Relationship Between Initial Population Density and Damage Caused *by Meloidogyne incognita* Populations from Ethiopia

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Abstract

Greenhouse experiments were conducted to determine: the damage potential (T) of *Meloidogyne incognita* on susceptible t mato, resistant tomato and maize. Plants were inoculated with initial inoculum level (pi) of 1,2,4,8 and 16-juveniles/ cm^3 soil and placed in greenhouse benches in a completely randomized block design. The Seinhorst model very well fitted for susceptible tomato due to *M. incognita* populations (r^2= 0.87 and T= 1.60 juveniles/cm^3 of soil) and poorly fitted for both resistant tomato (r^2=0.6) and maize (r^2=0.3). Sever root galling was also observed on susceptible and resistant tomato. Number of egg masses and number of eggs were also correlated positively. Maize didn't show sever root galling.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is an important cash crop grown by both small and commercial growers in Ethiopia. It is produced in both rainy and dry seasons. It is perhaps the most profitable crop for small-scale farmer's (Lemma et al. 1992). Root-knot nematode (*Meloidogyne incognita*) is an important problem and often a limiting factor in tomato cultivation in Ethiopia (Wondirad & Tesfamariam 2000)

Plant growth and yield depend on the number of nematodes invading that plant. Usually plants have certain inherent abilities to compensate for some injury and no yield decrease can be demonstrated up to a certain density. This density is called tolerance limit or damage threshold density (Schomaker et al. 1995)

Several methods have been used to relate nematode population density in the soil at planting and yield of host plants. A common technique to describe relationship between plant growth and pre plant nematode densities is to use a linear regression of plant growth and log transformed nematode population densities. The model used by Seinhorst 1965 commonly referred as the Seinhorst equation, has been used frequently since its publication. The model is as follows:

$$Y = ym.\ m + ym\ .\ (1\text{-}m).\ z^{(x-t)},\ \text{for } x > t \qquad (1)$$

$$Y = ym,\ \text{for } x \leq t, \qquad (2)$$

Where: Y= crop yield or other growth parameter; x= the nematode population density (often referred to as P); t = the nematode population density below which yield reduction can not be measured (t, the tolerance limit or damage threshold density, in many articles also represented as T); ym = mean crop yield where the nematode density is below the tolerance limit (t); m= a constant usually between zero and one, such that ym .m is the yield at the highest possible nematode density; and z= the slope determining parameter (value between zero and one) (Viaene & Abawi 1996). Therefore, the experiment was designed to determine relationships of *M. incognita* populations from Ethiopia on tomato and maize

Materials and Methods

Nematode culturing

Nematode populations were obtained from infected tomato plants from Ziway, Ethiopia. The nematodes were maintained on susceptible tomato 'Marmandae' in the greenhouse at the Agricultural Research Center, Merelbeke, Belgium.

To obtain a pure population, a single egg mass was obtained from a single female and inoculated on susceptible tomato 'Marmande'. The population was identified as *M. incognita* using perianal pattern, second stages juvenile measurements and electrophoresis (Tesfamariam 2000). After 7-8 weeks, re-inoculation was done on new tomato plants to increase the population. Juveniles from egg masses were extracted using Bearman funnel method.

Plastic pots of 500 cm^3 were filled with 2:1:1 ratios of sterilized soil, sand and organic matter, respectively. The pots were arranged in a complete randomized design and replicated eight times. Inoculum levels of 0, 1, 2, 4, 8 and 16 juveniles per cm^3 of soil were inoculated to susceptible cultivar 'Marmande', resistant cultivar 'Beaufort', and hybrid maize. Pots were kept in a greenhouse at a temperature varying between 25-30°C. Plants were fertilized once in a month with a complete fertilizer (NPK; 16:32:16). Foliar fungicide was used as needed.

After 60 days, plants were uprooted for evaluation. Shoot fresh weight, and root-knot index were recorded before processing for further evaluation. A root-knot index scale of 0-5 was used where: 0 = no galls; 1= 1-10% of the root system is galled; 2 = 11-35% of the root system is galled; 3 = 36-65% of the root system is galled; 4 = 66-90% of the root system is galled and 5 = 91-100% of the root system is galled.

