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Effect of *Meloidogyne incognita* and Importance of the Inoculum on the Yield of Eggplant

M. Di Vito, N. Greco, and A. Carella[1]

Abstract: The relationship between population densities of race 1 of *Meloidogyne incognita* and yield of eggplant was studied. Microplots were infested with finely chopped nematode-infected pepper roots to give population densities of 0, 0.062, 0.125, 0.25, 0.50, 1, 2, 4, 8, 16, 32, 64, and 128 eggs and juveniles/cm³ soil. Both plant growth and yield were suppressed by the nematode. A tolerance limit of 0.054 eggs and juveniles/cm³ soil and a minimum relative yield of 0.05 at four or more eggs and juveniles/cm³ soil were derived by fitting the data with the equation $y = m + (1 - m)z^{P-T}$. Maximum nematode reproduction rate was 12,300. Hatch of eggs from egg masses in water or from sodium hypochlorite dissolved egg masses was similar (41% and 39%), but egg viability was significantly greater from egg masses in water (58%) than from sodium hypochlorite dissolved egg masses (12%) after 4 weeks. Greater numbers of nematodes were collected from roots of tomatoes from soil infested with entire egg masses than from tomato roots from soil infested with egg masses dissolved by sodium hypochlorite.

Key words: root-knot nematode, tolerance limit, eggplant, inoculum, *Solanum melongena, Meloidogyne incognita.*

Eggplant (*Solanum melongena* L.) is severely damaged by the root-knot nematode *Meloidogyne incognita* (Kofoid and White) Chitwood (3,4). Eggplant is an important summer crop in Italy and damage by *Meloidogyne* spp. is often reported (8). With two exceptions (3,5), information on the relationship between yield losses and population density of *M. incognita* is lacking. The inoculum type has proved to affect hatching and infectivity of eggs and the extent of yield losses. Hussey and Barker (7) demonstrated that releasing eggs from egg masses of root-knot nematodes with 0.53–1.05% sodium hypochlorite provides a satisfactory inoculum, but this treatment can be detrimental to eggs of *Meloidogyne* since more juveniles emerged from intact egg masses than from eggs released by sodium hypochlorite. Root invasion by juveniles also was higher when egg masses were used. Vrain (11) obtained similar results and emphasized that problems may arise when using inocula of *Meloidogyne* spp. In microplot experiments we found a tolerance limit of pepper (*Capsicum annuum* L.) to *M. incognita* of 2.2 eggs/cm³ soil and minimum yield of 0.58 when dissolved egg masses had been used as inoculum, but under similar conditions a tolerance limit of 0.165 eggs/cm³ soil and a minimum yield of 0.20 were obtained using finely chopped infested roots as inoculum. We hypothesized that the inoculum type may have accounted for the largely different results. Therefore, three experiments were undertaken to study 1) egg

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[1] Istituto di Nematologia Agraria del Consiglio Nazionale delle Ricerche, Via G. Amendola, 165/A—70126 Bari, Italy.
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hatch and 2) infectivity of *M. incognita* as affected by methods of inoculum preparation and 3) the relationship between population densities of the nematode and yield of eggplant by inoculating the soil with infested chopped roots.

Materials and Methods

M. incognita hatch: This experiment was to investigate the hatch of eggs in undisturbed egg masses or from egg masses dissolved in a 1% sodium hypochlorite solution (7). There were five replicates per treatment, each containing 32,000 nematode eggs. Eggs and egg masses were placed in 1.5-cm-d sieves with 20-μm apertures. Sieves were arranged in 3-cm-d plastic petri dishes filled with water and incubated at 25 C for 4 weeks (6). Numbers of emerged juveniles were counted weekly. Unhatched eggs were also counted at the end of the experiment.

M. incognita infectivity: To compare the infectivity of juveniles from entire or dispersed egg masses, two lots of steam-sterilized sandy loam soil were each infested with 8.5 eggs/cm^3 obtained from chopped tomato (*Lycopersicon esculentum* Mill.) roots or by the sodium hypochlorite method (7). Twenty clay pots (750 cm^3) were filled with infested soil, and after 0, 1, 2, and 4 weeks, a 1-month-old Ventura tomato was planted in each of five pots of each inoculum lot and maintained in a greenhouse at 23–27 C. After 4 weeks, tomatoes were harvested, roots were washed free of the adhering soil and processed by Coolen's method (1), and the developmental stages of *M. incognita* within each root system were counted.

