

Joint Influence of *Pratylenchus penetrans* (Nematoda) and *Leptinotarsa decemlineata* (Insecta) on *Solanum tuberosum* Productivity and Pest Population Dynamics¹

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Abstract: The joint action of a plant parasitic nematode, *Pratylenchus penetrans* (root-lesion nematode), and an insect defoliator, *Leptinotarsa decemlineata* (Colorado potato beetle), on growth, development, and yield of *Solanum tuberosum* cv. Superior was studied in the field. Three population densities of *P. penetrans* were superimposed on each of three population levels of *L. decemlineata*. The major impact of *P. penetrans* on final yield was through a reduction in the number of tubers formed during tuber initiation. Defoliation by *L. decemlineata* increased with time as larvae advanced through successive instars and densities increased. This resulted in a significant reduction in tuber weight and numbers. Total yield of *S. tuberosum* was decreased by 66% with increasing population densities of *L. decemlineata* and 27% with increasing densities of *P. penetrans*. *L. decemlineata* feeding did not affect soil population densities of *P. penetrans*. Root population densities of *P. penetrans*, however, were significantly ($P = 0.05$) higher in plants maintained beetle free than in plants grown in the presence of the beetles.

Key words: yield, crop loss, interaction, root-lesion nematode, Colorado potato beetle, potato.

Solanum tuberosum L. (potato), widely cultivated in Michigan, is subject to attack by many pests that affect plant growth, development, and yield. *Pratylenchus penetrans* (Cobb, 1917) Filipjev and Schuurmans-Stekhoven, 1941 (root-lesion nematode) and *Leptinotarsa decemlineata* Say (Colorado potato beetle) are major pests of potato in Michigan. The symptoms commonly associated with *P. penetrans* include a gradual decline or lack of plant vigor, in striking contrast to the rapid plant decline resulting from defoliation by *L. decemlineata*. Despite these differences, both pests can significantly influence potato growth, development, and yield (1,3,6,7,9-11,14-16).

Few studies have examined the interaction of insect defoliators, or simulated plant defoliation, and root parasites on plant ontogeny (4,12). Knowledge of these interactions will enhance understanding of crop loss and provide information for pest management decisions. The objectives of this study were to determine 1) the individual and combined effects of *L. decemlineata* and *P. penetrans* on growth, development, and yield of *S. tuberosum* cv. Superior and 2) the influence of defoliation of potato by *L. decemlineata* on soil and root population dynamics of *P. penetrans*.

