Yield Losses in Fall-Maturing Vegetables Relative to Population Densities of Pratylenchus penetrans and Meloidogyne hapla

J. W. Potter and T. H. A. Olthof

Nematologists, Research Station, Agriculture Canada, Vineland Station, Ontario, L0R 2E0.

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ABSTRACT

Commercial cultivars of fall-maturing red beets, lettuce, and spinach were grown in microplots infested with either lesion nematodes (*Pratylenchus penetrans*) or root-knot nematodes, (*Meloidogyne hapla*) at 0, 666, 2,000, 6,000, or 18,000 nematodes/kg of soil. Yields of marketable product tended to be inversely correlated with preplant nematode population densities. With *P. penetrans*, losses in wt of marketable produce at the highest preplant density were: beets, 27%; lettuce, 43%; and spinach, 21%. With *M. hapla*, comparable losses in wt of marketable produce were: beets, 22%; lettuce, 81%; and spinach, 13%. Soil populations of *P. penetrans* were higher at harvest than at planting under lettuce, about equal at planting and harvest under spinach, and lower at harvest than at planting under beets. Soil populations of *M. hapla* larvae were lower at planting than at harvest for all three crops; all crops were galled, lettuce more severely than spinach or beets. Beet is recommended as a fall-maturing crop in soils infested with up to 6,000 *P. penetrans* or *M. hapla*/kg soil.

RESUME

Les variétés tardives de la betterave potagère, de la laitue et des épinards furent cultivées dans des micro-parcelles infestés de nématodes des prés, *Pratylenchus penetrans*, ou de nematodes des racines, *Meloidogyne hapla*, à la densité de 0, 666, 2,000, 6,000, ou 18,000 nématodes par kg de sol. Le rendement de ces légumes vendables sur le marché tendait à être inversement relié aux populations initiales des nématodes. Avec *P. penetrans*, les pertes en poid des légumes vendable sur le marché à la densité de nématode initiale la plus haute étaient pour la betterave potagère, 27%; la laitue, 43%; et les épinards, 21%. Avec *M. hapla*, les pertes en poid étaient comparables pour la betterave potagère, 22%; la laitue, 81%; et les épinards, 13%. A la récolte de la laitue, les populations de *P. penetrans* dans le sol étaient plus larges qu' à la plantation; ca. les mêmes à la plantation des épinards qu',a la plantation. Les populations larvaires de *M. hapla* qu'à la recolte, et plus basses a la recolte de la betterave potagere qu'a la plantation. Les populations larvaires de *M. hapla* etaient plus basses à la plantation qu'à la récolte pour toutes les cultures. Toutes les cultures étaient nodositées; la laitue plus sevèrement que les épinards et la betterave potagère. La betterave potagère est recommendée comme culture tardive dans les sols infestés de *P. penetrans* ou *M. hapla* jusqu'à une densité de 6,000 nématodes.

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Additional key words: population dynamics, economic loss threshold, microplots.

The muck and light mineral soils on which Ontario's vegetable industry is primarily located are generally infested with either the northern root-knot nematode *Meloidogyne hapla* Chitwood, the root-lesion nematode *Pratylenchus penetrans* (Cobb), or both (3). Because this zone of arable farm land has 130-180 frost-free days per year (1) and a growing season of 190-200 days (above 5.6 C mean temp), producing two crops per season on the same land is feasible. Crop damage is usually positively correlated with the nematode population density at the beginning of a crop growth period (8). The growth of a marketable fall-maturing vegetable depends in part, therefore, upon the nematode population in the soil after a summer-harvested crop. Fumigation between the crops is impractical because time is limited; hence the fall crop should preferably be a poor host or nonhost of lesion and root-knot nematodes. Nothing is known about the relationship of these nematodes to beets, lettuce, and spinach under fall conditions in Ontario, although their effects on summer-maturing lettuce has been reported (4, 5). Consequently, this study was undertaken to determine the relationship between various population densities of the two nematodes and yield losses of these fall-maturing vegetables.

