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Population Densities of *Meloidogyne incognita* and Yield of *Capsicum annuum*[1]

M. Di Vito, N. Greco, and A. Carella[2]

Abstract: Two microplot experiments in 1981 and 1983 provided information on the effect of different population densities of *Meloidogyne incognita* race 1 and yield of sweet pepper. Microplots were square concrete pipes (30 × 30 cm and 50 cm long) filled with 40 liters of soil infested with 0, 0.062, 0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512 eggs and juveniles/cm^3 soil. Tolerance limits of 2.2 and 0.165 eggs and juveniles/cm^3 soil and minimum yields of 58% and 20% of the controls were obtained in 1981 and 1983, respectively. Maximum reproduction rates of the nematode were 274 and 1,498 at the lowest initial population density. The population of the nematode declined rapidly after harvest, and only 13% and 6.5% of eggs and juveniles were detected in the soil after 1 and 6 months, respectively.

Key words: root-knot nematode, tolerance limit, population decline, sweet pepper.

The root-knot nematode *Meloidogyne incognita* (Kofoid & White) Chitwood occurs in almost all vegetable-growing areas of Italy where it suppresses sweet pepper (*Capsicum annuum* L.) yields (2,5). Nematode densities of 0.1 and 1 eggs and juveniles/cm^3 soil greatly limit the growth of chile pepper in the United States (6,9). However, information on the effect of various preplant population densities of *M. incognita* on sweet pepper yields is still lacking. Therefore, microplot experiments were performed in southern Italy, in 1981 and 1983, to determine i) the relationship between population densities of *M. incognita* and yield of pepper, ii) reproduction rate of the nematode on pepper at different initial populations, and iii) decline of *M. incognita* population in soil in the absence of plants.

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[2] Istituto di Nematologia Agraria del Consiglio Nazionale delle Ricerche, Via G. Amendola, 165/A, 70126 Bari, Italy.

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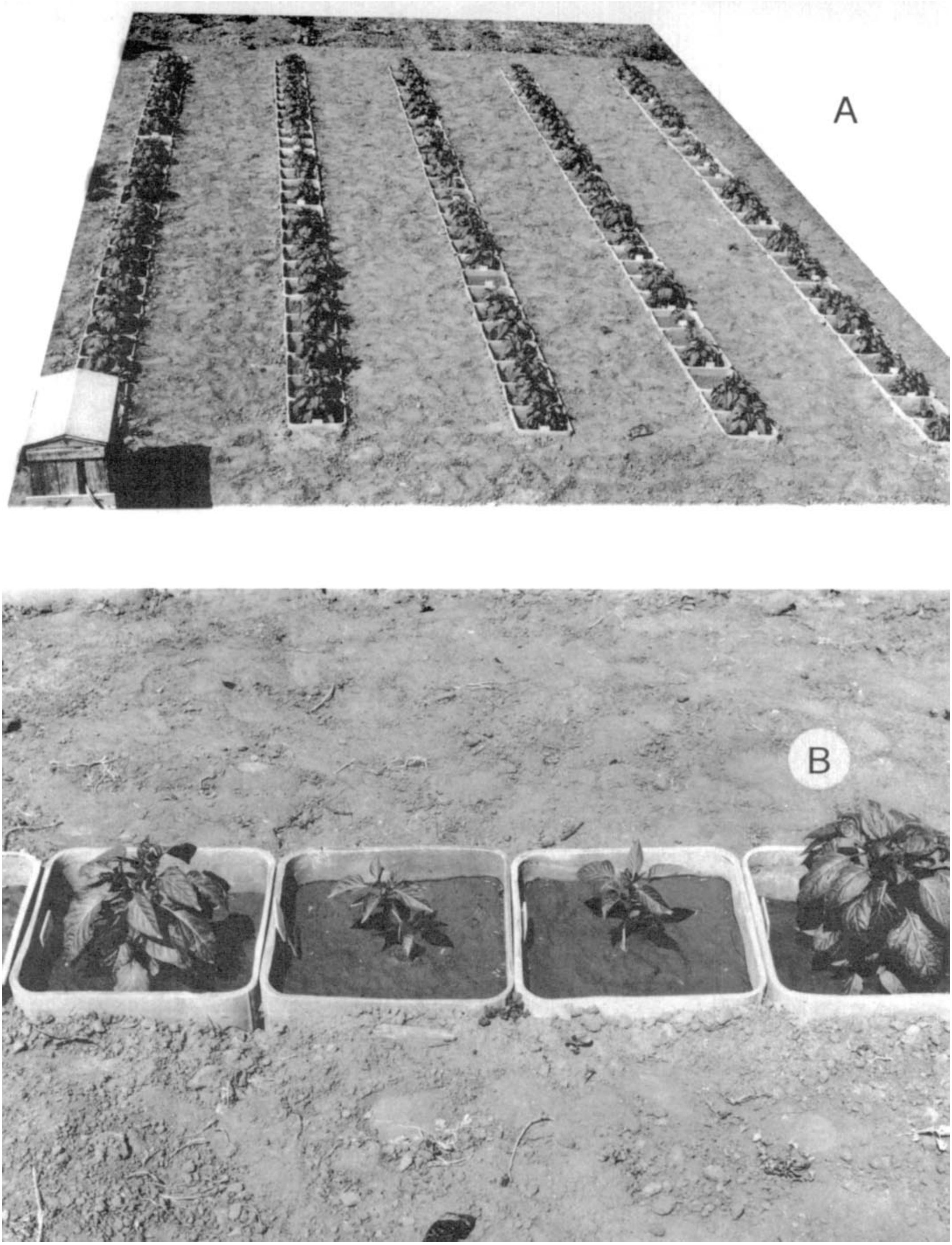

