Tolerance Limit of the Sugarbeet to Heterodera schachtii

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Abstract: Field and greenhouse experiments showed that yield losses of sugarbeet, *Beta vulgaris,* did not occur in soil infested with fewer than eight *Heterodera schachtii* eggs/g soil. However, larger population densities greatly reduced sugarbeet yield. In the field experiment, the yield in microplots inoculated with more than 64 eggs/g soil was less than 20% of yields in uninoculated microplots. Nevertheless, tolerance limits of 4 and 1.8 eggs/g soil, in greenhouse and field microplots, respectively, were derived by fitting the data with the equation $y = m + (1 - m)z^{P-T}$. Maximum rates of multiplication of 55 and more than 300, and equilibrium densities of 340 and 130 eggs/g soil, were estimated in greenhouse and field microplot tests, respectively.
Key words: sugarbeet cyst nematode, minimum yield, equilibrium density.

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The cyst nematode *Heterodera schachtii* Schmidt is a worldwide pest causing yield losses of sugarbeet. Many researchers have investigated this parasite to provide information for more effective control. In England, Jones (4) found that growing sugarbeet in a field infested with more than 10 eggs/g soil would be unsafe, but his microplot experiment (5) indicated that growing sugarbeet in soil infested with 30–40 egg/g would not lead to a severe yield loss. Seinhorst (7) derived a tolerance limit for *H. schachtii* of 10–20 eggs/g soil from data by Jones (5). Heijbroek (3) stated that in the Netherlands moderate damage is expected

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in soil infested with 3–8 eggs/g, while Cooke and Thomason (1) found, under field condition in California, a tolerance limit of one egg/g soil. In Italy, Tacconi et al. (14,15) found a tolerance limit of two viable cysts/100 g soil.

To provide more information on the relationships between nematode density at sowing, damage to sugarbeet, and final density of the nematode, a greenhouse experiment was done in 1977 and a field experiment in 1979.

MATERIALS AND METHODS

Greenhouse experiment: Ninety-six 1.8-liter clay pots were filled with a steam-sterilized soil (sand 35%, loam 33%, clay 32%, organic matter 1.9%) and infested with *H. schachtii.*

The inoculum was collected from infested field soil and incorporated into potting soil to give densities of 0, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512 eggs/g soil.

Also eight pots were each filled with 1.8 liters of the soil from which the inoculum was obtained. All pots but the latter eight were sown to sugarbeet (*Beta vulgaris*) cv. Kawemono on 25 July 1977 and arranged in randomized block design in a glasshouse maintained at 18–23 C. After the seedlings emerged, all but one per pot were removed. The pots were watered as needed. Tap roots and foliage were harvested and weighed on 18 December 1977 and a 200-ml soil sample was taken from each pot. Cysts were extracted using a Fenwick can, followed by ethanol flotation (9), counted, and crushed to estimate their egg content (11).

Field experiment: One hundred four concrete tile microplots 30×30 cm, × 50 cm long were placed vertically 45 cm deep in soil in a field in the Fucino Valley. Each microplot was filled with 40 liters of field soil, as in the greenhouse experiment, and infested with *H. schachtii.* The inoculum was prepared by extracting cysts from Fucino Valley field soil (containing 70 eggs/g) and mixing them thoroughly in 40 kg of sterilized soil. Eight 10-g subsamples of the inoculum were placed separately on a 200-μm sieve, and soil and small particles of debris were washed away. The cysts were gathered on a paper filter, counted, and their egg content estimated and refered to as eggs/gram soil. Then the microplots were infested separately by thoroughly mixing the soil with the appropriate portion of inoculum to obtain densities of 0, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, or 256 eggs/g soil. There were eight replications for each nematode density. Sugarbeet seeds cv. Kawemono were sown on 10 May 1979, and the plants thinned to one seedling per microplot. Eight microplots containing 48 eggs/g soil were left without plants. Tap roots were harvested and weighed on 24 October 1979. Soil from the first 30 cm of each microplot was separately mixed and the numbers of cysts and eggs determined in 200-g samples; one sample was taken from each microplot. The percentage of the eggs parasitized by fungi was determined according to the method of Kerry and Crump (6). Hatchability of eggs used in the field experiment was determined with 1,200 cysts equally divided in six batches. Each batch was put in a 2-cm-wide 215-μm sieve and placed in 4-cm-wide plastic Petri dishes containing 3 ml of a 3 mM $ZnCl_2$ solution. The percentage of eggs hatch was determined weekly.

RESULTS AND DISCUSSION

Only 11.7% of the eggs in the inoculum in the field experiment were found infected by fungi.

In the hatching test 55.5%, 84%, and 89.3% of the juveniles emerged in 1, 4, and 9 wk, respectively. Because roots of seedlings in the two-leaf stage may contain second- and third-stage juveniles (Greco et al., unpublished), we assumed that infestation occurred from seed germination onward. Tap root weights (Figs. 1, 2) at different nematode densities are in agreement with the equation $y = m + (1 - m)z^{P-T}$ [1] (7), for $P \geq T$ and $y = 1$ for $P \leq T$, where y is the rate of the yield at density P and the yield at a density of $P \leq T$, m = the minimum relative yield (the yield at very large initial population densities), z = a constant < 1 and T the tolerance limit, with $z^{-T} = 1.05$.