MATERIALS AND METHODS

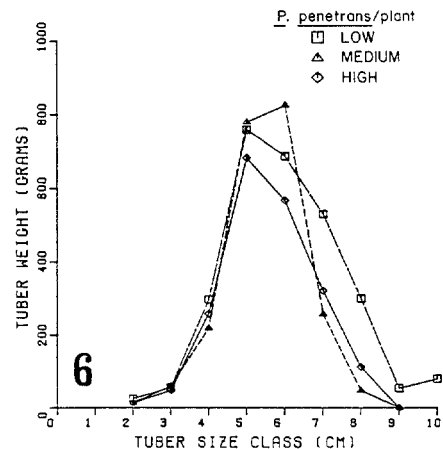
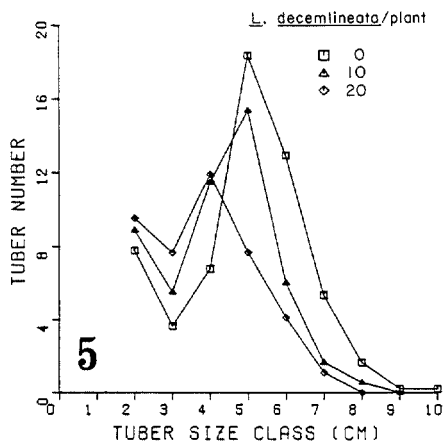
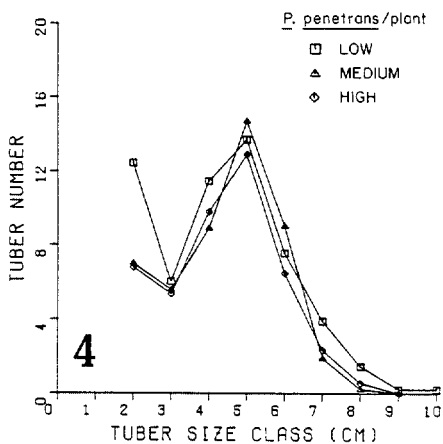
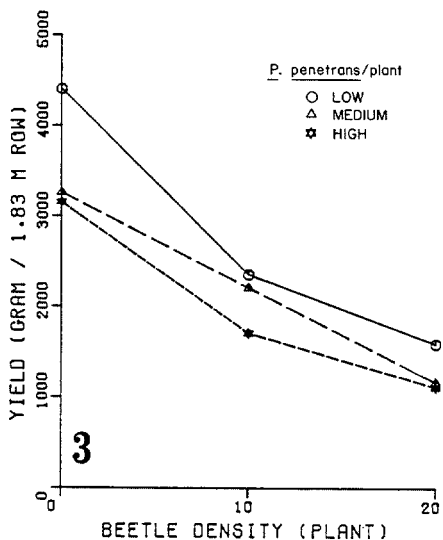
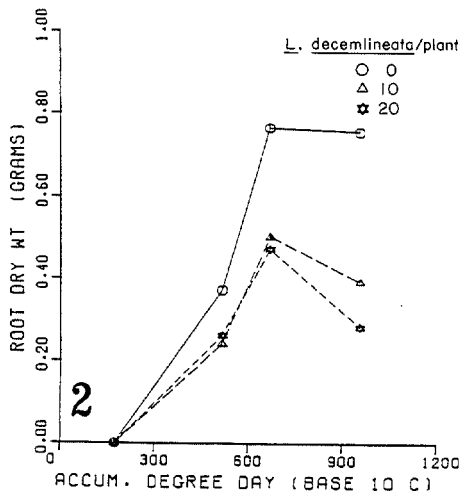
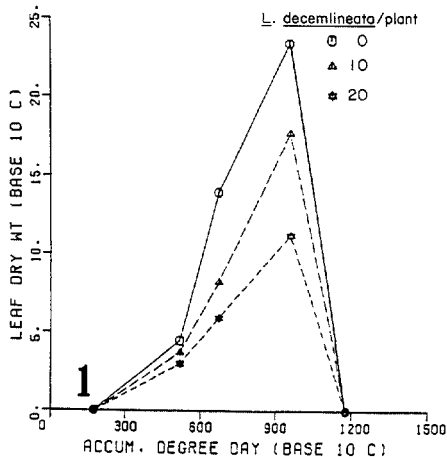
Seedpieces of *S. tuberosum* cv. Superior were hand planted in a McBride sandy loam (alfic fragiothod) on 24 May 1979 at the Montcalm Potato Research Farm in west central Michigan. Each plot consisted of two rows, 1.83 m in length and 0.86 m apart, with 0.20-m spacing between plants. Twenty-seven insect cages, each measuring 1.83 × 1.83 × 1.83 m, were erected over the plots and assigned one of nine

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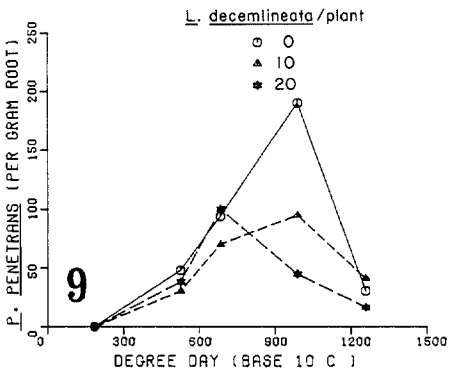
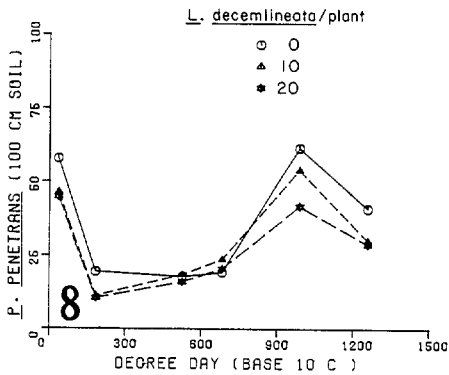
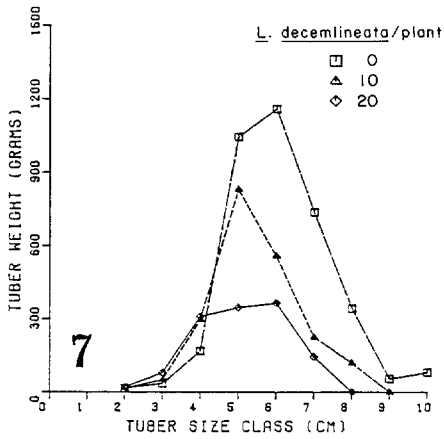
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FIGS. 1-6. 1) Influence of three densities of *Leptinotarsa decemlineata* on leaf dry weight of *Solanum tuberosum* cv. Superior. FIG. 2) Influence of three densities of *Leptinotarsa decemlineata* on root dry weight of *Solanum tuberosum* cv. Superior. FIG. 3) Influence of three population levels of *Pratylenchus penetrans* and *Leptinotarsa decemlineata* on final tuber yield of *Solanum tuberosum* cv. Superior. FIG. 4) Influence of three initial population levels of *Pratylenchus penetrans* on the average number of tubers in each of 10 different tuber size categories of *Solanum tuberosum* cv. Superior at harvest. FIG. 5) Influence of three plant densities of *Leptinotarsa decemlineata*



