Indian J. Nematol. 24 (1) : 31-37 (1994)

PATHOGENICITY OF *MELOIDOGYNE INCOGNITA* ON SMALL CARDAMOM, *ELETTARIA CARDAMOMUM* MATON

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Abstract : The relationships between a logarithmic series of five initial densities (Pi) of *Meloidogyne incognita* (0 to 400 nematodes/100 cm^3 soil) and growth as well as yield of a susceptible accession of small cardamom (*Elettaria cardamomum*) were investigated through a long term study. Maximum growth suppression and yield loss (46.1%) were noticed at Pi=4 nematodes/100 cm^3 soil followed by Pi=0.4/100 cm^3 soil. The earliest visible damage due to nematode infestation was noticed as reduction in number of tillers, observed six months after inoculation. However, stunting and narrowing of leaves were also observed at the fag end of the trial. No significant difference was observed in the final nematode densities in roots of cardamom plants of different Pi s. The nematode population stabilised after the initial temporal changes as a result of the self-regulatory, density dependent processes with time. Damage caused at the early part of the growth phase of cardamom plants was critical to the final yield and crop stand.

Key words : Root-knot nematode, *Elettaria cardamomum* pathogenicity, yield loss

Small cardamom, *Elettaria cardamomum* Maton is an important spice crop in India, which occupies around 81,[illegible]0 ha in the upper regions of the Western Ghats. The average annual production of cardamom in the country is about 4000 tonnes, which is roughly around 30% of the [illegible] production (Ramadasan, 1992). While [illegible] national productivity of cardamom is 75 [illegible] hectare, the potential yield is as high as [illegible] kg/ha (Nandakumar, 1992). Among [illegible] major constraints for not achieving high [illegible] production, the damage due to pests and [illegible] ranks high.

Several plant parasitic nematodes were [illegible] to be associated with cardamom [illegible] 1991). However, an exhaustive [illegible] conducted during 1979-82 revealed [illegible] occurrence and distribution of root-[illegible] nematodes in cardamom plantations [illegible]. Three species of root-knot [illegible] viz., *Meloidogyne incognita*, *M. javanica* and *M. arenaria* were observed in this survey (Ali, 1984; 1986; Ali & Koshy, 1982). Various symptoms of root-knot nematode infestation on cardamom were compiled by Kumaresan *et al.*, (1988). However no studies were conducted to understand the exact nature of damage and the precise yield losses due to their attack. A knowledge of the relationship between crop yield and numbers of nematodes is fundamental to nematode management decisions. Hence, the present study was taken up to elucidate the symptomatology of root-knot nematode infestation on cardamom and to quantify the crop loss.

MATERIALS AND METHODS

A long term study was conducted at the Research Centre during 1987-91 in microplots (0.78m^2). The microplots were (cement tubs of 1.0 m height and 1.0m diameter) partially buried in soil at 1.5 m apart, at a selected site within a cardamom

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plantation. Channels were provided in between the pots for better drainage during the monsoon period. These pots were filled with a nematode-free potting mixture (5 parts of ordinary loamy soil, 3 parts of organic jungle soil and one part of sand).

Monoclonal suckers of a 'Malabar' cardamom accession (P1), raised in nematode free conditions were uprooted, washed thoroughly and the roots were pruned. Uniform planting units, out of the above were planted in each pot on 10 December, 1987, with a plant to plant distance of two meters. During March, 1988 these plants were inoculated with *Meloidogyne incognita* larvae, obtained from single egg mass cultures multiplied on tomato (local variety). Nematodes were extracted from tomato roots by a combination of maceration and filteration (Hooper, 1970). Aqueous suspensions of a series of initial population densities viz., 0,0.4, 4.0, 40.0, 400.0/100 cm^3 soil (0, 100, 1000, 10000 & 100000/ plot) were prepared and poured to the vicinity of cardamom roots through PVC tubes (three numbers), fixed around the base of the plant at the time of planting. Immediately following inoculation, these tubes were removed and the holes were plugged by sprinkling steam sterilized sand. The five treatments were randomnly assigned within each row of microplots and had ten replications.