Fitting curves according to the above equation (Figs. 1, 2) to the data suggest tolerance limits of 4 and 1.8 eggs/g soil and

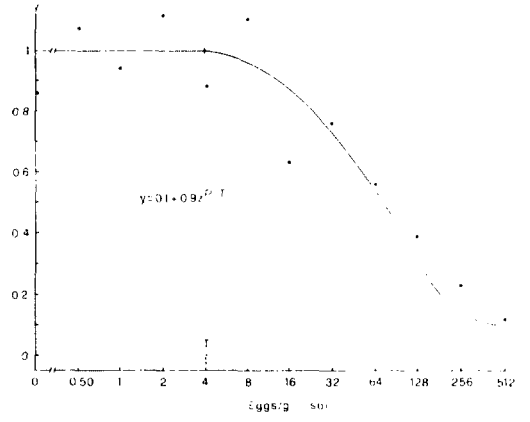

Fig. 1. Relationship between initial population of *H. schachtii* and yield of sugarbeet in greenhouse pots.

m = 0.15 and 0.05 for the greenhouse and field experiments, respectively. These values of the tolerance limit are close to those found by other authors for *H. schachtii* on sugarbeet (1,3). Similar values of T were found for some other cyst nematodes: 1.5 eggs/g soil of *Globodera rostochiensis* on a nonresistent potato cultivar (12) and 4.4 eggs/ml soil of *H. goettingiana* on pea (2).

The relation between initial and final nematode population density, *Pi* and *Pf*, in the pots (Fig. 3) is in good agreement with the equation $Pf = y\ a\ (-^e\log\ q)^{-1}\ (1 - q^{Pi}) + s(1 - y)\ Pi$ [2] (8). Where y = the ratio between the sizes of root systems not including the tap root (and therefore the size of the source of food of the nematodes) at nematode density *Pi* and without reduction by nematode attack, a = the maximum rate of multiplication

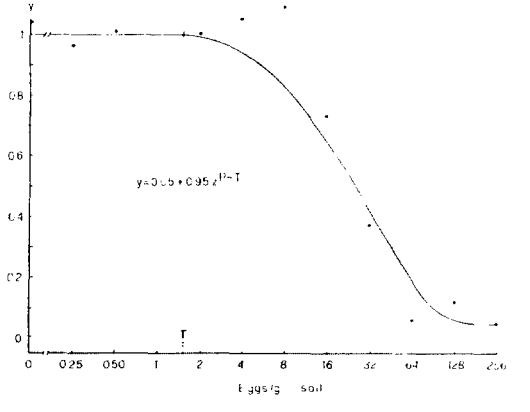

Fig. 2. Relationship between initial population of *H. schachtii* and yield of sugarbeet in field microplots.

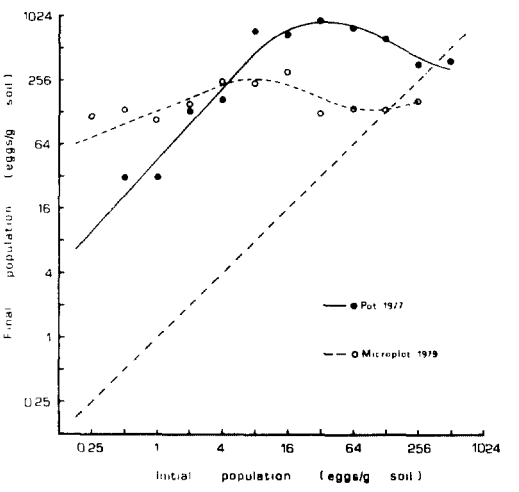

Fig. 3. Relation between initial and final population of *H. schachtii*.

($Pf \rightarrow aPi$) for $Pi \rightarrow 0$, q is a constant < 1 and s the decrease of the nematode population in the absence of a host and therefore in the portion of the soil not occupied by roots. For the curve of Fig. 3, a = 55, $a\ (-^e\log\ q)^{-1}$ = (*Pf* for $Pi \rightarrow \infty$ if y remains 1) 1,500 eggs/g soil. Further, y was calculated according to equation [1] from observed differences between total plant weight and tap root weight, thus assuming that the ratio between weights of above ground parts and fine roots is not affected by nematode attack (10,13). According to these calculations m = 0.27, but m = 0.21 gives the best fit.

It was impossible to find a curve according to equation [2] which fits well to the observed initial and final nematode density in the field experiment, and the maximum rate of increase could not be estimated accurately from the observed final densities but it certainly was larger than the estimated 300 times at *Pi* = 0.25 egg/g soil.

At *Pi* = 512 eggs/g soil in pots and *Pi* = 256 in microplots, the rate of increase of the nematode was < 1 ($Pf < Pi$).

The decrease of nematode population in pots and microplots, in absence of plants, was 85% and 78%, respectively, and the equilibrium density 340 and 130 eggs/g soil in greenhouse and in the field, respectively.

The tolerance limit of the sugarbeet to *H. schachtii* found in our investigation is closer to those of Heijbroek (3) and Cooke and Thomason (1) than that of Jones (4,5). A number of factors may account for the

discrepancy of tolerance limits reported. Since the temperature in the Fucino Valley is similar to that of Central Europe, sugarbeet differences in sugarbeet cultivar may be involved. Dissimilar size of planting containers, pots and/or microplots, dissimilar amounts of roots per unit of soil, and extent of egg parasitism may effect the calculation.

These results may help agriculturalists to integrate cultural and chemical control methods by predicting crop losses based upon the initial nematode population density.

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