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Pathogenicity of *Pratylenchus penetrans* to Navy Bean (*Phaseolus vulgaris* L.)¹

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Abstract: The pathogenicity of *Pratylenchus penetrans* (root-lesion nematode) to *Phaseolus vulgaris* (navy bean) was evaluated in greenhouse experiments. Shoot and root fresh weight of cv. Sanilac plants were increased 4 and 21%, respectively, by an initial population density (Pi) of 25 *P. penetrans* per 100 cm³ soil. Leaf area and shoot fresh and dry weights were decreased by a Pi of 50 or more *P. penetrans* per 100 cm³ soil. A significant positive linear relationship existed between initial soil population densities of *P. penetrans* and final soil and root population densities of this nematode. Three dry bean cultivars, Sanilac, Seafarer, and Tuscola, were susceptible to *P. penetrans*, and yields were reduced by 43-76% when plants were exposed to a Pi of 150 *P. penetrans* per 100 cm³ soil. *P. penetrans* also reproduced on bean cultivars Saginaw, Gratiot, and Kentwood, but did not decrease bean yields, suggesting that these cultivars were tolerant to this nematode.

Key words: root-lesion nematode, bean yields, cultivars, population densities.

About 250,000 ha of dry beans (*Phaseolus vulgaris* L.) are grown annually in Michigan. A survey for plant parasitic nematodes associated with this crop in Michigan indicated that *Pratylenchus penetrans* (Cobb, 1917) Filipjev & Schuurmans-Stekhoven, 1941 was the most common root-lesion nematode species present (2). *Pratylenchus* spp. have wide host ranges and are pathogenic to many important crop plants, including *P. vulgaris* (5,10). No information is available on the susceptibility to *P. penetrans* of the cultivars of navy beans grown in Michigan. Our objectives were 1) to study the pathogenicity of *P. penetrans* to one cultivar of navy bean and 2) to determine the relative susceptibility of six navy bean cultivars to *P. penetrans*.

MATERIALS AND METHODS

Experiment 1: A completely randomized greenhouse experiment of six replicates of six initial population densities (Pi) of *P. penetrans* (0, 25, 50, 100, 150, and 300/100 cm³ soil) was used to evaluate the patho-

genicity of *P. penetrans* to Sanilac navy beans. Thirty-six 21.5-cm-d clay pots were filled with 3,000 cm³ of sandy clay loam soil (6% silt, 26.5% clay, 67.5% sand, 1.8% organic matter, pH 6.1) containing the desired nematode population densities. Experimental soils were obtained by mixing steam-sterilized sandy clay loam soil with *P. penetrans*-infested soil from greenhouse cultures maintained on dry beans. Three bean seeds were planted in each pot. Plants were thinned 2 days after emergence to one seedling per pot, watered daily, and maintained at 26.7 ± 2.8 C for 108 days. Shoot, root, and bean fresh weights were measured. Relative estimates of leaf area were determined by passing individual leaves through a Lambda optical scanner, Model LI 3000®. The shoot systems were then oven dried at 30 ± 5 C and shoot dry weights recorded. Soil and root samples were analyzed for *P. penetrans* using the centrifugal-flotation and shaker techniques and light microscopy (1,4).

Experiment 2: A second greenhouse test evaluated the susceptibility of six navy bean cultivars (Sanilac, Seafarer, Tuscola, Saginaw, Gratiot, and Kentwood) to *P. penetrans*. A completely randomized design was used with three replicates of each of the six navy bean cultivars analyzed at each of seven sampling dates. One hundred twenty-six 12.6-cm-d clay pots were filled with 1,000 cm³ steam-sterilized sandy clay loam

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soil or the same soil containing an initial population density of 150 *P. penetrans*/100 cm³. The desired nematode density was obtained by mixing steam-sterilized McBride sandy clay loam soil with an appropriate quantity of *P. penetrans*-infested soil from greenhouse cultures. Three seeds were planted per pot, and plants were thinned 2 days after emergence to one seedling per pot. Plants were watered daily and maintained at 23.9 ± 5.6 C in the greenhouse for up to 108 days.

Shoot dry weights and leaf areas were measured after 14, 21, 28, 42, 56, 70, and 84 days. Bean yields were taken at the end of the experiment. Time intervals were converted to accumulative degree days at a base of 10 C (DD₁₀) for comparison of the stages of physiological development of plants and nematodes. Relative plant growth rates (RGR) were calculated (2,3):

$$\text{RGR} = \ln dW_2 - \ln dW_1 / T_2 - T_1$$

where W_2 = dry weight of navy bean shoot system at time T_2 , W_1 = dry weight of shoot at time T_1 , and T = time in weeks. Soil and root samples were analyzed for *P. penetrans* using the centrifugal-flotation and shaker techniques and light microscopy (1,4).

