Population Increase of *Pratylenchus hexincisus* on Corn as Related to Soil Temperature and Type[1]

M. E. Zirakparvar,[2] D. C. Norton,[2] and C. P. Cox[3]

Abstract: Population increase of *Pratylenchus hexincisus* on corn was tested over 3 months at 15, 20, 25, and 30 C in Marshall silt loam, Clarion silt loam, Buckner coarse sand, and Haig silty clay loam soils. The optimum temperature for increase was 30 C in all soils. The nematode population was significantly larger in Buckner coarse sand than in other soil types at 30 C. The recovered *P. hexincisus* populations equaled or exceeded initial inoculum levels at the two higher temperatures in Marshall silt loam and Haig silty clay loam and at 30 C in Clarion silt loam and Buckner coarse sand. *P. hexincisus* required 32,400 heat units in Haig silty clay loam and more than 40,000 heat units in the three other soil types to reach a level that is known to cause significant height and biomass reduction in corn under controlled condition. *Key Words:* lesion nematode, physical factors, heat units.

Pratylenchus hexincisus Taylor and Jenkins is a common nematode of economic significance to corn production in Iowa (9, 15,16). Large numbers of the nematode occur in fine-textured (7,12) as well as in sandy soils (9,15). Few ecological studies with *P. hexincisus* have been made, and these have not included interactions of soil texture and temperature on population increase of the nematode. Soil temperature, texture, and type are important as parameters affecting distribution and population levels of nematodes (8) and host responses to them (2,5,14). The purpose of this study was to determine the relationships of soil temperature and type on population increase of *P. hexincisus* in corn.

Received for publication 10 March 1980.

[1]Journal Paper No. J-9811 of the Iowa Agriculture and Home Economics Experiment Station, Ames, IA 50011. Project 2285.

[2]Department of Plant Pathology, Seed and Weed Sciences, Iowa State University, Ames, IA 50011.

[3]Department of Statistics, Iowa State University, Ames, IA 50011.

MATERIALS AND METHOD

Treatments: A factorial growth chamber experiment was designed to measure the population growth of *P. hexincisus* on corn in four soils at four temperatures (Table

1). The four soils used were Marshall silt loam (19% sand, 55% silt, 26% clay, 21% field capacity [FC], 3.8% organic matter [OM], pH 5.3); Clarion silt loam (16% sand, 58% silt, 26% clay, 23% FC, 5.3% OM, pH 6.2); Buckner coarse sand (86% sand, 9% silt, 5% clay, 6% FC, 1.9% OM, pH 6.3); and Haig silty clay loam (60% sand, 19% silt, 21% clay, 20% FC, 4.% OM, pH 5.9). All soils were steam sterilized at 15 lb pressure for 6 h. Twelve 15-cm-d clay pots, each containing 1,500 cm^3 of soil, were used for each soil type and temperature combination, providing four single-pot replications harvested at each of three times—1, 2, and 3 months after planting.

Pioneer Brand 216 x 238 corn, a hybrid known to be susceptible to *P. hexincisus*, was germinated in petri dishes lined with wet paper, and one seedling was planted 2.5 cm deep in the center of each pot. Ten milliliters of water containing 2,000 ± 100 nematodes were pipetted into a 3-cm-deep hole near the seedling 3 d after planting at each of the four temperatures. Pots were watered as needed with water at the same temperature as the growth chamber. Fertilizer (N-P-K, 6-10-4) was added at 6 g/pot 1 month after planting.

Nematode recovery: The roots and soil were removed from each pot, and the soil was shaken gently from each root system and mixed thoroughly. *P. hexincisus* was extracted from 100 cm^3 of soil from each pot using the centrifuge-flotation method (6). Adhering soil was washed from the roots, and 1–2 g of roots from each root system were selected randomly and cut into 1.5-cm segments for nematode extraction by the shaker method (1). The remaining root mass and the roots used for extraction were dried at 90 C for 5 d. Numbers of *P. hexincisus* per gram of dry root and per whole root system were calculated. Numbers of *P. hexincisus* per pot were determined by multiplying the number of nematodes per 100 cm^3 of soil by 15 and adding the result to the number of nematodes per whole root system. Because of the large range of nematode numbers for any given sample, the data were transformed as follows: $X = \log(x + 1)$, where x is the original nematode count.

RESULTS

Soil and temperature interactions: At 30 C numbers of *P. hexincisus* per gram dry root and per pot differed ($P < 0.01$) among the four soils at all sampling times (Figs. 1, 2). After 3 months at this temperature, the highest numbers of *P. hexincisus* per gram dry root and per pot occurred in Buckner coarse sand and the lowest numbers in Marshall silt loam (Figs. 1, 2). At 25 C a difference ($P < 0.01$) in numbers of *P. hexincisus* per gram dry root and per pot occurred in Buckner coarse sand at the second sampling. At 20 C numbers of *P. hexincisus* per pot increased significantly ($P < 0.05$) only in Marshall silt loam by the third month (Fig. 2). At 15 C no significant differences in nematode numbers among the four soil types were obtained, and numbers decreased through the second and third months.

