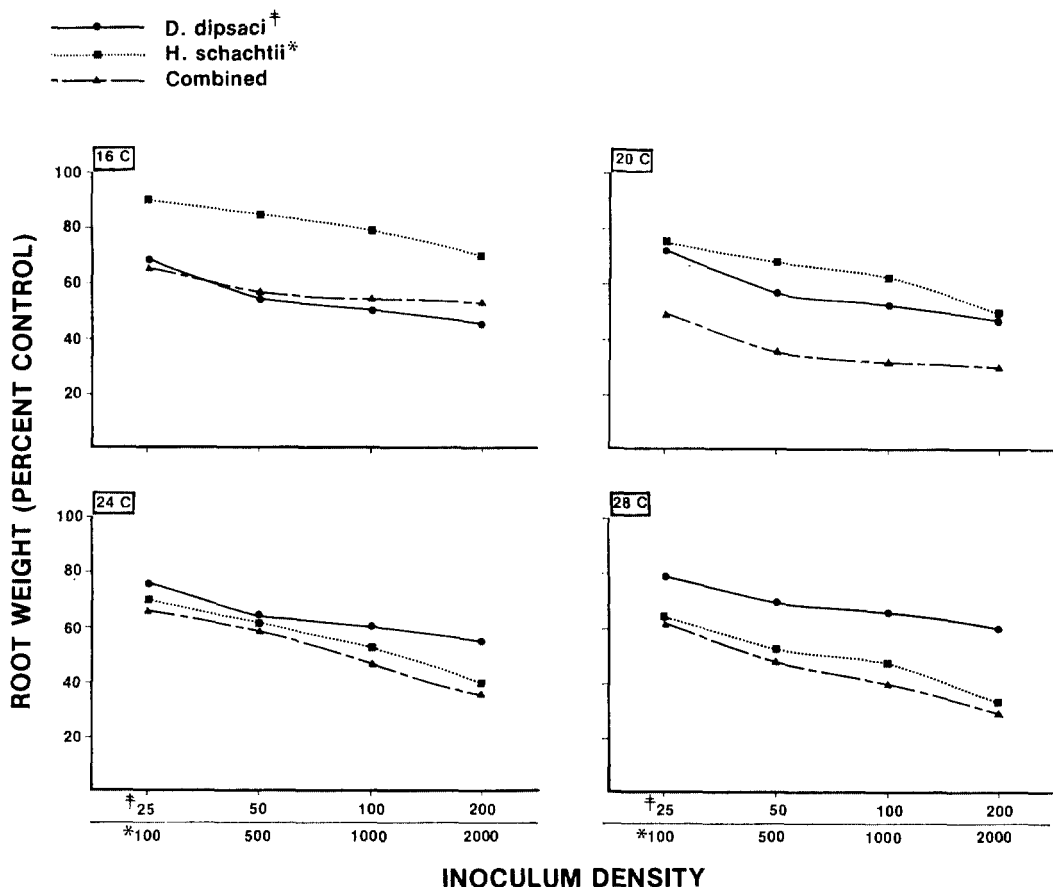


Fig. 2. Effect of single and combined inoculations of *Heterodera schachtii* and *Ditylenchus dipsaci* on sugarbeet (*Beta vulgaris* cv. TASC0 AH 14) root growth. Average uninoculated control weights were 1.85, 2.62, 3.59, and 4.86 g at 16, 20, 24, and 28 C, respectively. LSD ($P = 0.05$) = 15.