FIG. 1. Microplots. A) Overall view of microplots. B) Microplots with pepper plants showing growth as affected by different initial population densities of *Meloidogyne incognita.*

MATERIALS AND METHODS

One hundred forty microplots made of square concrete pipe, 30 × 30 cm and 50 cm long, were placed 45 cm deep in the field. Microplots, replicated 10 times, were arranged contiguously in rows with 90 cm between rows in a randomized block design (Fig. 1A).

The horizon and subsoil of the plots were treated with 300 liters/ha of ethylene dibromide 45 days before placing the concrete pipes.

Microplots were filled to within 5 cm of the top with 40 liters of a sandy loam (89.1% sand, 7% clay, 3.9% silt, and 2.3% organic matter) which was also treated 7 months earlier with 300 liters/ha of ethylene dibromide.

Effect of initial population, 1981: Meloidogyne incognita host race 1 (8) was reared on pepper in a glasshouse at 25–27 C. Eggs and second-stage juveniles (9:1) were collected from the roots by the sodium hypochlorite method (4) and thoroughly mixed with the soil of each microplot to give a range of initial population densities (Pi) of 0, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512/cm³ of soil. Ten grams of 15-15-15 fertilizer were also added to each microplot.

Two-month-old Yolo Wonder sweet pepper seedlings, grown in a glasshouse at 25–27 C, were transplanted one to a microplot on 30 April 1981.

Fruits were harvested on 9 and 29 July, 20 August, and 9 September 1981, counted, and weighed. A 1.5–2-kg composite soil sample of 20 cores was collected from the top 30 cm of each microplot on 10 September, using a 2.5-cm-d soil sampler to measure the post harvest population (Pf) of *M. incognita.*

Effect of initial population, 1983: The same microplots were used in 1983 for another trial. Roots of pepper infested with *M. incognita* were finely chopped and mixed, and 10 subsamples of 10 grams each were processed by the sodium hypochlorite method (4) to estimate numbers of available eggs and juveniles of the nematode. The roots were then thoroughly mixed in a known quantity of soil, and proper amounts of this were added to the fumigated soil of the microplots to give a range of population densities of 0, 0.062, 0.125, 0.25, 0.5, . . . , 128 eggs and juveniles/cm³ of soil.

Transplanting date and maintenance of the plants during the growing season were the same as in 1981.

Fruits harvest dates of microplots with plants were 7 July, 3, 19, 31 August, and 16 September 1983. To estimate nematode final population, soil samples were collected on 17 September 1983 as in 1981.