Observations on growth and yield characters were recorded every three months during the first year of the experiment and there after at half yearly intervals. Yield was recorded from 1989 onwards by harvesting the individual plants at two week intervals during the respective seasons. Nematode level in each plot was assessed once in a year by drawing root (10-20g) and soil (250cc) samples from each plot. The soil was processed by a combination of bucket sieving method and a miniature version of Whitehead and Hemming's (1965) tray method.

Roots were stained by acid fuchsin-sodium hypochlorite method (Byrd *et al.*, 1983) and nematode population in roots was estimated by extraction through maceration in a laboratory mixer (Marks & Mc Kenna, 1981).

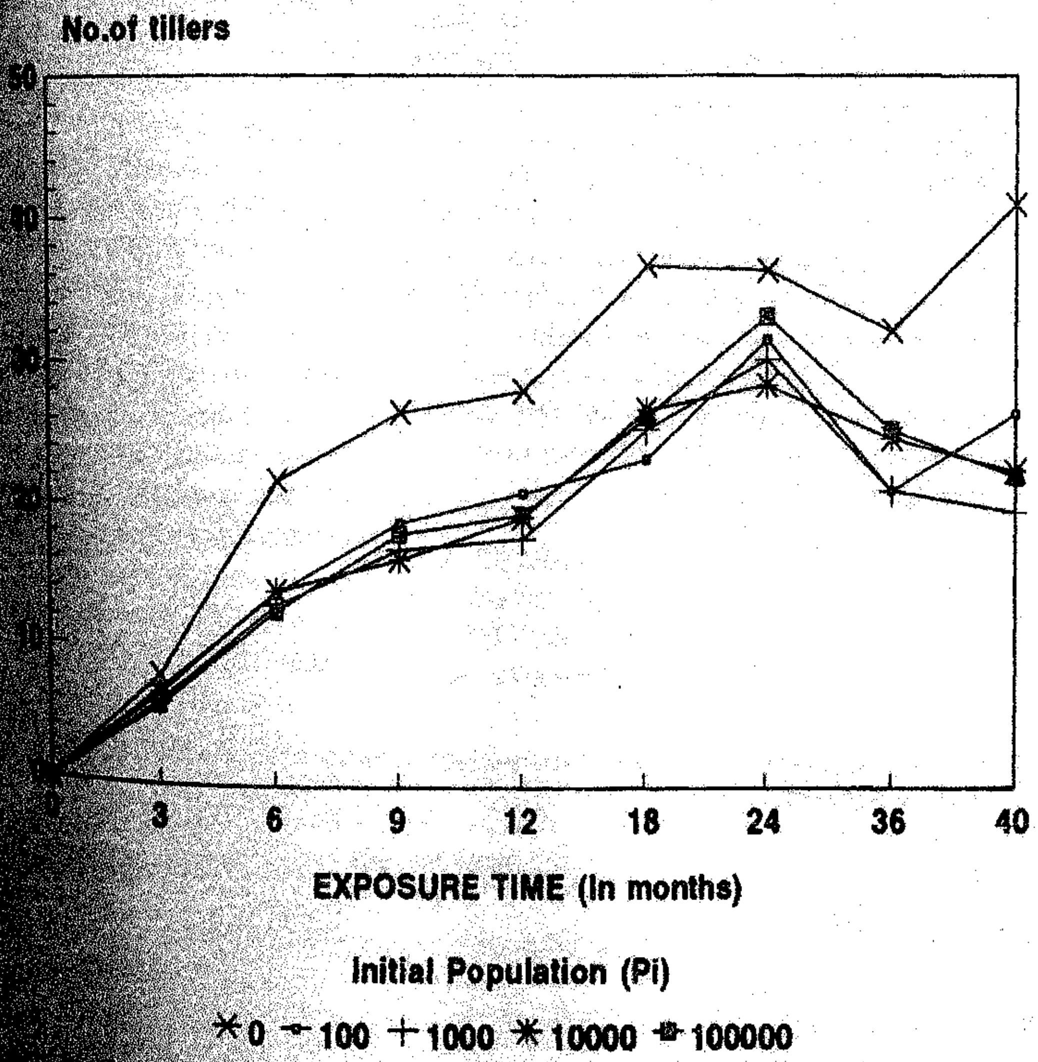
The experiment was concluded in July 1991, after taking the final observations of the uprooted test plants. The data was subjected to analysis of variance and treatment means were compared with the least significant difference.