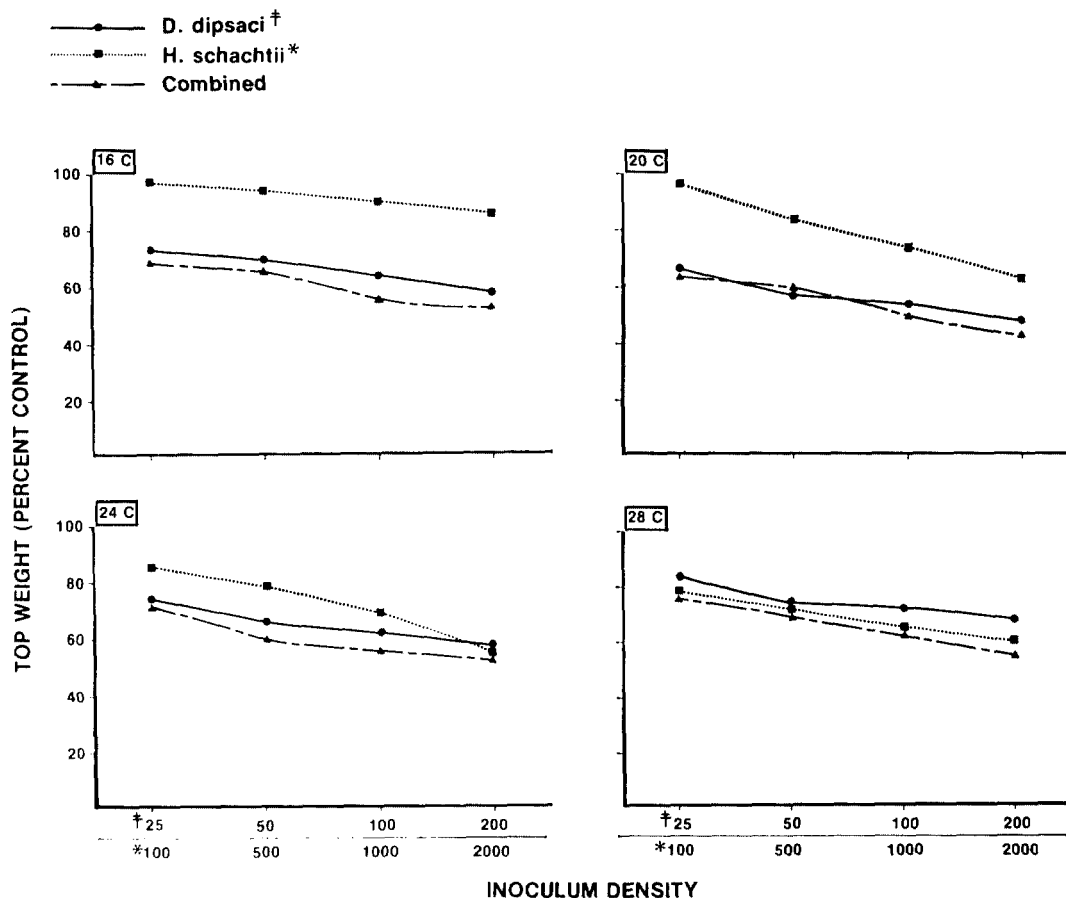


Fig. 3. Effect of single and combined inoculations of *Heterodera schachtii* and *Ditylenchus dipsaci* on sugarbeet (*Beta vulgaris* cv. TASC0 AH 14) top growth. Average uninoculated control weights were 6.87, 8.43, 9.97, and 12.16 g at 16, 20, 24, and 28 C, respectively. LSD ($P = 0.05$) = 12.

4). The greatest nematode virulence (percent mortality) from a combination of *D. dipsaci* and *H. schachtii* was found at 24 C.

Sequential inoculations failed to reduce either root or top plant growth below that of a single inoculation of one or both nematode species. All inoculation patterns, however, consistently reduced root and top growth below that of uninoculated controls. Plant growth was suppressed more at 16 and 20 C by *D. dipsaci* and at 24 and 28 C by *H. schachtii* ($P = 0.05$) (Table 1).

D. dipsaci affect on *H. schachtii* development and reproduction: The *D. dipsaci* obtained from alfalfa failed to reproduce on sugarbeet at any soil temperature (11), and infection did not affect development or reproduction of *H. schachtii* on sugarbeet. There were no differences in the numbers of *H. schachtii* females per plant between

single and combined inoculations, and *H. schachtii* development was only affected by the availability of root tissue (Fig. 5). The greatest number of females per plant (70) was from a combined inoculation of 200 *D. dipsaci* and 2,000 *H. schachtii* (J2) at 24 C. However, when nematode development was based on the number of females per gram of tissue, the greatest development occurred with the same inoculum densities at 28 C (160 females/g root).

The combined inoculation did not significantly ($P = 0.05$) affect nematode reproduction. The average number of eggs per cyst from all inoculum levels in single and combined inoculation was 264, 271, 275, and 272 at 16, 20, 24, and 28 C and 266, 277, 268, and 270 per cyst at temperatures of 16, 20, 24, and 28 C, respectively.