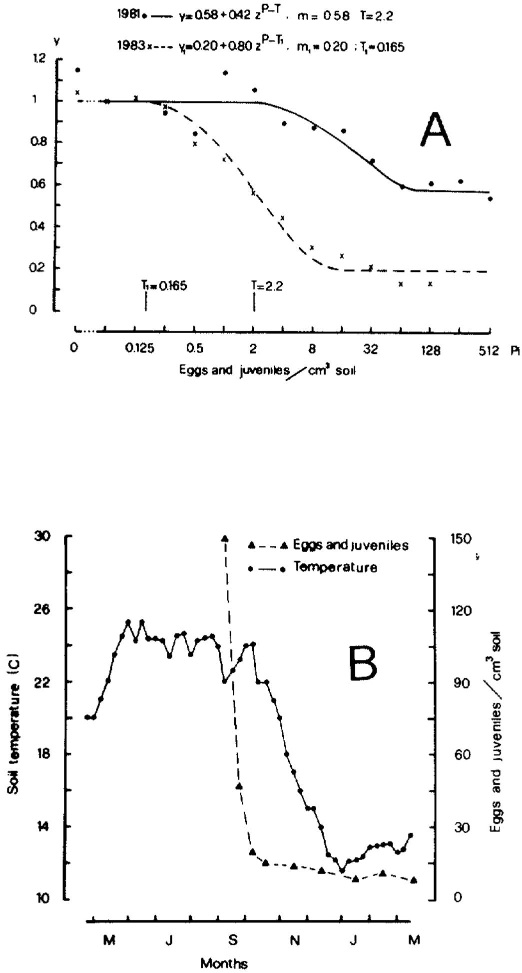

FIG. 2. *Meloidogyne incognita* on *Capsicum annuum.* A) Relationships between initial population densities of *M. incognita* and yield of cv. Yolo Wonder sweet pepper. B) Mean soil temperature at 25 cm deep recorded during 1981 and decline of eggs and juveniles of *M. incognita* in soil after harvest.

Decline of the nematode population, 1981: Ten microplots inoculated with 41 eggs and juveniles/cm³ of soil were left without plants in order to investigate the decline of the nematode population in the absence of a host.

In eight microplots, from which pepper plants had been removed on 10 September, soil sampling was continued every 2 weeks through 22 October and then monthly until 18 March 1982. To achieve information on a possible downward movement of the nematode, 16 soil samples were also collected from the soil beneath the

TABLE 1. Effects of initial population densities (Pi) on reproduction of *Meloidogyne incognita* and on fruit size of pepper Yolo Wonder.

Eggs and juveniles/cm³ soil				Reproduction rate Pf/Pi		Fruit weight g	
Pi		Pf					
1981	1983	1981	1983	1981	1983	1981	1983
0	0					95.6	97.2
	0.062		92.8		1,497.6		87.0
	0.125		110.8		886.4		91.2
0.25	0.25	68.4	126.3	273.8	505.1	82.1	81.9
0.5	0.5	113.4	125.1	226.7	250.1	82.1	83.0
1	1	98.6	168.4	98.6	168.4	81.9	73.8
2	2	131.5	129.1	65.7	63.5	78.7	73.6
4	4	128.4	175.3	32.1	43.8	73.5	75.7
8	8	170.7	142.7	21.3	17.8	80.3	75.2
16	16	171.0	174.2	10.6	10.8	88.1	65.4
32	32	156.6	184.5	4.8	5.7	83.0	62.6
64	64	149.9	198.2	2.3	3.0	64.7	55.2
128	128	99.8	223.7	0.7	1.7	79.2	45.9
256		79.1		0.3		83.0	
512		117.9		0.2		69.1	
41*	27.5*	11.1	16.5	0.2	0.6		
LSD: ($P = 0.05$)		NS	73.7	65.9	204.4	15.3	9.3
($P = 0.01$)		NS	NS	87.3	270.5	NS	12.4

* Without plant.

microplots at this time. The soil had been removed on 10 September 1981 from eight of these microplots and from the others on 18 March 1982.

Decline of the nematode population, 1983: Decline of nematode populations in the absence of plants was studied in 10 microplots infested with 27.5 eggs and juveniles/cm³ of soil by collecting soil samples at harvest.