on the average tuber number in each of 10 different tuber size categories of *Solanum tuberosum* cv. Superior at harvest. FIG. 6) Influence of three initial populations of *Pratylenchus penetrans* on mean tuber class weight in each of 10 different tuber size categories of *Solanum tuberosum* cv. Superior at harvest.



FIGS. 7-9. 7) Influence of three plant densities of *Leptinotarsa decemlineata* on mean tuber class weight in each of 10 different tuber size categories of *Solanum tuberosum* cv. Superior at harvest. FIG. 8) Influence of three plant densities of *Leptinotarsa decemlineata* on the soil population density of *Pratylenchus penetrans*. FIG. 9) Influence of three plant densities of *Leptinotarsa decemlineata* on the root population density of *Pratylenchus penetrans*.

treatments. Each treatment consisted of one of three population levels of *L. decemlineata* and one of three superimposed initial population densities (P_i) of *P. penetrans*. A complete randomized block, two factorial experimental design was used. Each treatment was replicated three times. The three population levels of *L. decemlineata* were achieved by stapling leaves with egg masses obtained from adjacent potato fields to the leaves of newly emerged plants within the cages on 22 June 1979. Eggs were allowed to hatch, and larval population levels were manipulated to either 0, 10, or 20 larvae per plant.

The P_i of *P. penetrans* within each plot was determined by preplant sampling and analysis of the soil in each cage site. Cage sites were numerically ranked and separated into three population density groups: low, intermediate, and high. Cage sites with low population densities ($P_i = 2-4$ *P. penetrans*/100 cm³ soil) were fumigated with 1,3-D (Telone II®, 93.5 liters/ha) on 1 May 1979. The medium population density sites were left as unaltered field populations ($P_i = 15-25$ /100 cm³ soil). High population density areas were achieved by supplementing the natural field populations ($P_i = 11-32$ /100 cm³ soil) with an aqueous suspension of *P. penetrans* obtained from roots of potato cultured in the greenhouse. A 10-ml nematode suspension of 500 *P. penetrans* was added at planting to the future rhizosphere of each plant. The plants were maintained throughout the growing season under standard commercial irrigation and disease control practices.

Plant growth and development was monitored every 2-4 weeks throughout the growing season. Randomly selected plants were carefully removed from one row within each cage at each sampling date. The soil immediately below each plant was removed to a depth of 0.35 m and sifted in a hand-driven mechanical soil shaker. Roots and tubers removed from the shaker screens were bagged and returned to the laboratory with the foliage and a representative 1,000-cm³ soil sample. Tuber numbers were determined at each sampling period. Root and shoot weights were determined after drying to a constant weight at 35 C. Total leaf area of each

plant was calculated with a Lambda leaf area meter, Model LI 3000®.

Soil and root population densities of *P. penetrans* were estimated from samples taken at 2–4 week intervals. Preplant soil samples for nematode analysis were taken by core samples (5–6 cores, 3 cm each, to a 30–48-cm soil depth) from each plot. After plant emergence, samples were obtained by removing the soil adjacent to the roots of the plant. Root samples were collected and returned to the laboratory for tuber and root weight determinations. Soil and root populations of *P. penetrans* were determined by processing 100 cm³ soil by centrifugal flotation (8) and 1.0-g root tissue by the shaker technique (2), respectively. Quantitative population density estimates were made by counting the nematodes recovered.

The remaining undisturbed row within each cage plot was harvested on 14 September 1979. Individual tubers from each cage plot were separated into 10 tuber size categories (1–10 cm). The tubers in each size class were counted and the weight of tubers in each size class determined.

RESULTS

The population density of *L. decemlineata* larvae was inversely related to the increase in leaf dry weight of *S. tuberosum* over time (Fig. 1). As *L. decemlineata* reduced the rate of leaf weight increase, there was a corresponding significant ($P = 0.05$) reduction in plant root dry weight increase (Fig. 2). This was especially pronounced during the later stages of plant growth.