RESULTS AND DISCUSSION

The final observations on growth characters of cardamom plants are given in Table1. Significant reductions ($P < 0.05$) in number of tillers, primary roots, panicles and leaves were noticed in inoculated plants. The height of the plant, the leaf length and width were also reduced significantly, compared to that of uninoculated control plants. However, among the inoculated plants which received varying initial inoculum [illegible] significant differences were noticed [illegible] regard to any of the above param[illegible] Damage due to nematode infestat[illegible] visible from the sixth month after [illegible] tion. This was manifested as the red[illegible] number of tillers produced per clum[illegible] 1). The drastic reduction (35.9 - 4[illegible] number of tillers is the only sym[illegible] cardamom plants, visible at the ear[illegible] of the nematode attack. All oth[illegible] of damages were exhibited at the [illegible] the trial. Among the various [illegible] reported on cardamom, only st[illegible] narrowing of leaves were found t[illegible] by nematode attack, eventhou[illegible] come apparent several month[illegible] initial infestation. The root biom[illegible] tode infested cardamom plan[illegible] had an unhealthy appearance [illegible] sional incidence of rotting. The [illegible]

TABLE 1. Effect of *Meloidogyne incognita* on growth of *Elettaria cardamomum* plants- observations recorded 40 months after inoculation (Mean of 10 replications).

Initial Population (Pi)	Height (m)	Number of Tillers	Number of Primary Roots	Number of Panicles	Number of Leaves	Leaf Length (cm)	Leaf Width
0	2.05	41.0	724.10	35.37	456.00	47.95	7.08
100	1.78	20.4	225.30	16.00	151.00	43.06	6.11
1000	1.36	19.5	304.90	10.40	139.50	44.64	6.23
10000	1.60	22.4	451.98	19.69	226.87	47.71	6.71
100000	1.63	22.0	410.40	22.50	204.30	47.46	6.49
LSD 0.05	0.30	7.14	282.15	9.58	144.81	3.75	0.57



[illegible] of initial inoculum densities of *Meloidogyne incognita* on tillering of cardamom over time.

primary roots was significantly reduced in nematode infested plants (Table 1). However, galling was less prominent in these roots. Eapen (1992) has reported the smaller size of galls in root-knot nematode infested roots of cardamom vegetaive suckers.