Relationship between population densities of M. incognita and eggplant yield: One hundred forty microplots consisting of bottomless square sections of concrete tube (30 × 30 × 50 cm) were buried in soil to within 5 cm of the upper edge. Microplots were contiguous along the rows and spaced 1.20 m between rows. Each microplot contained 40 dm^3 sandy loam soil fumigated with 300 liters/ha of ethylene dibromide 6 months before planting.

Meloidogyne incognita, race 1, was reared on pepper in a greenhouse. When large egg masses were formed, the roots were finely chopped and thoroughly mixed and 10 samples of 10 g each were processed by the sodium hypochlorite method (7) to estimate the nematode population. Roots were then thoroughly mixed with 80 kg fumigated soil. Proper amounts of infested soil were mixed into the soil of each microplot to give population densities of 0.0, 0.062, 0.125, 0.25, 0.50, 1, 2, 4, 8, 16, 32, 64, and 128 eggs and juveniles per cm^3 soil. The use of infested roots was selected because it was considered more efficient than dispersed eggs. The experimental design was a randomized block with 10 replicates of each population level. One day after inoculation (3 May 1983) each microplot was planted with a 2-month-old Lunga Violetta di Romagna eggplant seedling. Proper experimental procedures in relation to irrigation, fertilization, and disease, pest, and weed control were followed. Eggplant fruits were harvested and weighed on 19 and 23 July, 3, 12, 22 and 31 August, and 12 September 1983.

To obtain information on the decline of the nematode population in the absence of a host, 10 more microplots were inoculated with 27.5 eggs and juveniles of *M. incognita*/cm^3 soil and left without plants.

A 2-kg soil sample, composite of 20 cores, was collected with a 2.5-cm-d soil sampler from the top 30 cm of each microplot 1 day after the last harvest. Samples (500 cm^3) were processed by Coolen's method (1,2) to estimate final populations of the nematode and determine rates of reproduction.

Data of the third experiment were analyzed by the Seinhorst equation (10), and LSD comparison of the others were calculated.

Results

M. incognita hatch: No differences were observed in the hatching percentage of the eggs from either undisturbed egg masses or those treated with sodium hypochlorite (Fig. 1). However, visual estimates indicate that only 12% of eggs treated with sodium hypochlorite were viable after 4 weeks, whereas all remaining eggs within the entire egg masses (58%) were still viable. Viable eggs were considered those showing intact egg shell and in which juveniles were observed or egg division was definite.

M. incognita infectivity: At all transplanting intervals, numbers of *M. incognita* recovered from roots of tomato inoculated

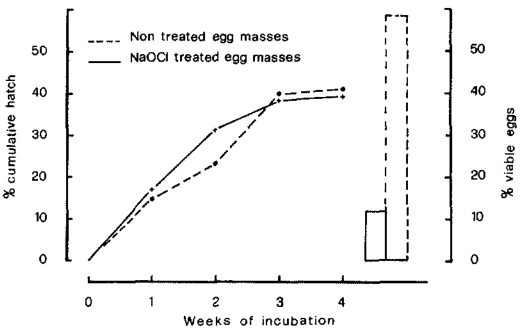

FIG. 1. Hatching of *Meloidogyne incognita* from intact egg masses or from eggs released by sodium hypochlorite treatment and viability of the eggs after 1 month.

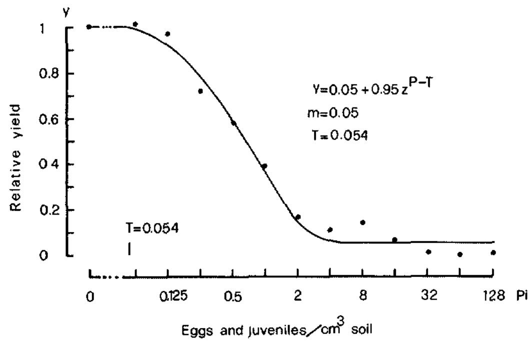

FIG. 3. Effect of initial population density (Pi) of *Meloidogyne incognita* on the relative yield (y) of Lunga Violetta di Romagna eggplant. The relative yield (y) is the yield at Pi divided by the yield at Pi $\leq T$.

with entire egg masses were significantly ($P = 0.01$) greater (3–22.5 times) than those found in the roots inoculated with the eggs treated with sodium hypochlorite (Fig. 2). Infectivity of juveniles hatched from the eggs treated with sodium hypochlorite remained rather constant at all transplanting intervals, while infectivity of untreated eggs was greater but more variable.