The optimum temperature for *P. hexincisus* increase in all soils was 30 C, with final populations (P_f) being greater ($P = 0.01$) than initial populations (P_i) (Fig. 2). At 25 C, *P. hexincisus* invaded the roots and increased slightly. Only in Haig silty clay loam and Marshall silt loam soils did the P_f exceed the P_i level after 3 months (Fig. 2). Few *P. hexincisus* were recovered from roots growing at 15 C and 20 C in any soil (Fig. 1).

P. hexincisus numbers in roots were correlated ($P < 0.05$) with percentage sand ($r = 0.25$), silt ($r = 0.22$), clay ($r = 0.30$) pH ($r = 0.25$), organic matter ($r = -0.24$), field capacity ($r = -0.28$), saturation ($r = -0.27$), and cation exchange capacity ($r = -0.23$). Numbers of *P. hexincisus* in soil were correlated ($P \leq .05$) with organic matter ($r = 0.12$) and cation exchange capacity ($r = 0.11$).

Heat units: The time and temperature combinations for development of *P. hexincisus* can be expressed in heat units (13). Each celsius degree above 10 C acting for 1 h is counted as 1 heat unit. Populations of *P. hexincisus* increased in the same soil with increasing heat units at 25 and 30 C but not at 15 and 20 C (Table 1). The heat unit requirement for *P. hexincisus* increase changed according to the temperature at which it was maintained. For example, in