RESULTS

Experiment 1: Shoot and root fresh weights, shoot dry weights, leaf areas, and bean yields of Sanilac plants exposed to Pi of 50, 100, 150, or 300 *P. penetrans* per 100 cm³ soil were significantly ($P = 0.05$) lower than those of plants grown in nematode-free soil (Figs. 1, 2). A Pi of 25 *P. penetrans* per 100 cm³ soil resulted in a significant ($P = 0.05$) increase in shoot and root fresh weights, whereas shoot dry weight and leaf area decreased.

Final soil and root population densities of *P. penetrans* increased with increases in Pi (Fig. 3). Regression of the log of initial soil densities of *P. penetrans* indicated a sig-

nificant linear relationship, $\log Y = 0.90 + 1.04(\log X)$ where Y = log of final densities of *P. penetrans* plus one and X = log of initial densities of *P. penetrans* plus one. Regression of the log of the final root population densities of *P. penetrans* also indicated a significant linear relationship, $\log Y = 0.10 + 0.99(\log X)$ where Y = log of final densities of *P. penetrans* plus one and X = log of initial densities of *P. penetrans* plus one.

Experiment 2: The RGR of navy bean cultivars Sanilac, Seafarer, and Tuscola infected with *P. penetrans* were lower than those of noninfected plants (Fig. 4). The RGR of Sanilac was higher in noninfected than infected plants throughout the experimental period. Growth rates of noninfected Seafarer and Tuscola plants were higher than those of *P. penetrans* infected plants through 930 accumulated degree days at a base of 10 C. *P. penetrans* did not influence the RGR of Gratiot, Saginaw, or Kentwood (Fig. 5). Compared to noninfected plants, dry bean yields of Sanilac, Seafarer, and Tuscola were significantly ($P = 0.05$) lower—71, 43, and 46%, respectively—when grown in the presence of *P. penetrans* (Fig. 6). Yields of Gratiot, Saginaw, and Kentwood navy beans were not significantly ($P = 0.05$) influenced by *P. penetrans*.

Pratylenchus penetrans were recovered from the roots of all six bean cultivars. Significantly higher total root and soil population densities of *P. penetrans* were associated with Sanilac, Seafarer, and Tuscola than with Gratiot, Saginaw, and Kentwood (Fig. 7). Nematode population density maxima of 310, 390, and 430 *P. penetrans* per 100 cm³ soil plus 1.0 g root tissue were observed at 740 DD₁₀, respectively, on Seafarer, Sanilac, and Tuscola. This was followed by a decrease in *P. penetrans* population density until 1,080 DD₁₀, and then an increase at the end of the growth period

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FIG. 1. Influence of *Pratylenchus penetrans* on shoot fresh and dry weight and leaf area of *Phaseolus vulgaris* cv. Sanilac.

FIG. 2. Influence of *Pratylenchus penetrans* on root dry weight and bean yield of *Phaseolus vulgaris* cv. Sanilac.

FIG. 3. Relation between the initial and final soil and root population densities of *Pratylenchus penetrans* associated with *Phaseolus vulgaris* cv. Sanilac.

FIG. 4. Influence of *Pratylenchus penetrans* on the relative growth rate of *Phaseolus vulgaris* cultivars Sanilac, Seafarer, and Tuscola.