Roots were stained with Pheloxine B to selectively stain the egg masses on the root for counting. Galled roots were placed in an aqueous solution of Pheloxine B (0.15g/liter) for 15 minutes. Then, root systems were rinsed in tap water to remove residual stain in the roots (Daykin & Hussey 1985).

Counting of eggs was made after extracting the eggs using an automatic apparatus for free living nematodes. Roots were chopped to 1-5 cm long, blended for 3 minutes and diluted to make 1000 ml of nematode suspension. The machine is adjusted to take aliquot samples of 10 ml three times (Hendrickx 1995).

A computerized program, Seinfit, was used to calculate the best fitting Seinhorst equation for the experiment and determine the damage threshold density (Schomaker et al. 1995, Viaene et al. 1997). Correlation analysis was also done for egg masses and number of eggs and for root galling index and inoculum levels.

Analysis of variance and correlation analysis were done using a computer program Statistica (1998).

Results

The relationship between fresh weight of the three test plants and initial density (Pi) of *M. incognita* was described with the Seinhorest model (Fig. 1,2,3). The Seinhorst model fitted very well for susceptible tomato (r^2=0.87) and fitted poorly for resistant tomato and maize with r^2 values of 0.6 and 0.13, respectively. Different damage potential levels were observed for the different crops. An initial population density of 1.60 /cm^3 of soil were found to cause a minimum tolerance limit on susceptible tomato (Fig.1). Fresh weight of both hybrid maize and resistant tomato was not affected by different nematode densities (Fig. 2,3).

Continuous decline in fresh weight was observed upon increasing initial inoculum level (Fig. 4). However, no significant effect was obtained for resistant tomato and hybrid maize inoculated with populations of *M. incognita* even at the highest nematode density of 16 juveniles/ cm^3 of soil.

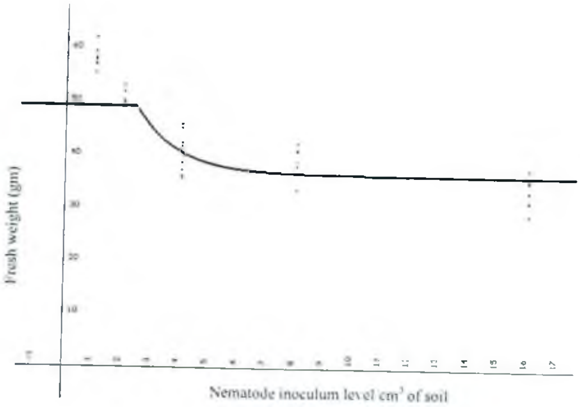


Fig.1. Relationship between initial population of *M. incognita* and fresh weight on susceptible tomato

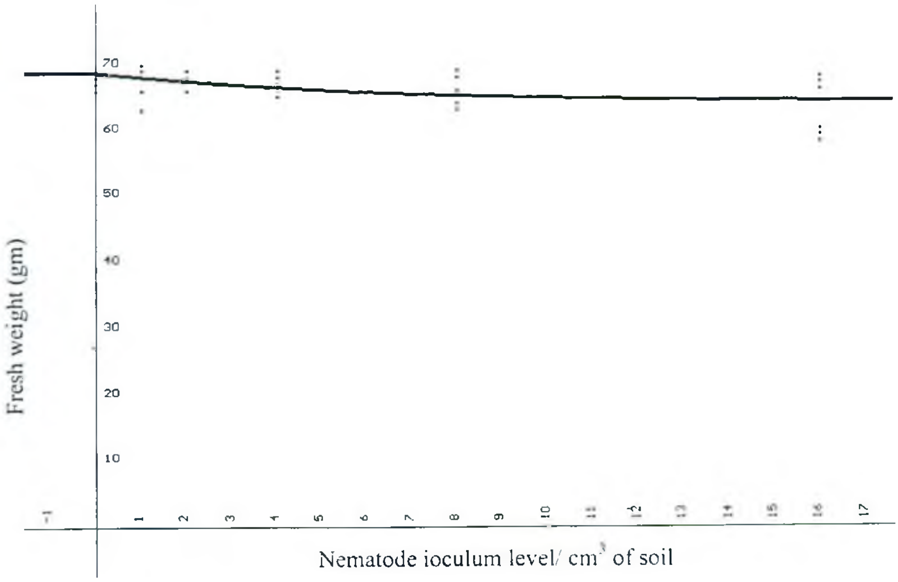


Fig.2. Relationship between initial population of *M. incognita* and fresh weight on resistant tomato