Eggs and juveniles were extracted from soil by the method of Coolen (1). However, the soil suspension was not separated into organic and mineral fraction. Instead, a few drops of an antifoam agent and commercial sodium hypochlorite to give a concentration of 0.4% were added to the suspension before bubbling air to improve the recovery of eggs and juveniles.

Soil temperature at 25 cm deep was recorded during the experiment (Fig. 2B). Fruit weights, final nematode population, and nematode reproduction rates from microplots with plants were compared by calculating LSDs.

RESULTS

Effect of initial population, 1981: The nematode limited pepper yield (Fig. 1B), but symptoms of *M. incognita* infestation of roots were not evident at inoculum level ≤ 16 eggs and juveniles/cm³ of soil. Yield data were fitted to the equation $y = m + (1 - m)z^{P-T}$ proposed by Seinhorst (7), where T = the tolerance limit (the nematode density below which there is no yield loss), y = the ratio between the yield at nematode density P and the maximum yield (when $P \leq T$), m = the minimum yield (y at very large population density), and z = a constant ≤ 1 with $z^{-T} = 1.05$. Fitting this equation to the data gave a tolerance limit of 2.2 eggs and juveniles/cm³ of soil and a minimum yield of 0.58 (Fig. 2A). The observed differences between mean weight of single pepper fruits at different inoculum levels were significant ($P = 0.05$).

The relation between Pi and Pf shows a maximum reproduction rate, Pf/Pi, of 274 at Pi of 0.25 eggs and juveniles/cm³ of soil (Table 1), which decreased ($P = 0.01$) as the initial population increased.

In 1983 the effect of nematode infestations on the yield of pepper was much greater than in 1981, and a tolerance limit of 0.165 eggs and juveniles/cm³ of soil and a minimum yield of 0.2 were estimated as previously described. Fruit size was greatly influenced ($P = 0.01$) by Pi and at the largest Pi was 48% less than that of noninoculated controls (Table 1). The maximum reproduction rate of the nematode, Pf/Pi, was 1,498 at Pi of 0.062 eggs and juveniles/cm^3 of soil.

Decline of the nematode population: Final populations observed at the last harvest in the microplots without plants were 73% and 40% less than those at planting in 1981 and 1983, respectively. Numbers of newly formed eggs declined rapidly from 10 September 1981 through 18 March 1982 and were 86.7% and 93.5% fewer than at harvest, respectively, 1 and 6 months after the end of the experiment (Fig. 2B). Soil samples collected 50–75 cm deep contained up to 50% as many nematodes as found in the top 25 cm of soil at the same date, and no differences could be seen between microplots from which the soil had been removed on 10 September 1981 or 18 March 1982, suggesting that no downward movement of juveniles and eggs occurred in the absence of the host plant in this soil, either by active movement or by percolating water.

Discussion

The tolerance limit of sweet pepper to *M. incognita* and the minimum yield in 1983 were lower than in 1981 (Fig. 2A). These differences may be caused by the different infestation techniques used in the two experiments. In 1981 the sodium hypochlorite treatments may have reduced the numbers of infective second-stage juveniles reducing the degree of initial root infestation, leading to a higher apparent tolerance limit of sweet pepper to *M. incognita* in 1981 than in 1983. The tolerance limit observed in 1983 should occur under field conditions in southern Italy; it is close to values reported for chile pepper in the United States (6) and for cantaloupe in Italy (3) to *M. incognita.*

The lower value of the reproductive rate registered at the lowest Pi in 1981, compared with 1983, was also due to differences in infestation methods rather than to differences in environmental conditions which were similar in both years. An overestimation of the actual initial population may account for the lower rate observed in 1981.

Almost all *M. incognita* recovered from the soil 1 month after harvest onward were juveniles, suggesting that the overwintering population is mostly second-stage juveniles if the soil temperature remains above 12 C. However, juveniles may have been released from embryonated eggs during extraction of nematodes from the soil. The rapid decline of the soil nematode population, observed after harvest in 1981, suggests that soil samples should be collected and processed very soon after removal of plants to avoid erroneous Pf estimates due to rapid nematode mortality in the absence of a host. Finally, the rather constant population of *M. incognita* observed from January onward (Fig. 2B) indicates that soil samples collected in this period would be useful to predict yield losses of spring host plants.

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