Final tuber yield decreased with increasing *L. decemlineata* and *P. penetrans* population levels (Fig. 3). Only at the low nematode population density without beetles, however, was yield significantly higher ($P = 0.05$) than the other treatments. Both the medium and high initial soil populations of *P. penetrans* significantly ($P = 0.05$) decreased the number of tubers in the smallest tuber size category (Fig. 4). Increasing densities of *L. decemlineata* from 0 to 20 beetles per plant shifted a greater number of tubers into the smaller tuber size categories and significantly ($P = 0.05$) reduced the number of tubers per tuber size class (Fig. 5). Similar kurtotic trends were also observed in the mean tuber class

weight distribution between tuber size classes for final tuber yield per 1.83-m row (Figs. 6, 7). *P. penetrans* did not influence final tuber weight distribution among size classes (Fig. 6), although mean tuber size class weights were consistently lower in the high initial soil population levels. Total tuber weight was significantly ($P = 0.05$) reduced by *L. decemlineata* densities (Fig. 7). A greater proportion of the total tuber weight shifted to the smaller size classes as *L. decemlineata* densities increased.

L. decemlineata feeding did not significantly influence soil population densities of *P. penetrans* (Fig. 8). In contrast, root population densities of *P. penetrans* were significantly ($P = 0.05$) higher during the latter part of the season in plants maintained beetle free (Fig. 9).

DISCUSSION

Feeding of *L. decemlineata* on leaves of *S. tuberosum* has an important negative influence on final tuber yield. The rate and degree of defoliation increases as larvae advance through successive instars and population densities increase. The quantity of photosynthetic activity, therefore, decreases with increasing beetle densities. As beetles reduce leaf dry weight, there is a corresponding reduction in root dry weight. Changes in leaf and root dry weights are directly reflected in reduced tuber weight and number. Hare (6) showed that early defoliation did not contribute as heavily to determining final tuber yield as did late defoliation during tuber bulking.

Few significant differences attributable to *P. penetrans* were evident in any of the plant growth parameters measured. Similar responses in yield and plant parameters were observed in concurrent field studies examining initial soil populations of *P. penetrans* and the temporal effects of plant defoliation by *L. decemlineata* (13). The influence of caged environment on plant growth, development, or yield was not assessed. Changes in root weight were small and statistically not significant. Total yield of *S. tuberosum* was decreased 66% (significant, $P = 0.05$) at the highest density of *L. decemlineata*, and 27% at the highest population density of *P. penetrans*. Yield reductions were associated with a decrease in tubers set or in leaf area during the tuber

bulking process rather than a reduction in the average weight per tuber. There were no statistically significant ($P = 0.05$) interactive yield effects, although the combined impact of *P. penetrans* and *L. decemlineata* on final tuber yields conforms most closely to a multiplicative damage model (5).

The reduction of shoot system weight by *L. decemlineata* appeared to influence the size of the total root system available for *P. penetrans* colonization. Small root systems limit infection sites available to soil nematodes, thereby reducing the probability of feeding and survival. Even nematodes which detect and penetrate potato roots may be influenced by *L. decemlineata* defoliation. As *L. decemlineata* feeding continued into the season, a shift in plant maturity occurred. Initially, early defoliation appeared to delay plant maturity. As defoliation increased, the plant was not able to sustain normal growth, resulting in early senescence of roots and decrease in the number of *P. penetrans* per gram of roots or 100 cm³ soil. Limited nematode reinfection could have decreased nematode survival or reproductive potential within the roots, or a change in the nutritional quality of the roots could have caused the decrease in the number of *P. penetrans* per gram in the beetle-infested treatments.

The growth response of *S. tuberosum* to increasing population densities of *P. penetrans* and *L. decemlineata* showed that these pests disproportionately influenced the growth, development, and yield of *S. tuberosum*. Final tuber yield decreased much more significantly ($P = 0.05$) with increasing densities of *L. decemlineata* than with increasing population levels of *P. penetrans*. The major influence of *L. decemlineata* on final tuber yield occurs as a result of defoliation and its depressing effect on tuber bulking. The major influence of *P. penetrans* on yield occurs during tuber set, early in *S. tuberosum* ontogeny. In addition to its influence on final tuber yield, *L. decemlineata* also influences the population dynamics of *P. penetrans*. Defoliation significantly ($P = 0.05$) reduced the growth and development of the root system and root population densities of *P. penetrans*.

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