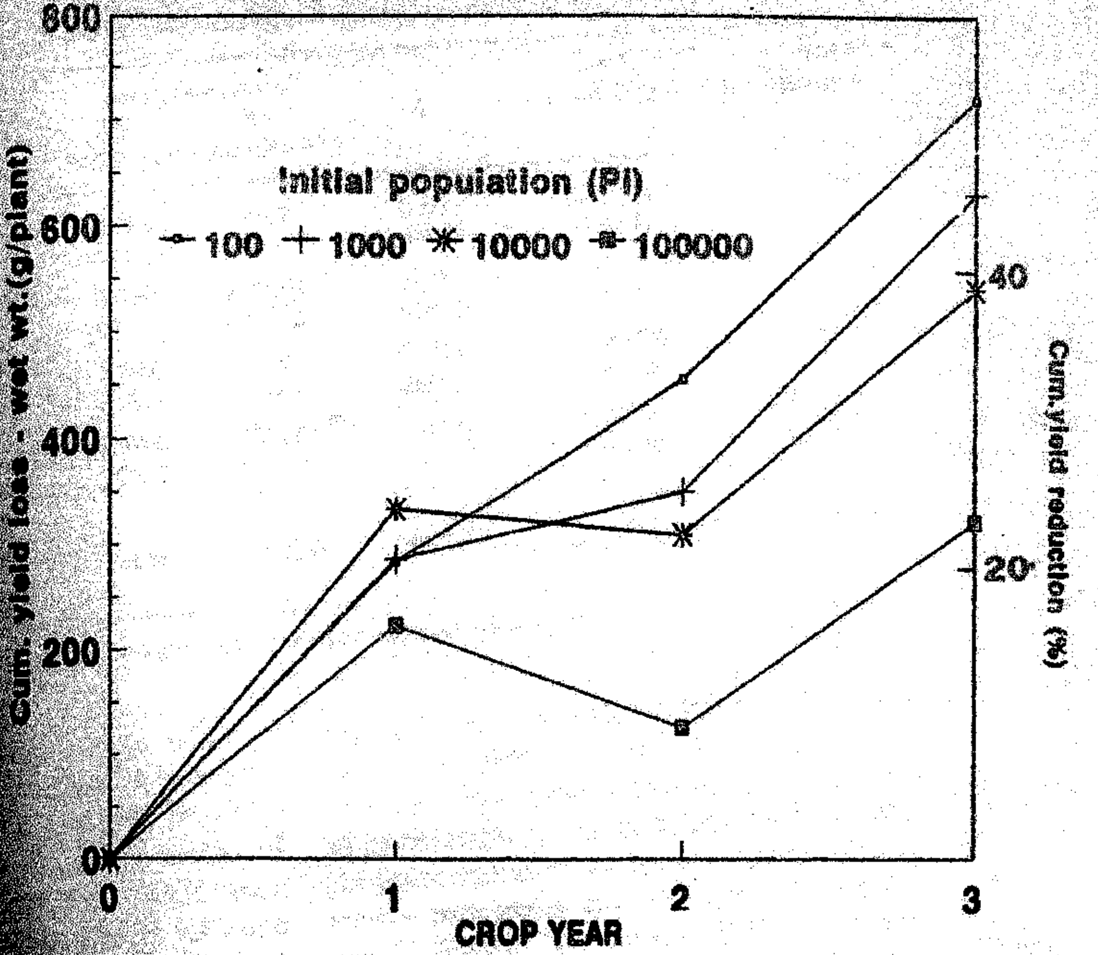
The tillering pattern in cardamom plants which received various treatments clearly reflected the nematode-plant relationship. Initially the greatest reduction in number of tillers was noticed at the highest Pi and subsequently this was shifted to the plants with lower Pis. This is because of the high intraspecific competition and subsequent reduction in nematode populations, occuring in the case of higher Pis, especially at the initial stages. Meanwhile, the nematodes at lower Pis maintain steady increase in their growth rate and simultaneously inflicted more damages to the growth and yield of cardamom plants. In perennials, root growth and increase of nematode numbers are mutually dependent and have this phenomenon (Seinhorst, 1979).

Yield was progressively reduced at all levels of *M. incognita* (Table2) compared to that of nematode free controls. However there was no significant difference in between the yields of cardamom plants with various Pis of 100-100000. The yield levels decreased over time irrespective of the treatment with the exception of two higher Pis for the first and second harvests. But the rate of decrease was enhanced by the presence of *M. incognita* to losses exceeding 45% (Fig. 2). This progressive reduction in yield reflects the effects of prolonged exposure of the crop to *M. incognita*. The cumulative yield losses are inversely proportional to the Pi of *M. incognita*. In nematological systems damage per nematode decreases to a minimum asymptotic level as Pi increases (Noling & Ferris, 1987). In the first crop, lowest reduction in yield was noticed at Pi=10,000 followed by Pi=1000 and not at Pi=100,000. This proved that the effect of the nematode attack on the ultimate size and yield of cardamom plants was largely determined during the early phase of the plant growth. In other words, the plants are more sensitive to nematode infestation in the initial stages of their growth. Reduction of plant size or yield is not a result from repeated destruction by the nematodes, but from a reduction of growth rate during a certain stage of growth (Seinhorst, 1979).

