Influence of Temperature on Population Development of Eight Species of Pratylenchus on Soybean

NELIA ACOSTA and R. B. MALEK

Abstract: In a soil temperature study, population increase on 'Clark 63' soybean was most rapid at 30°C in *Pratylenchus alleni*, *P. brachyurus*, *P. coffeae*, *P. neglectus*, *P. scribneri*, and *P. zeae* and at 25°C in *P. penetrans* and *P. vulnus*. The last two were the only species that reproduced at 15°C. Populations of all species increased over the range of 20-30°C, except those of *P. neglectus* at 20°C and *P. coffeae*, which was not tested below 25°C. Only *P. brachyurus*, *P. neglectus*, *P. scribneri* and *P. zeae* reproduced at 35°C. At their optimum temperatures, *P. scribneri* exhibited the greatest population increase, 1248-fold, and *P. penetrans* the least, 32-fold. This is the first report of soybean as a host for *P. vulnus*. Key Words: *Pratylenchus alleni*, *P. brachyurus*, *P. coffeae*, *P. neglectus*, *P. penetrans*, *P. scribneri*, *P. vulnus*, *P. zeae*. lesion nematodes, host-parasite relationships, ecology, susceptibility, *Glycine max*.

The activity of soil-inhabiting nematodes is influenced to some degree by each of the many biotic and abiotic factors in their complex environment. Temperature is particularly important, affecting movement, rate of growth and reproduction, sex determination, relative abundance of food, and expression of nematode damage to plants (11). There have been numerous reports concerning the influence of this factor on host-nematode relationships but few involving soybean (*Glycine max* [L.] Merr.) and lesion nematodes. Knowledge of the effects of temperature on population development of these nematodes on soybean is limited to findings of Lindsey and Cairns (6), who reported that the density of

Pratylenchus brachyurus (Godfrey) Filipv. and Schuurm.-Stekh. populations in roots of several cultivars generally increased with temperature up to the test maximum of 29°C.

Greenhouse culture tests have indicated that several species of *Pratylenchus* reproduce rapidly on soybean during the summer months. This study was conducted to determine the influence of temperature on the population development on soybean of *P. alleni* Ferris, *P. brachyurus*, *P. coffeae* (Zimmerman) Filipv. and Schuurm.-Stekh., *P. neglectus* (Rensch), Filipv. and Schuurm.-Stekh., *P. penetrans* (Cobb) Filipv. and Schuurm.-Stekh., *P. scribneri* Steiner, *P. vulnus* Allen and Jensen, and *P. zeae* Graham.

MATERIAL AND METHODS

Original sources of nematodes were: *P. alleni* from *Syringa persica* L., Onarga, Illinois; *P. brachyurus* from *Ananas comosus* Merr., Corozal, Puerto Rico; *P. coffeae* from *Dioscorea rotundata* Poir., Corozal, PR; *P.
neglectus from Chenopodium album L., Fort Michell, Nebraska; P. penetrans from Medicago sativa L., callus tissue, University of Maryland; P. scribneri from Zea mays L., Urbana, IL; P. vulnus from Rosa sp. (greenhouse), Pana, IL; P. zeae from Glycine max, Mayaguez, PR. Where species identities had not been fully established, they were subjected to comprehensive morphological and morphometric comparison with original descriptions. Nematode populations were increased on soybean and inocula extracted from roots in a mist chamber by the funnel-spray method of Oostenbrink (7).

Two 'Clark 63' soybean seedlings were planted in each of 152 fifteen-cm-diam plastic pots containing 1,400 cm³ of steam-sterilized Sparta loamy fine sand, a non-organic, heterogeneous soil with a pH of 4.5. When cotyledons emerged, an inoculum of 1,000 nematodes of the appropriate species/pot was poured into a hole in the center of the pot and the hole was filled with soil. Inocula consisted of only vermiform stages in approximately equivalent numbers within and among species. After 5 days of incubation on a greenhouse bench, each pot was nested in a impervious pot of similar diam. Four pots of each species were arranged randomly in 15, 20, 25, 30, and 35 C constant-temperature tanks, except for P. coffeae, which was studied only at the upper three temperatures because of low availability of inoculum. No nodulating bacteria were added to the plants, but a 23-19-17 fertilizer solution was applied monthly.