Relationship between population densities of M. incognita and eggplant yield: Eggplant growth and yield were greatly reduced by *M. incognita*. Symptoms were evident at population densities (Pi) $\geq$ 0.5 eggs/cm³ soil. Data were consistent with the equation $y = m + (1 - m)z^{P-T}$ (10), where y is the ratio between the yield at Pi and that

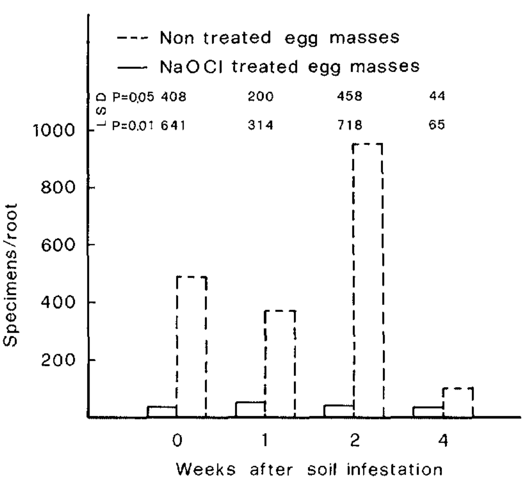

FIG. 2. Numbers of *Meloidogyne incognita* recovered per root of tomato planted in pots at intervals after infestation with eggs and juveniles released by sodium hypochlorite or intact egg masses.

at $P \leq T$, m the minimum relative yield (y at very large Pi), z a constant < 1 with $z^{-T} =$ 1.05, and T the tolerance limit (Pi at which no yield is lost). Fitting the data to the above equation (Fig. 3) gave a tolerance limit (T) of the eggplant of 0.054 eggs/cm³ soil and a minimum yield of 0.05 at Pi $\geq$ 4.

Maximum reproduction rate (Pf/Pi) of 12,300 occurred at the lowest initial population (0.062 eggs/cm³ soil) (Table 1). The reproduction rate decreased with an increase in Pi and was 0.73 at Pi = 128 eggs/cm³ soil. The decline of the nematode population in the absence of the host was 53% over 132 days.

DISCUSSION

The third experiment confirmed the susceptibility of eggplant to *M. incognita*. Dhawan and Sethi (3) did not estimate the tolerance limit of eggplant to *M. incognita* but reported significant growth reduction following inoculation with one juvenile per gram of soil. Gaur and Prasad (5) observed significant damage of eggplant inoculated with juvenile numbers equivalent to 0.08/cm³ soil, and a tolerance limit of 0.04 juveniles/cm³ soil could be derived from their data. Unfortunately pot size, type of inoculum, and cultivars were dissimilar from those used in our experiment, and therefore direct comparison is difficult. We found that reproduction rates of *M. incognita* were higher than those reported (3,5), which may be due to different experimental conditions.

The hatching test showed that the method of collecting inoculum may greatly af-

TABLE 1. Relationship between initial (Pi) and final (Pf) populations of *Meloidogyne incognita* on eggplant.

Eggs and juveniles/cm³ soil		
Pi	Pf	Pf/Pi
0.062	762	12,301
0.125	840	7,623
0.25	937	3,749
0.5	863	1,735
1	939	939
2	678	339
4	246	62
8	278	35
16	207	13
32	102	3
64	65	1
128	93	0.73
27.5 (without plant)	13	0.47

fect the viability of eggs. After 1 month, only 50% of *M. incognita* eggs treated with sodium hypochlorite were viable, whereas all the unhatched eggs within undisturbed egg masses were viable.

The infectivity test confirmed the finding of the hatching experiment: the method of collecting inoculum also affects the invasion of the host plant root by *M. incognita,* and more juveniles penetrated the roots when entire egg masses were used.

Our results are consistent with those of Hussey and Barker (7) and especially those of Vrain (11), who found greater hatch and root invasion with intact egg masses than with dispersed eggs. Recently O'Bannon et al. (9) observed no differences in development of eggs dispersed either in 0.525% sodium hypochlorite solution or in water, during 3 weeks incubation at ≤15 C, but development of eggs extracted with sodium hypochlorite was slowed after 3 weeks at 20 C.

Our findings, however, and those of the mentioned authors do not fully explain the large differences of yield losses caused by different inoculum type (2). Most probably when dispersed and unprotected eggs are used as inoculum they are easily injured. Injury may be caused by friction with soil particles during the mixing operation, by environmental stress, and by soil organisms that occur in field soil.

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