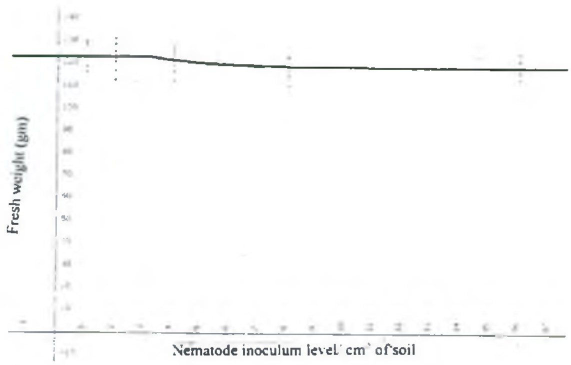


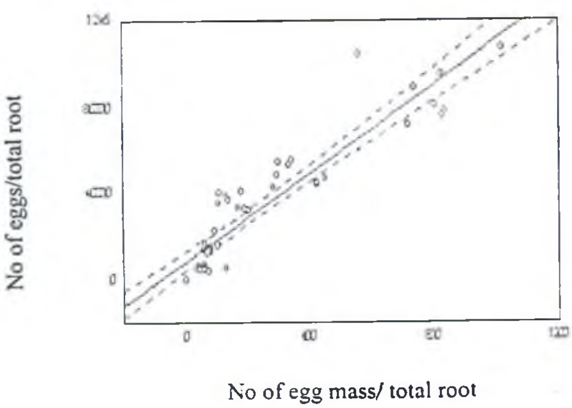
Fig.3. Relationship between initial population of *M. incognita* and fresh weight on hybrid maize

Table 1. Effect of *M. incognita* on fresh weight and root damage on susceptible and resistant tomato and maize 60 days after inoculation.

Test crop	Initial nematode density/cm³ of soil						Sig **
	0	1	2	4	8	16	
	Shoot fresh weight (gm) *						
Susceptible tomato	57.3	58.1	50.8	40.6	39.4	36.6	S
Resistant tomato	68.8	67.8	67.1	67.6	60.9	36.6	Ns
Hybrid maize	120.6	125.7	123.6	122.0	118.4	119.6	Ns
	Root-knot index (1-5) *						
Susceptible tomato	0.00	1.00	1.25	2.50	3.37	4.13	S
Resistant tomato	0.00	0.50	0.62	0.62	1.62	2.50	S
Hybrid maize	0.00	0.00	0.00	0.00	0.25	0.50	S

* *Values of parameterare averages of eight replicated greenhouse pots*
** *S = Significant, and NS = non significant differences between inoculum leveles ($p < 0.05$)*

A.