Sequential inoculations (Table 1) failed

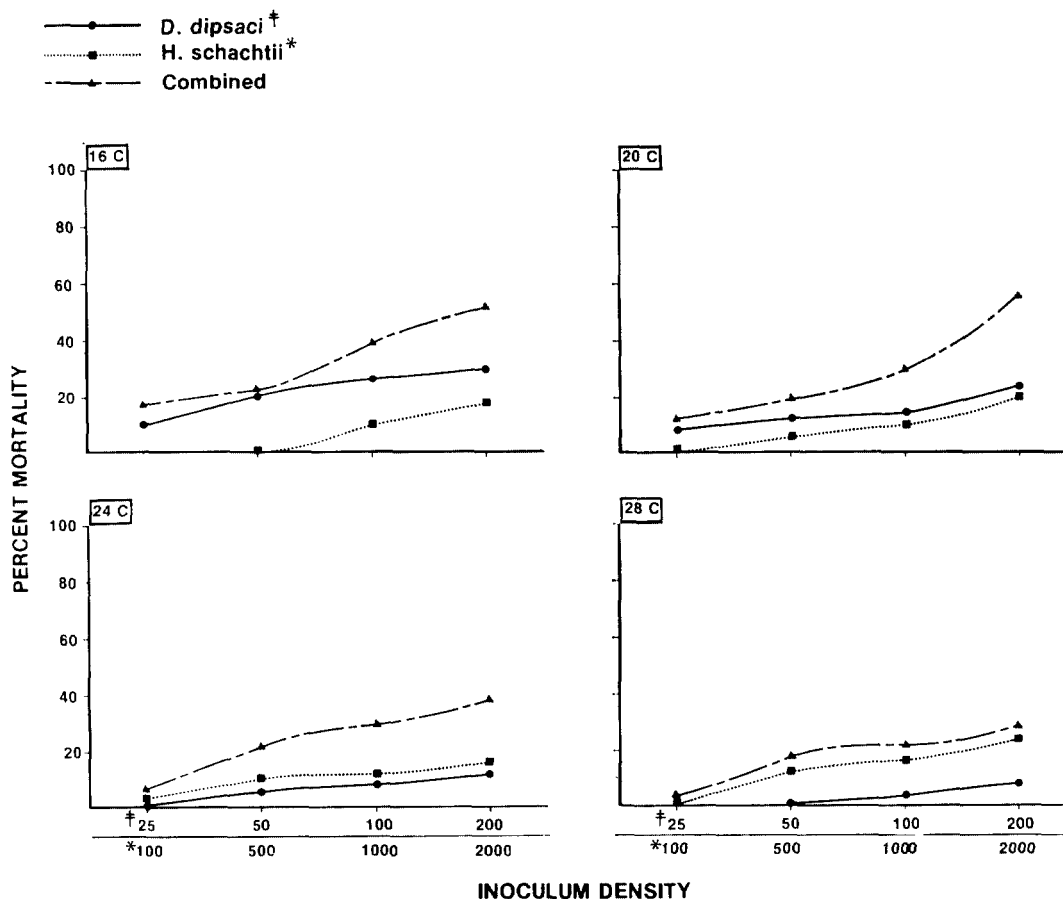


Fig. 4. Effect of single and combined inoculations of *Heterodera schachtii* and *Ditylenchus dipsaci* on sugarbeet (*Beta vulgaris* cv. TASC0 AH 14) plant mortality. LSD ($P = 0.05$) = 8.

Table 1. Effect on various parameters of sequential inoculations of sugarbeet, *Beta vulgaris* (TASC0 AH14) by *Heterodera schachtii* and *Ditylenchus dipsaci* at various temperatures.

Temperature	Parameter	Inoculation sequences*					Uninoculated control	LSD ($P = 0.05$)
		<i>H. schachtii</i> †	<i>D. dipsaci</i> ‡	Com-bined‡	Com-bined§	Com-bined		
16 C	Root weight (g)	1.43	0.88	0.87	0.90	1.03	1.70	0.29
	Top weight (g)	7.16	4.13	4.09	4.16	4.97	7.28	0.82
	Mortality (%)	10	25	35	0	30	0	
20 C	Root weight (g)	1.67	1.12	0.84	0.98	1.13	2.46	0.43
	Top weight (g)	6.83	4.23	4.16	4.59	4.74	8.53	1.16
	Mortality (%)	10	15	30	15	15	5	
24 C	Root weight (g)	1.79	1.94	1.72	1.82	1.90	3.64	0.58
	Top weight (g)	7.13	6.34	5.79	6.12	6.53	10.16	1.28
	Mortality (%)	15	10	30	10	10	0	
28 C	Root weight (g)	1.98	3.19	1.67	1.99	2.83	4.73	0.74
	Top weight (g)	7.24	8.48	7.64	7.86	8.27	12.09	2.03
	Mortality (%)	15	10	25	10	10	0	

*Sugarbeet inoculated with 1,000 *H. schachtii* and 100 *D. dipsaci* singly or in combination. Plants harvested and readings made 50 days after final inoculation.

†Single inoculation of pregerminated seed with *H. schachtii* or *D. dipsaci*.

‡Simultaneous inoculation of pregerminated seed with *H. schachtii* and *D. dipsaci*.