MATERIALS AND METHODS.—The populations of *P. penetrans* used in 1970 were isolated from rye (*Secale cereale* L. 'Tetra Petkus') (5) in 1966 and were reared on celery (*Apium graveolens* L. *dulce* 'Utah') growing in Vineland loam in a greenhouse groundbed. Population densities of ca. 666, 2,000, 6,000, or 18,000 nematodes/kg of soil were obtained by mixing infested groundbed soil with appropriate portions of steam-treated Vineland loam.

Treatments were prepared as previously described (4, 5). Within 2 days after the clay-tile microplots were filled with infested soil (10 kg), a 2-wk-old seedling of lettuce (*Lactuca sativa* L. 'Great Lakes 6238'), two to six beet seedlings (*Beta vulgaris* L. *vulgaris* 'Detroit Dark Red'), or two to three spinach seedlings (*Spinacia oleracea* L. 'Cold Resistant Savoy') were transplanted into each tile in the appropriate block. After 2 wk, the beets and spinach were thinned to two plants per tile. Initial nematode densities were determined on soil samples taken from all treatments at transplanting by the modified Baermann method (11). The plots were managed as in previous studies (4, 5).

Marketable yields (9) and other growth data were obtained at crop maturity, 75 days after the experiment was initiated. The final soil nematode population in each microplot was also determined by the modified Baermann method (11). Nematodes were extracted from