Plants were grown in the tanks for 75 days, which preliminary tests indicated was the optimum incubation period before nematode-population ceiling levels were reached in some of the species at favorable temperatures. Plant weights were recorded for comparison of growth. Nematodes were extracted from washed intact root systems in a mist chamber (7) and from soil by a modification of the method of Christie and Perry (2).

RESULTS AND DISCUSSION

The eight species of Pratylenchus differed considerably in their temperature requirements and ability to reproduce on soybean (Table 1). The optimum temperature for population development of P. alleni, P. brachyurus, P. coffeae, P. neglectus, P. scribneri, and P. zeae was 30 C, while that for P. penetrans and P. vulnus was 25 C. The last two were the only species that reproduced at the relatively low temperature of 15 C. Populations of all species increased to some extent over the range of 20 to 30 C, except those of P. neglectus at 20 C and P. coffeae, which was not tested at the lower temperature. Only P. brachyurus, P. neglectus, P. scribneri, and P. zeae reproduced at 35 C. The temperature optima for all but P. alleni and P. penetrans were well defined by substantially reduced population development at ±5 C of the optimum. Where reproduction was significant, 95–99% of the nematodes were recovered from roots.

Among the species at their respective optimum temperatures, P. scribneri had the

<table>
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<th>Species</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
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<td>30.9ab</td>
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<td>—</td>
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<td>352.2bc</td>
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<td>2.2c</td>
<td>1106.6d</td>
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<td>271.1d</td>
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<td>1.7a</td>
<td>7.5c</td>
<td>138.5ab</td>
<td>33.0b</td>
</tr>
</tbody>
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*Each value is the mean of four replications; column means followed by unlike letters differ (P ≤ 0.05), according to Duncan's new multiple-range test.
greatest amount of reproduction, increasing in numbers 1248-fold over the initial level at 30°C. Its population also increased more than that of any other species at 35°C. In general, *P. neglectus* and *P. zeae* behaved similarly to *P. scribneri*, but reproduction was less extensive. Population development of all three species at 35°C may have been restricted by retarded plant growth caused by high-temperature stress. Development was much reduced at 25°C and negligible at 20°C. Unpublished results of a related study (1) confirmed the temperature response of *P. scribneri* and indicate that its real optimum on soybean is 33°C or 34°C. Comparable trends in temperature response were found by Thomason and O'Melia (10) with *P. scribneri* on sugar beet (*Beta vulgaris* L.), Sudan grass (*Holcus sudanensis* Bailey), and snap bean (*Phaseolus vulgaris* L.), and by Graham (5) with *P. zeae* on tobacco (*Nicotiana tabacum* L.) and corn (*Zea mays* L.).

*Pratylenchus brachyurus*, *P. coffeae* and *P. alleni* had similar temperature requirements, which were lower than those of the more thermophilic species. Unlike those species, *P. brachyurus* and *P. alleni* populations increased at least 5-fold at 20°C. Within this group at their optimum of 30°C, population development was most extensive in *P. brachyurus*, which increased 529-fold. Lindsey and Cairns (6) also found that population densities of this species increased in roots of soybean as temperature approaches 30°C. Graham (5) obtained a similar response to temperature in *P. brachyurus* on corn and tobacco. The temperature optimum for *P. coffeae* was the same as that found by Radewald et al. (8) on rough lemon (*Citrus ×jambhiri* Lush). Population development by *P. alleni* was comparatively low. Although its numbers at 25 and 30°C did not differ widely, unpublished results of related work (1) with this species confirmed that its optimum is close to 30°C and that reproduction ceases at 35°C.