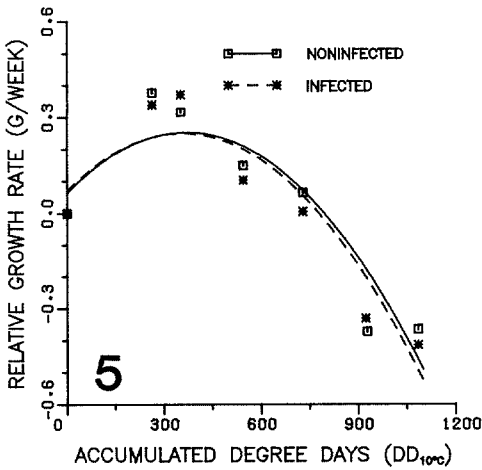
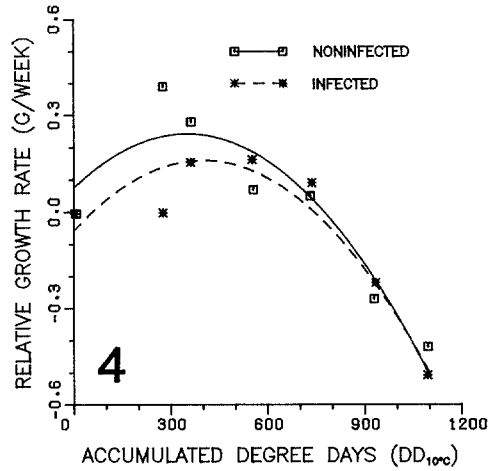
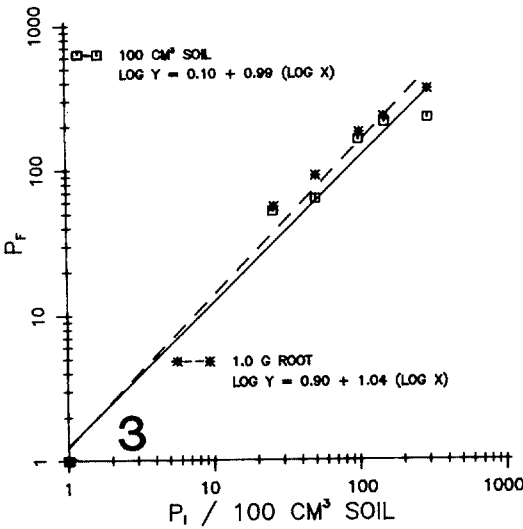
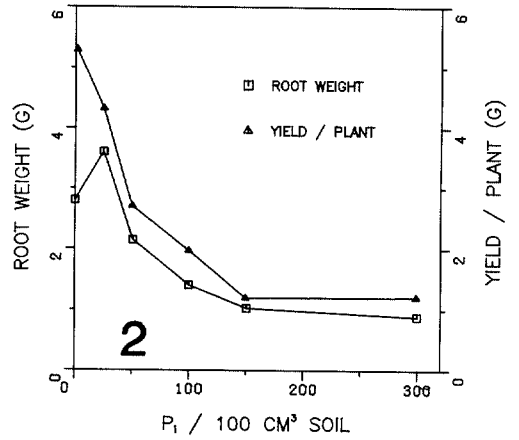
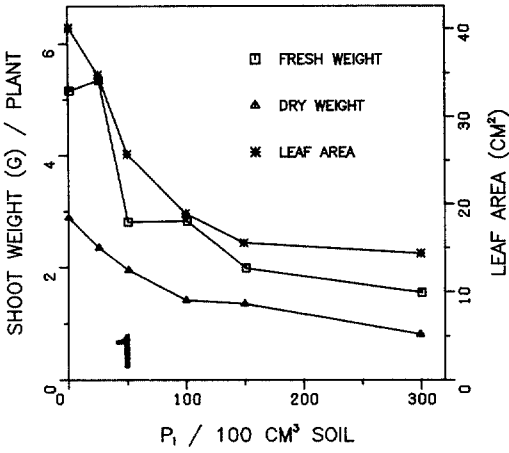


FIG. 5. Influence of *Pratylenchus penetrans* on the relative growth rate of *Phaseolus vulgaris* cultivars Gratiot, Saginaw, and Kentwood.

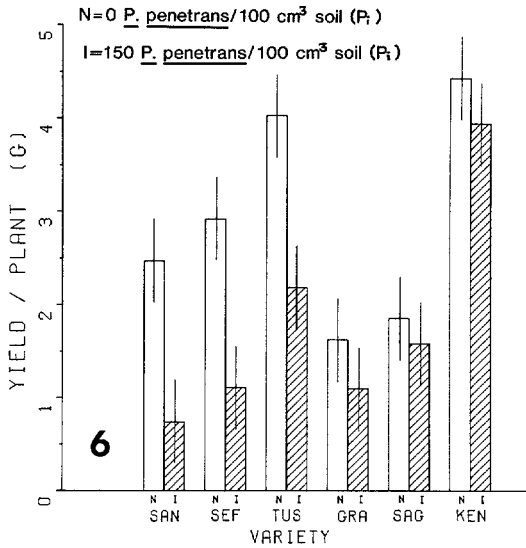


FIG. 6. Influence of *Pratylenchus penetrans* on the bean yield of six cultivars of *Phaseolus vulgaris*.

at 1,140 DD₁₀. Population densities associated with Gratiot, Saginaw, and Kentwood decreased until 340 DD₁₀ and then steadily increased reaching maxima at 725 DD₁₀. This was followed by a decrease in *P. penetrans* population density until the end of the experiment.