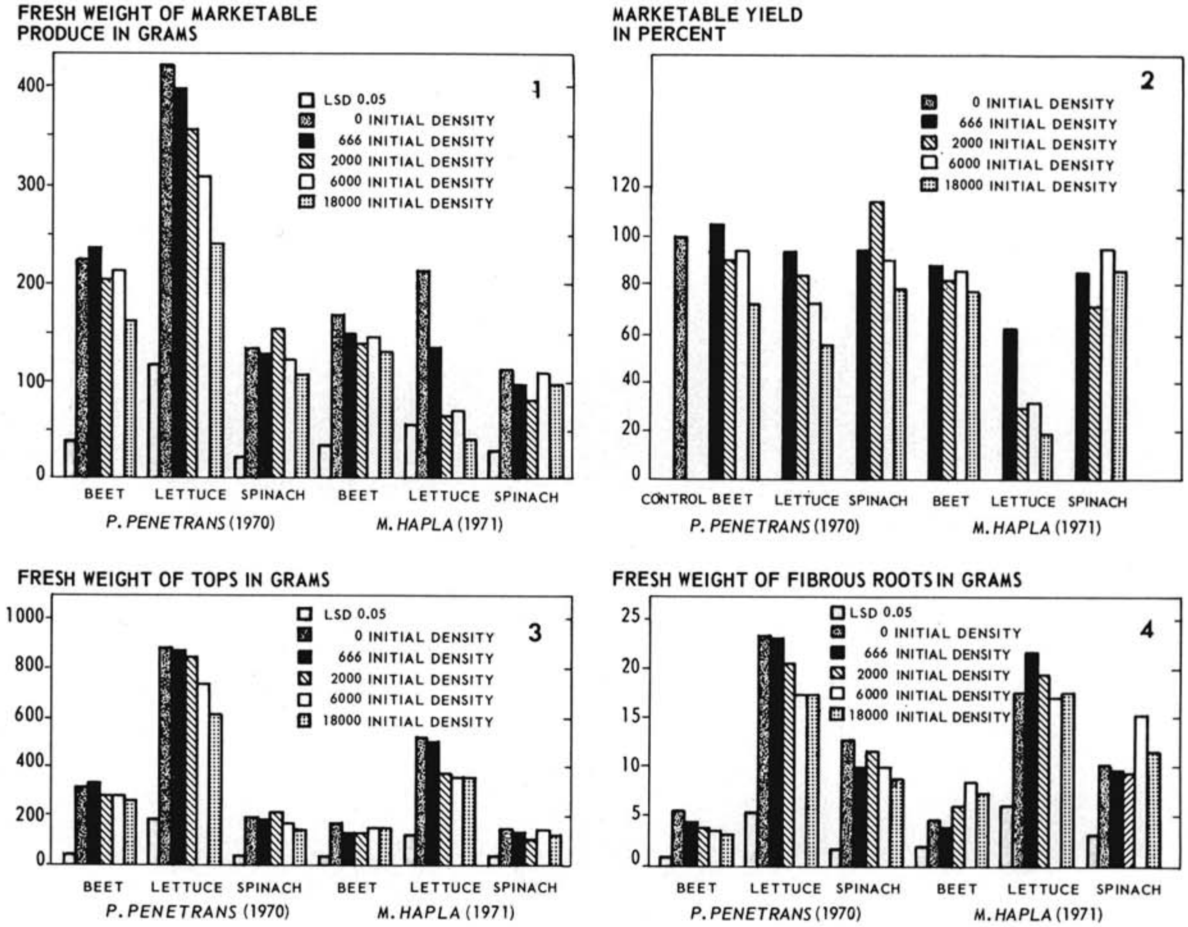

Fig. 1-4. The relationship between yield losses in fall-maturing vegetables and population densities of *Pratylenchus penetrans* (1970 study) and *Meloidogyne hapla* (1971 study). **1)** Marketable yields in grams. **2)** Marketable yields expressed as percent of control. **3)** Fresh weight of tops in grams. **4)** Fresh weight of roots, (excluding marketable portions of beets).

each root system (excluding marketable portions of beets) for 1 wk in a mistifier.

In 1971, a local isolate of *M. hapla* (4) was reared in large numbers for 6 mo on peanut (*Arachis hypogaea* L. NC-2) grown in Vineland loam in greenhouse groundbeds. The mixing required to obtain differential larval populations of *M. hapla* and the procedures for installation, management, and harvest of the experiment in 1971 were like those of the *P. penetrans* experiment in 1970 described above. Transplanting was similar to the previous year, except that the beets were thinned to one per tile. Marketable yields and other data were obtained at crop maturity, 81 days after the experiment was initiated. Root populations of the nematode were not determined by mist extraction, but the degree of galling of each root system was rated by the Daulton-Nusbaum Index (2).

RESULTS.—*Pratylenchus penetrans*.—Marketable wt of all three vegetables was significantly reduced by initial populations of 18,000 *P. penetrans*/kg of soil (Fig. 1) and that of lettuce also with 6,000 nematodes/kg. Losses in yields of beets and spinach at 18,000 nematodes/kg were 27% and 21%, respectively; losses in

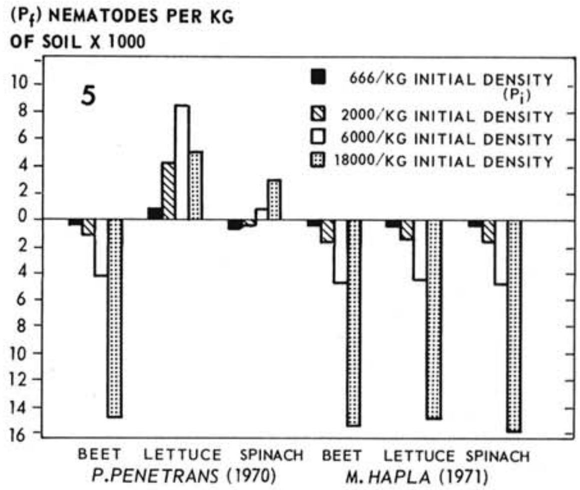

Fig. 5. Differences between initial (P_i) and final (P_f) densities of *Pratylenchus penetrans* and *Meloidogyne hapla* in soil on three fall-maturing vegetables. Columns above the base line signify more nematodes and those below the base line fewer nematodes at harvest than at planting.