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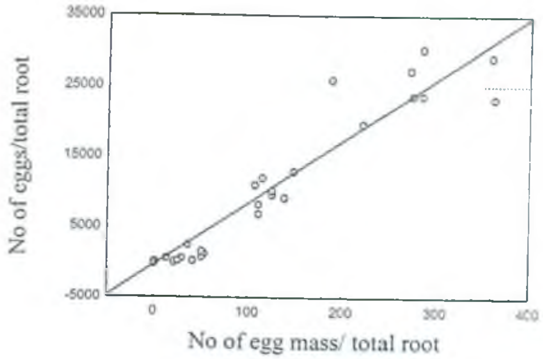
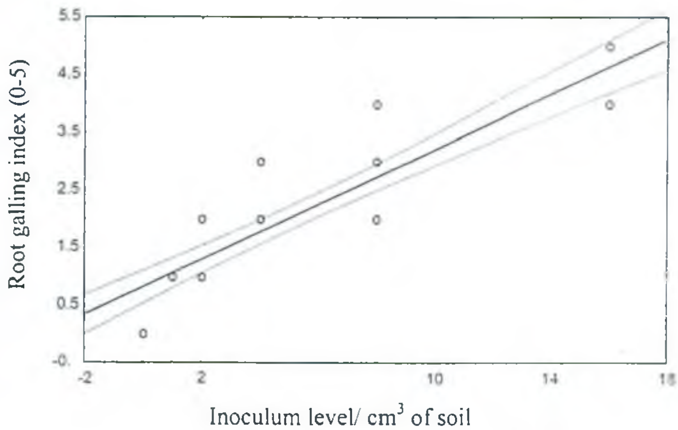
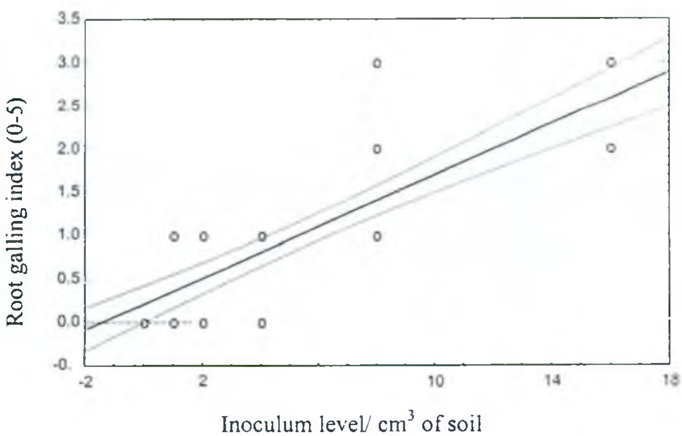


Fig. 4. Correlation between number of egg masses and number of eggs on the whole root system after 60 days of inoculation on (A) Susceptible tomato (B) Resistant tomato.

A.



B



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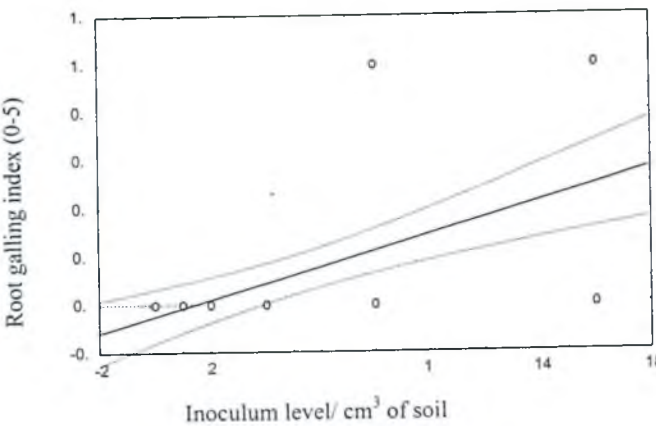

Fig. 5. Correlation between inoculum level (juveniles/cm3 of soil) and root galling index of *M. incognita* on (A). Susceptible tomato (B). Resistant tomato and (C). Hybrid Maize.

Analysis of variance for the effect of *M. incognita* on fresh weight of susceptible tomato showed that there is a significant difference ($P < 0.05$) due to nematode inoculum. Correlation analysis between number of egg masses and number of eggs are shown in Fig. 5,6. There was a significant positive correlation between number of egg masses and number of eggs for susceptible ($r= 0.93$) and resistant ($r= 0.96$) tomato varieties. However, no visible egg masses with only few eggs were found on hybrid maize inoculated with *M. incognita*. Though *M. incognita* produces eggs and egg masses on resistant tomato, the number is by far less compared with the number on susceptible tomato.

Root galling severity increases with increasing densities in susceptible and resistant tomato varieties, $r = 0.88$ and $r = 0.84$, respectively. While on maize *M. incognita* infection was less ($r = 0.56$) with only trace galling at highest densities (Table 1) (Fig. 6).

Discussion

Results from *M. incognita* on susceptible tomato indicated a tolerance level of 1.60 juveniles per cm^3 of soil. Even though damage on resistant tomato was not significant, the cultivar supports reproduction of nematode population to the next crop. The study showed the resistant tomato do not have complete resistance; rather it is a tolerant cultivar where it allows nematode multiplication without showing yield reduction. Use of tolerant tomato as rotation crop results in build up of residual population for the next crop.