DISCUSSION

Pratylenchus penetrans, a pathogen of navy beans, reproduced on this plant. Response to infection varied with different initial population densities of *P. penetrans*. Population densities greater than a P_i of 25 *P. penetrans* per 100 cm³ soil had a detrimental impact on Sanilac navy beans, resulting in a significant reduction in dry bean yield.

The importance of P_i in relation to final density (P_f) and yield of plants has been studied by many investigators (6-8, 11). The lowest P_i included in the Sanilac experiment was 25 *P. penetrans* per 100 cm³ soil. The regression of the log of P_i of *P. penetrans* on the log of P_f suggests that additional studies with lower P_i of *P. penetrans* are needed for a more complete understanding of this host-parasite relationship.

Evans (3) outlined the significance of considering relationships between plants and their environments and stated that the complete cycle should be examined. In the current study, the significance of examining the dynamics of plant growth over time was evident. Studies of this type should as-

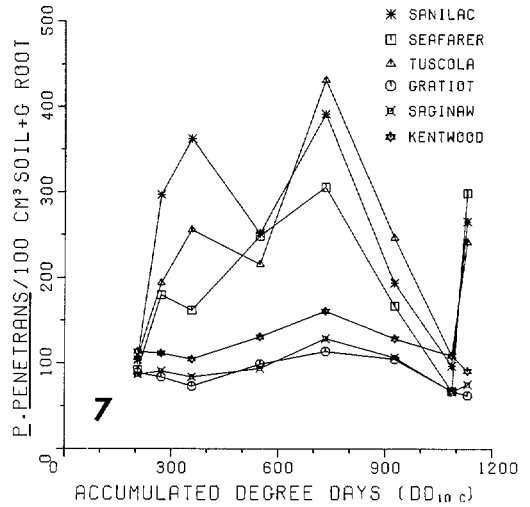


FIG. 7. Population dynamics of *Pratylenchus penetrans* associated with six cultivars of *Phaseolus vulgaris*.

sist in elucidating critical periods when environment, pest, and host interact to determine the functioning of the pest-crop system.

Pratylenchus penetrans reproduced in roots of all six dry bean cultivars studied. The response to infection, however, varied among the cultivars. The relative growth rate was not affected by *P. penetrans* infection in Gratiot, Saginaw, or Kentwood, whereas growth of Sanilac, Seafarer, and Tuscola was decreased. The latter were highly susceptible to infection by *P. penetrans*, whereas Gratiot, Kentwood, and Saginaw were tolerant. The reproductive potential of *P. penetrans* on Saginaw, Gratiot, and Kentwood was low compared with its reproductive potential on Sanilac, Seafarer, and Tuscola.

The number of generations of *P. penetrans* during the experimental period is most likely reflected by the number of maxima in nematode population densities. Under this assumption, three generations were completed on Sanilac, Seafarer, and Tuscola, whereas fewer generations may have been completed on Saginaw, Gratiot, and Kentwood. Because of the overlapping nature of life cycles of *P. penetrans*, there are a number of important questions concerning the accuracy of using maxima in nematode population densities as an indication of the number of life cycles.

The RGR index was used to examine the relationship between plant growth and the

physiological time parameter of growing degree days at the base of 10 C. There are, however, practical difficulties associated with the use of RGR (4). Destructive sampling was necessary since it was not possible to use the same plant to determine initial dry weight and final dry weight for any two growth or sampling periods. At low population densities of *P. penetrans*, RGR were generally lower than in noninfected plants during the early phases of plant growth. Plants, however, were able to overcome the detrimental effects of nematode infection. RGR were similar in *P. penetrans* infected and noninfected plants during the latter phases of plant growth, although exceptions were observed. In one case, infection by low (10 *P. penetrans*/100 cm³ soil) increased the RGR. Slinger (9) observed initial decreases followed by increases and then decreases in RGR of carrots (*Daucus carota* L.) infected by *Meloidogyne hapla*. In this case, however, the initial decrease was explained by changes in the source-sink relationships associated with formation of the tap root. For navy beans, RGR initially increased, reaching a peak during the growth period, and then decreased at the onset of senescence. At high nematode population densities, RGR was generally lower in nematode infected than in noninfected plants.

The development and appropriate use of navy bean cultivars tolerant to *P. penetrans* is critical for the design of integrated nematode management strategies for dry bean production in Michigan. The choice

of cultivar, however, is dependent on many other factors such as tolerance to other pests, yield potential, and the economics of the production system.

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