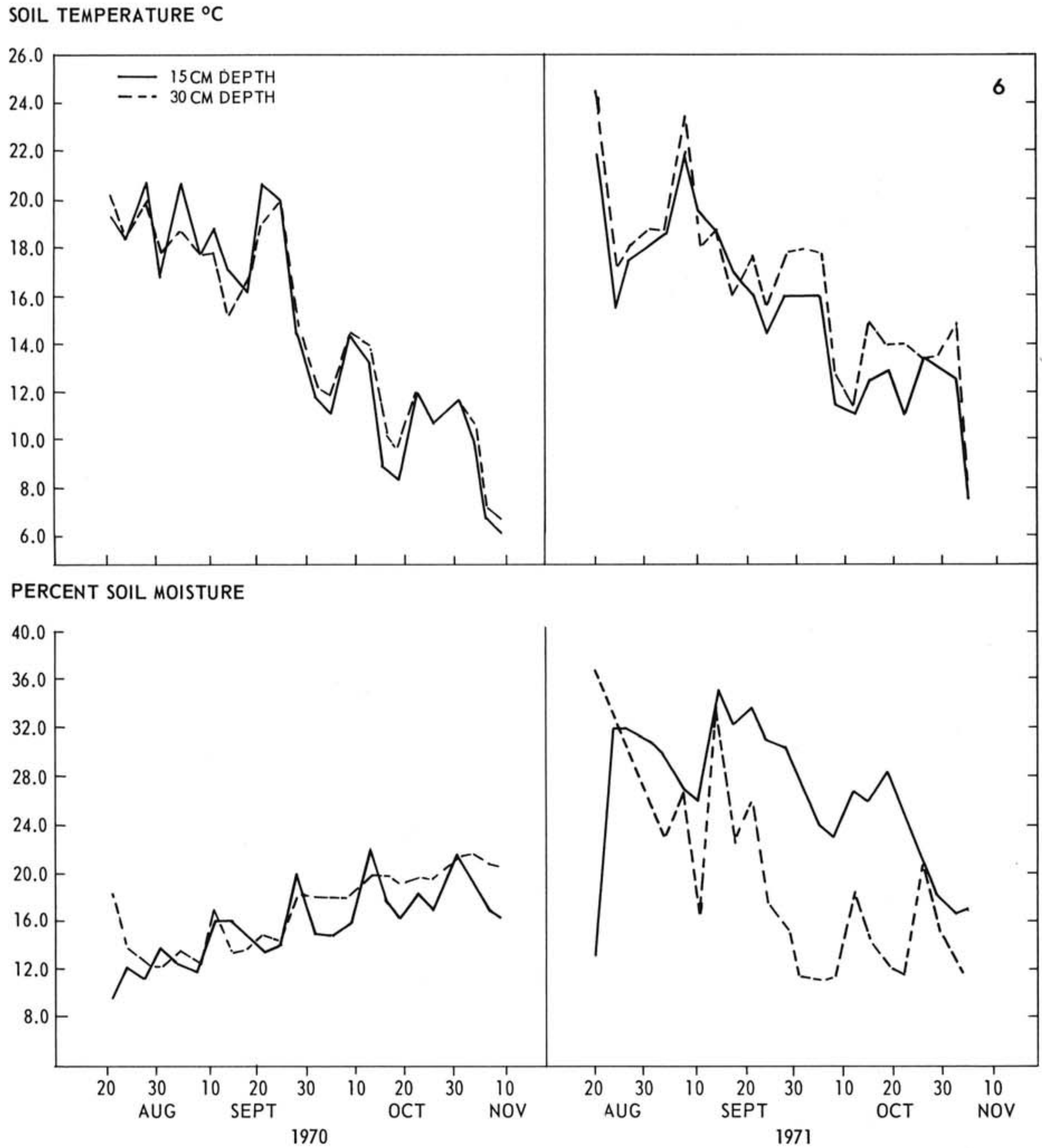

Fig. 6. Soil temp and moisture in lettuce microplots at Vineland Station, Ontario, monitored twice weekly in 1970 and 1971.

lettuce yield were 27% and 43% at the 6,000 and 18,000 densities, respectively (Fig. 2). Total fresh top wt of all three crops were reduced only at the 18,000 density (Fig. 3). Root wt of beets (excluding marketable portions) was reduced at all nematode densities; that of lettuce at the 6,000 and 18,000 densities; and that of spinach at 666; 6,000, and 18,000 densities (Fig. 4). With the latter crop, root wt at the 2,000 density was not significantly reduced.