*P. penetrans* and *P. vulnus* had similar requirements for relatively cool temperatures. There was some degree of population increase at temperatures as low as 15°C but little development at 30°C and none at 35°C. *P. penetrans* showed the least increase of any of the eight species, only 31-fold at its optimum of 25°C. Numbers were not substantially lower at 20°C, indicating that its real optimum on soybean probably lies at 22 or 23°C. Dickerson et al. (3) reported that populations of this species increased most rapidly at 24°C on corn and at 16°C on potato (*Solanum tuberosum* L.). Dunn (4) obtained highest numbers from alfalfa plants at 30°C in 90 days, although the ceiling level may have been reached earlier at lower temperatures, because he recorded greater population growth at 27°C than at 30°C on alfalfa callus. Sher and Bell (9) found that *P. vulnus* reproduced on rose (*Rosa* sp.) throughout a range of 18–32°C but that populations increased most rapidly between 24 and 29°C. *P. vulnus* has not heretofore been known to parasitize soybean. The finding that it readily reproduces on that plant thus constitutes the first report of soybean as a host.

Results of this study demonstrate considerable physiological differences among species of *Pratylenchus* with respect to temperature requirements. The individual preferences may be a significant factor governing the distribution of at least some of the species, as was concluded by Wallace (11) for many other nematodes. The results also show that temperature plays an important role in the relative susceptibility of soybean to members of the genus *Pratylenchus*.

**LITERATURE CITED**

Wave Forms of Caenorhabditis elegans in a Chemical Attractant and Repellent and in Thermal Gradients

T. A. RUTHERFORD and N. A. CROLL

Abstract: The wave forms and activity patterns of Caenorhabditis elegans were examined on agar in the presence of known chemical attractants (NaCl) and repellents (D-tryptophan), and in thermal gradients. Total activity was reduced in both attractants and repellents. Different combinations of transfers between chemicals were investigated. Two thresholds were found for NaCl: 10^{-3} M NaCl caused reduced activity; 10^{-5} M NaCl increased reversals. D- or L-tryptophan influenced neither orientation nor the ability of thermally acclimatized individuals to remain at their ecritnic temperature. Key Words: Behaviour; wave patterns; movement; thermotaxis; chemotaxis; acclimatization; neurobiology.

The influence of chemicals on the behaviour of Caenorhabditis elegans has been studied exclusively in chemical gradients (6, 11). NaCl, cyclic nucleotides, and alkaline pH are attractants. The D-isomer of tryptophan has been described as a ‘repellent’ (6). The non-directional behavioural movements of C. elegans have also been analysed in sterile conditions, or in bacteria or nutrient media (2, 3, 4). The detailed effects of chemicals on the wave forms and frequencies in movement have not been investigated. C. elegans and other nematodes accumulate at ecritnic temperatures to which they have been acclimatized (7). No studies have described the influence of temperatures on the wave forms and frequencies of C. elegans. Analysis of the behaviour of C. elegans in NaCl and D-tryptophan, and when given thermal changes, is hoped to further understanding of the nature of nematode orientation.

MATERIALS AND METHODS

Caenorhabditis elegans wild type (Bristol strain) was used throughout; they were cultured in 5-cm-diam petri dishes containing 10 ml Czapek-dox agar (1.4%) (Difco Laboratories, Detroit, Michigan) with Escherichia coli at 20 C (2). Gravid females (ca 6 ± 1 days old) were used, and, unless stated otherwise, all observations were carried out at 20 C. A water-filled temperature controlled microscope stage ensured that this temperature was constant. The observation chamber was made of clear plastic, and temperature equilibrium of thin layers of agar occurred within 30 sec of being placed in the stage.

The time patterns of the activities of individuals were recorded with a multi-channel event recorder. Events recorded were: 1) backward waves (BW) resulting in forward motion; 2) forward waves (FW) arising from a reversal and resulting in backwards motion; and 3) “Omega” waves (OW), which result in sharp turns of around 180° (2).

All individuals were from cultures with a substantial bacterial lawn in which the nematodes were considered to be well-fed.