Results obtained from previous research are comparable, however, there are some variations accounted for: growing conditions, type of cultivar under study, the nematode species involved, soil type, etc. (Barker et al. 1976) (Viaene & Abawi 1996). Low damage threshold levels of *M. incognita* per 100 cm^3 were reported for watermelon (2-50), tobacco (1-40), soybean (10-250), snap bean (100-600), peach (2), cotton (10-100), and cabbage (150-1000). The tolerance level of *M. incognita* on tomato was 2-100 nematodes/

100 cm^3 soils depending on the host status and nematode race (Barker et al. 1976). Comparably, Ethiopian isolates of *M. incognita* in this study has shown high pathogenecity.

Hybrid maize showed non-significant difference in fresh weight at all inoculum levels in this particular experiment. However, other studies showed tolerance level of 50-1000 / 100cm^3 in corn due to *M. incognita* (Barker et al. 1985). This deviation could be explained due to variation in variety, growing conditions, population pathogenecity, etc. Hybrid maize showed low root galling severity due to *M. incognita* population.

Root galling severity increased with increasing inoculum level of *M. incognita* on susceptible and resistant tomatoes (Table 1). Because *M. incognita* has high damage potentials and reproduction capacity on susceptible tomato, research is needed in the development of resistant cultivars. The experiment also indicated that, controlling nematodes in subsistence agriculture of the tropics could be achieved by using resistant cultivars. Crop rotation should also be considered for control, provided that crops only support limited nematode reproduction. Because of large variation in host suitability within species of root-knot nematodes, all crops being considered for rotation must be tested for host resistance against local isolates before recommendation.

Number of eggs and egg masses were counted from roots, assuming that most of the population of root-knot nematodes was present as eggs in the roots. Egg mass number and number of eggs were also higher on susceptible tomato. Number of eggs correlated very well with number of egg mass, which shows the possibility of counting egg masses only for evaluation of different root-knot experiments.

This investigation provides information about tolerance limit of *M. incognita* on tomato, relationship between egg mass number and number of eggs, the use of alternative crops in controlling nematodes.

References

Barker KR and THA Olthof. 1976. Relationship between nematode population densities and crop responses. Annual review of Phytopathology **14**: 327-353.

Barker KR, DP Schmitt and JL Imbriani.1985. Nematode population dynamics with emphasis on determining damage potential to crops. *In:* Barker KR, CC Carter and JN Sasser (eds). Advanced Treatise on Meloidogyne: Vol II, Methodology, pp. 135-145. A cooperative publication of the Department of Pathology and USAID. North Carolina University.

Daykin ME and RS Hussey. 1985. Staining and histopathological techniques in Nematology. *In:* Barker KR, CC Carter and JN Sasser (eds). Advanced Treatise on Meloidogyne. Vol. II, Methodology. pp. 41. A cooperative publication of the Department of Pathology and USAID. North Carolina University.

Hendrickx G. 1995. An automatic apparatus for extracting free-living nematode stages from soil. International Journal of Nematological Research. **41**: 308.

Lemma D, Yayeh Z and Herath E. 1992. Agronomic studies on Tomato and Capsicum. I*n:* Lemma D and E Herath (eds). Horticultural research and development in Ethiopia. pp153-163. Proceedings of the second horticultural workshop of Ethiopia. IAR, Addis Abeba, Ethiopia.

Tesfamariam Mekete. 2000. Damage potentials of *Meloidogyne incognita* and *M. javanica* populations from Ethiopia and Belgium. M.Sc. thesis. University of Ghent, Belgium. 46 pp.

Oostenbrink M. 1966. Major characteristics of the relation between nematodes and plants. Medede. Landbouwhogesch. Wageningen. No. 66-64. pp. 46.

Schomaker CH, TH Been and JW Seinhorst. 1995. A growth model for plants attacked by nematodes. *In:* Harercot AJ and DKL Mackerron (eds).Potato Ecology and Modeling of Crops under Conditions Limiting Growth. pp. 197-214.

Seinhorst JW 1965. The relation between nematode densities and damage to plants. Nematologica **11:** 137-154.

Viaene NM, P Simoens and GS Abawi. 1997. Seinfit, a computerised programme for estimation of Seinhorst equation. Journal of Nematology **29**: 474-477

Viaene NM and GS Abawi. 1996. Damage threshold of *Meloidogyne hapla* to Lettuce in organic soil. Journal of Nematology **28**: 537-545.