With lettuce and spinach, final population densities (P_f) of *P. penetrans* in the soil at harvest were generally higher than initial densities (P_i) at planting; the opposite occurred with beets (Fig. 5). The average numbers of nematodes per root system for the 666, 2,000, 6,000, and 18,000 initial densities, respectively, were for beets 1, 3, 11, and 50; for lettuce 430, 1680, 2880, and 4660; and for spinach 170, 580, 990, and 1720.

Meloidogyne hapla.—Marketable wt of beets was significantly reduced by *M. hapla* only by the initial population of 18,000 nematodes/kg of soil (Fig. 1), while that of lettuce was reduced by all densities, and that of spinach only by 2,000 nematodes/kg. Loss in yield of beets was 22% at the 18,000 density (Fig. 2); losses in lettuce yields were 37%, 70%, 68%, and 81%, respectively, at the 666, 2,000, 6,000, and 18,000 densities; and loss of spinach yield at the 2,000 density was 28%. Total fresh wt of beet tops was reduced at the 666 and 2,000 densities (Fig. 3); that of lettuce at the 2,000; 6,000; and 18,000 densities, and that of spinach only at the 2,000 density. Differences in fresh root wt of the three crops are shown in Fig. 4.

Final soil population densities (P_f) of *M. hapla* at harvest were lower than initial densities (P_i) at planting with all crops (Fig. 5). Root galling indices for the 666, 2,000, 6,000, and 18,000 densities were for beets 1.4, 2.5, 3.4, and 3.3; for lettuce 3.8, 4.2, 4.2, and 4.2; and for spinach 2.0, 2.8, 3.7, and 3.6.

Soil temp and moisture data at 15 cm and 30 cm under lettuce in 1970 and 1971 are presented in Fig. 6. Soil temp remained above 5.6 C during both experiments, while moisture remained near field capacity.

DISCUSSION.—The concept of the economic loss threshold, as developed in previous studies (4, 5, 6), specified a different threshold for each crop based partly on the farm value for the crop. In the present study, the economic loss thresholds for beets (17%), lettuce (10%), and spinach (13%) were derived from farm values/hectare (ha) averaged over the 1970 and 1971 crop seasons (7) and from an assumed broadcast fumigation cost of \$200/ha (\$80/acre). In recent work (5, 6), both the economic loss thresholds and the statistical significance of the yield reductions were used to decide at what nematode density fumigation was economically feasible. On the basis of statistical significance of yield reductions, fumigation would be warranted against *P. penetrans* in excess of 2,000/kg on lettuce and in excess of 6,000/kg on beets and spinach, while against *M. hapla*, fumigation is indicated at all densities on lettuce, and in excess of 6,000/kg on beets. The significant reduction at the 2,000 density on spinach was not sustained at higher densities; the reason for this anomaly is not understood at this time.

Of the three vegetables included in this study, beets seem to offer the best possibility as a fall-maturing second crop. Reductions in yield of beets took place only at high nematode densities (Fig. 1) of either *P. penetrans* or *M. hapla*. In addition this vegetable is apparently not a favorable host for either nematode (Fig. 5) which supports Sherf's (10) acceptance of beets as a satisfactory crop in rotations designed to starve out the root-knot nematode. Spinach would be a less satisfactory fall-maturing second crop, because it supports a large number of *P. penetrans*. Also, while spinach does not seem to be as good a host for *M. hapla*, spinach yields are reduced by lower initial densities of *M. hapla* than of *P. penetrans*. Fall-grown lettuce suffered losses from these nematodes comparable to those sustained by a summer-maturing lettuce crop (4, 5). Our work, and that of Wong and Mai (12, 13), suggests that massive larval invasion soon after germination reduces growth and prevents formation of marketable heads. The lack of size of marketable heads, especially with *M. hapla* (Fig. 1), as well as the persistence of *P. penetrans* on the crop, indicates that lettuce is not well suited as a fall-maturing second crop in infested fields.

Our work has shown the feasibility of producing a fall-maturing second crop of beets or spinach on soil infested with up to 6,000 *P. penetrans*, or *M. hapla*/kg. In addition, these crops either reduce or at least do not greatly increase the number of nematodes remaining in the soil after the second crop.

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