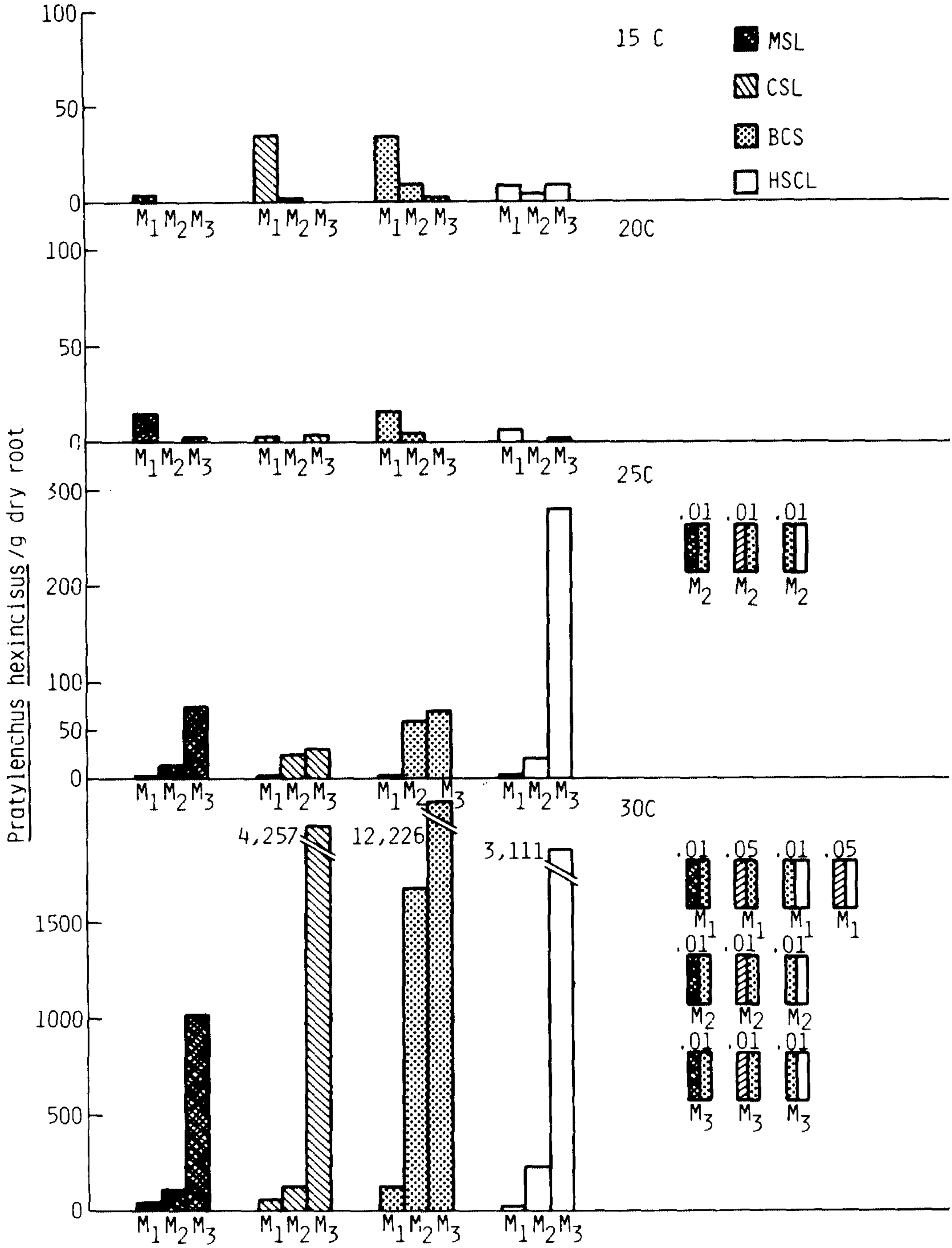

Fig. 1. Numbers of *Pratylenchus hexincisus* per gram dry root of corn obtained after 1, 2, and 3 months' growth (M_1, M_2, M_3) at four temperatures in four soils: Marshall silt loam (MSL), Clarion silt loam (CSL), Buckner coarse sand (BCS), and Haig silty clay loam (HSCL). An inoculum of 2,000 *P. hexincisus* was used. Differences between boxed pairs at right are significant at levels indicated.