TABLE 2. Yield of cardamom plants inoculated with dellerent initial populations of *Meloidogyne incognita* (Mean of ten replications)

Initial population (Pi)	No. of Harvests I	II	III	Cumulative yield
0	671.9*	431.6	342.7	1831.74
100	387.9	259.5	78.7	726.11
1000	385.8	367.0	62.8	717.48
10000	338.0	455.9	111.8	898.54
100000	448.8	529.1	146.9	1124.9[illegible]
L.S.D. 0.05	200.06	N.S.	126.62	[illegible]

* Yield given is wet weight (g) of cardamom capsules per plant



...fect of *Meloidogyne incognita* on cumulative yield loss of cardamom through time for each of four initial ...densities.

...nematode population in soil samples ...paratively low and hence was ex- ... The nematode level in roots of ... plants inoculated with Pi-1000 ...00 increased till the 18th month ...ation and subsequently decreased ...quilibrium level.

...100 maintained comparatively ... throughout the course of the ... 24th month after inoculation ... significant difference in nema- ...ons in roots of nematode in- ...om plants and the population ... stabilise around 100 nema- ... of root. The figures for final ...pulation (Pf) also supported ... (Table 3). The growth of cardamom plants at the end of the first year reflected Pi of *M. incognita*, but by the end of the third year, all Pi had equivalent effects. Similar observations were made by Bird (1969) in peach inoculated with *Pratylenchus penetrans*. *M. incognita* populations responded initially to unlimited food source by increasing exponentially at rates decreasing with Pi. But as the root biomass decreased with increasing nematode attack, there was corresponding reduction in both multiplication and reproduction rates from their maximum values. However, the continuous or cyclic root growth process in a perennial crop like cardamom, allowed populations of *M. incognita* to gradually attain the maintenance value of one. The rates of multiplication were uniform for the two highest Pis. In

TABLE 3. Effect of *Meloidogyne incognita* initial populations on final nematode populations, their densities over time and multiplication factors in roots of *Elettaria cardamomum*. (Mean of 10 replications)

Initial Population (Pi)	Final Population (Pf)	Nematodes/g root: 9	18	24	40	Multiplication factor (Pf/Pi)
		Months after inoculation				
100	49691.8 (4.455)	84.3 (1.921)	95.5 (1.960)	288.9 (1.683)	179.4 (2.093)	496.92
1000	51572.0 (4.518)	31.7 (1.564)	1017.3 (2.955)	260.6 (2.072)	179.5 (2.187)	51.57
10000	42561.0 (4.031)	127.3 (1.920)	791.0 (2.862)	364.0 (1.910)	108.0 (1.783)	4.25
100000	34346.8 (4.434)	273.3 (2.324)	251.5 (2.365)	448.2 (1.695)	99.9 (1.929)	0.34
L.S.D. 0.05	N.S.	(0.219)	(0.032)	N.S.	N.S.	218.7[illegible]

Data were log 10 (x+1) transformed for analysis. Figures in parentheses are log values.

fact, the multiplication factor (Pf/Pi) is less than one for Pi=100,000 and can be the reason for relatively higher yields in those plants. *Meloidogyne* spp. is reported to be a 'K' selection species and maintain relatively stable populations on perennial plants (Norton, 1978; Barker *et al.*, 1985). Therefore, the quantity and (or) quality of the available food supply was the major governing factor determining the population growth of *M. incognita*, as in alfalfa (Noling & Ferris, 1986).

The life span, female size and fecundity values are also said to be reduced from one generation to the next because of the deterioration of food quality or insufficient food supply. The present study contributes experimental evidence on the existence of self-regulatory, density dependent mechanisms governing root-knot nematode population growth. Ceiling population densities are not necessarily constant values, but are regulated through time by the relative growth rate of the host plant, cultivation practices and other edaphic conditions (Noling & Ferris, 1986).

The study confirmed the [illegible] effects of *M. incognita* infestation [illegible] mom. In addition, the study points [illegible] Pi below detection thresholds [illegible] niles/1000 cm^3 soil) can build [illegible] densities rapidly and inflict serious [illegible] cardamom yields.

ACKNOWLEDGEMENT[illegible]

I wish to thank Dr. K.V. Ram[illegible] helpful suggestions during the [illegible] study and also for the critical [illegible] manuscript. I also gratefully [illegible] the assistance from Mr. Jose [illegible] statistical analysis of the data.

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Accepted for Publication : May. 1993