§Pregerminated seed inoculated with *D. dipsaci* and 21 days later with *H. schachtii*.

||Pregerminated seed inoculated with *D. dipsaci* and 42 days later with *H. schachtii*.

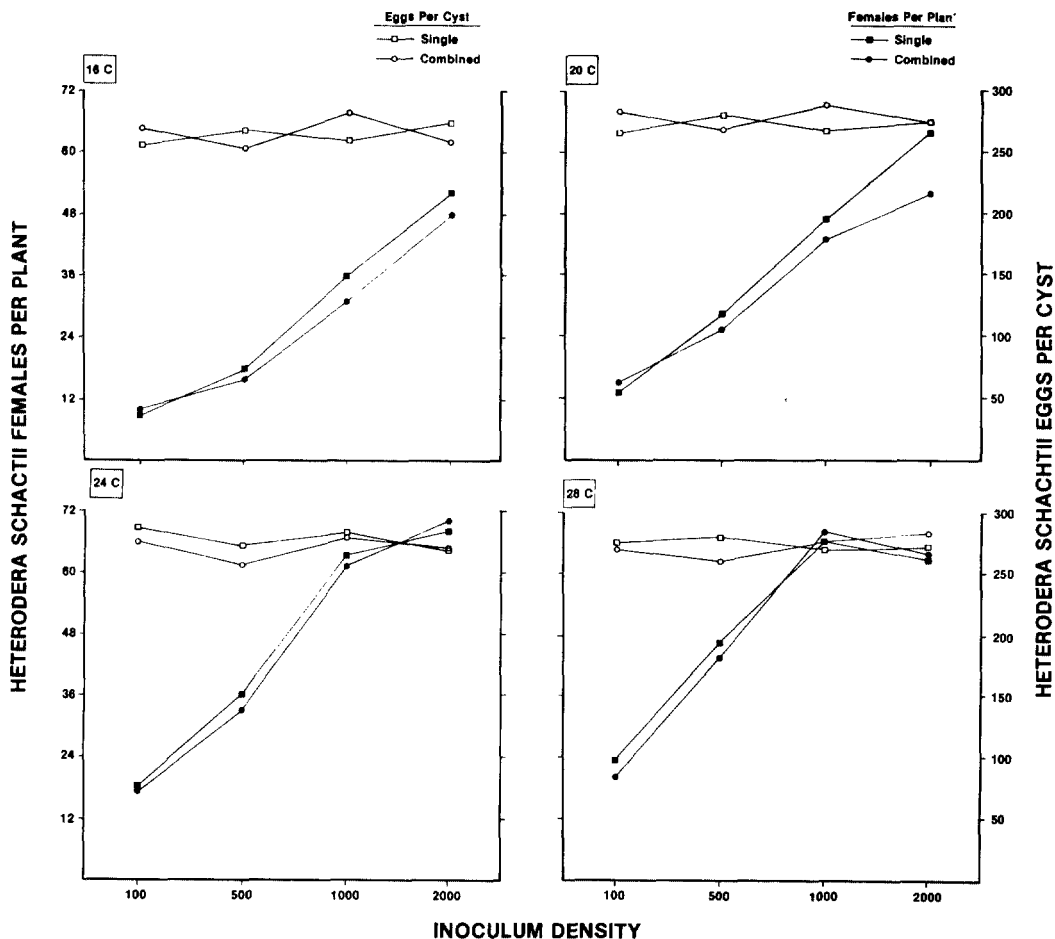


Fig. 5. Effect of combined inoculations of *Heterodera schachtii* and *Ditylenchus dipsaci* on development and reproduction of *Heterodera schachtii* on sugarbeet (*Beta vulgaris* cv. TASC0 AH 14) LSD ($P=0.05$) = Females—18, Eggs—34.

to affect *H. schachtii* development, and results were similar to those shown in Figure 4. Sequential inoculations did not affect nematode reproduction, and the number of eggs per cyst were similar to those shown in Figure 5.

The interaction of *Heterodera schachtii* and *Ditylenchus dipsaci* shows the effect of a combination of two physiologically different plant-parasitic nematodes on the growth of sugarbeet. The results of these experiments confirm that *D. dipsaci* is more virulent at the lower soil temperatures and *H. schachtii* is more virulent at the higher temperatures on sugarbeet.

No competition was observed between the two nematodes. Therefore, under field conditions where both nematodes are present, *D. dipsaci* is expected to inflict more

damage at low soil temperatures prevalent during the early stages of sugarbeet development while damage by *H. schachtii* is accentuated at the higher soil temperatures. Hence, a combination of the two nematodes may inflict serious losses to sugarbeet stands and yields.

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