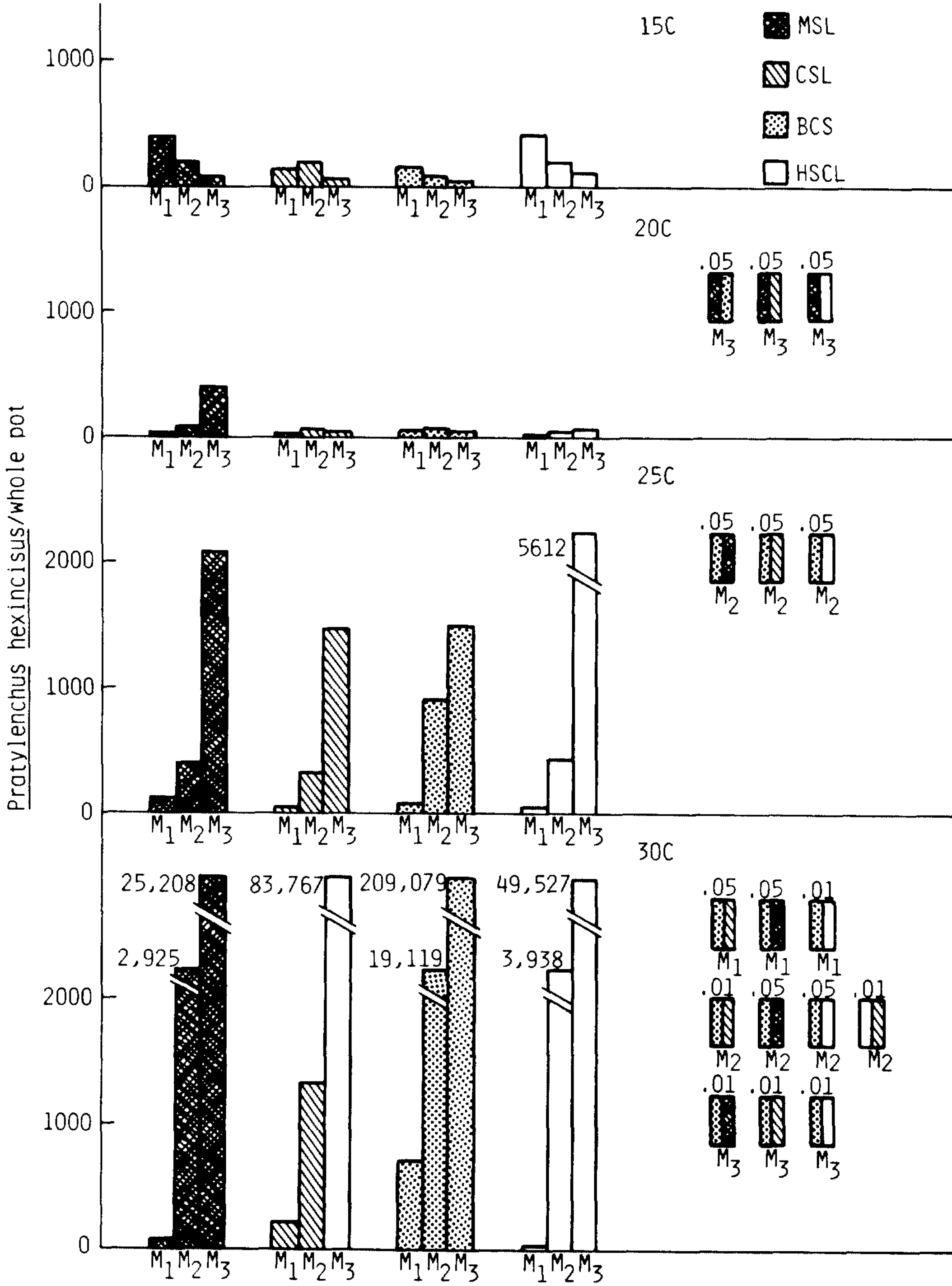

Fig. 2. Numbers of *Pratylenchus hexincisus* per pot obtained after 1, 2, 3 months' growth (M_1, M_2, M_3) at four temperatures in four soil types: Marshall silt loam (MSL), Clarion silt loam (CSL), Buckner coarse sand (BSC), and Haig silty clay loam (HSCL). An inoculum of 2,000 *P. hexincisus* was used. Differences between boxed pairs at right are significant at levels indicated.

Table 1. Numbers of *Pratylenchus hexincisus* obtained after 1, 2, and 3 months' growth on corn at four temperatures in four soil types. Initially 2,000 *P. hexincisus* were added.

Soil type	Heat units	Months	°C	*P. hexincisus*/pot*
Buckner coarse sand	3,600	1	15	174a
	7,200	1	20	51b
	10,800	1	25	71b
	14,400	1	30	723c
	7,200	2	15	113a
	14,400	2	20	74a
	21,600	2	25	917b
	28,800	2	30	19,114c
	10,800	3	15	42a
	21,600	3	20	23a
	32,400	3	25	1,495b
	43,200	3	30	209,072c
Clarion silt loam	3,600	1	15	146a
	7,200	1	20	36b
	10,800	1	25	41b
	14,400	1	30	236c
	7,200	2	15	213a
	14,400	2	20	74b
	21,600	2	25	326a
	28,800	2	30	1,331c
	10,800	3	15	68a
	21,600	3	20	58a
	32,400	3	25	1,483b
	43,200	3	30	83,767c
Haig silty clay loam	3,600	1	15	434a
	7,200	1	20	16b
	10,800	1	25	46b
	14,400	1	30	46b
	7,200	2	15	202a
	14,400	2	20	49b
	21,600	2	25	435c
	28,800	2	30	3,938d
	10,800	3	15	116a
	21,600	3	20	86a
	32,400	3	25	5,612b
	43,200	3	30	49,527c
Marshall silt loam	3,600	1	15	298a
	7,200	1	20	25b
	10,800	1	25	130c
	14,400	1	30	89c
	7,200	2	15	191a
	14,400	2	20	79b
	21,600	2	25	413c
	28,800	2	30	2,925d
	10,000	3	15	86a
	21,600	3	20	394b
	32,400	3	25	2,082c
	43,200	3	30	25,208d

*Values followed by the same letters within each column of four do not differ ($P \leq 0.05$) using Duncan's multiple range test.

Buckner coarse sand 28,800 heat units were accumulated after 60 d at 30 C, during which *P. hexincisus* increased to 19,114/pot. Yet, in the same soil the P_f was only 1,495/pot when 32,400 heat units accumulated after 90 d at 25 C (Table 1). P_f numbers differed with the same number of heat units in different soils. For example, 43,200 heat units accumulated for 90 d at 30 C resulted in 209,072, 83,767, 49,527, and 25,208 nematodes/pot in the Buckner, Clarion, Haig, and Marshall soils, respectively (Table 1).

DISCUSSION

Although *P. hexincisus* increased in higher numbers in all soils at 30 C, numbers per gram of dry root and per pot were significantly higher in Buckner coarse sand than in the other soil types. Our results support those of others (7,9,12,15), who found that *P. hexincisus* is abundant in fine-textured as well as coarse-textured soils and that 30 C is optimum for *P. hexincisus* reproduction (10). The number of heat units needed for a nematode to complete its life cycle or produce a certain number of individuals may differ with such environmental factors as nutrients or host and soil type (4,11,13).

The numbers of heat units from May through September in Iowa are adequate for large increases of *P. hexincisus.* The average soil temperatures at the 5- to 15-cm depth in central Iowa reach 25 C by the end of May and peak at 27–31 C in July (3). Accumulations of over 35,000 heat units occur during a corn growing season in Iowa, explaining the natural occurrence of large numbers of this nematode in the field. Up to 39,000 *P. hexincisus*/g dry root have been associated with severely stunted corn plants in Iowa. Other stresses, however, such as below-normal moisture, low fertility, and other organisms, including nematodes, can reduce the number of *P. hexincisus* necessary to cause measurable injury in the field (9).

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