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# Susceptibility of Seven Tomato (*Lycopersicon esculentus*) Varieties to Root-Knot Nematode, *Meloidogyne incognita*

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## ABSTRACT

A study was conducted to determine the effect of tomato variety on the infestation and population development of root-knot nematode, *Meloidogyne incognita* (Kofoid and White) in pot experiments. Seven tomato varieties namely $T_{245}$, B-1 'Ravi', HT-148-3-11 'Tharindu', BT-15-1 'Thilina', HT 01 'Rashmi', HT.01.16.38 'Rajitha', and 'Maheshi' were tested against the second stage juveniles of *M. incognita* at a rate of 15 and 30 nematodes per plant. The nematodes could multiply rapidly within the root system of all the tomato varieties tested. However, $T_{245}$ and B-1 'Ravi' did not show significant damage by the nematodes at any of the doses tested. In contrast, there was a significant reduction of root length and root weight in HT.01.16.38 'Rajitha' and 'Maheshi' at the higher nematode dose. These four varieties had comparatively less root gall formation at both doses tested. Significant reduction in plant height, root length and root weight and a high rate of gall formation and nematode reproduction were observed in HT-148-3-11 'Tharindu', BT-15-1 'Thilina' and HT 01 'Rashmi'. Overall the tested varieties exhibited a higher number of chlorotic leaves at the higher dose of nematodes. By integrating the experimental data, $T_{245}$ and B-1 'Ravi' could be categorized as less susceptible, HT.01.16.38 'Rajitha' and 'Maheshi' as susceptible and HT-148-3-11 'Tharindu', BT-15-1 'Thilina' and HT 01 'Rashmi' as highly susceptible to *M. incognita*.

**Keywords:** chlorosis, pot experiment, root galls, varieties

## INTRODUCTION

Plant parasitic nematodes are obligatory parasites of almost every agricultural and horticultural crop. The root-knot nematodes, *Meloidogyne* spp. are sedentary endoparasites and they have a wide host range. Many important field crops, vegetable crops, fruit trees, ornamental plants and weeds are good hosts of these nematodes and they are among the most important species of phyto-nematodes. Six species of *Meloidogyne* have been recorded from Sri Lanka, the most destructive of which is *M. incognita* in all vegetable-growing areas. Estimated yield loss in tomato due to *M. incognita* ranges from 10 to 85% (Ekanayake *et al.* 2003). Infestation of *Meloidogyne* spp. is a major constraint to obtaining higher yields of many vegetable crops in all agro-ecological regions. Tomato, *Lycopersicon esculentus*, is one of the agriculture crops most seriously affected by root-knot nematodes (Jacquet *et al.* 2005).

After hatching in the soil, infective second stage juveniles of root-knot nematodes, *Meloidogyne* spp. must locate and penetrate a root, migrate into the vascular cylinder, and establish a permanent feeding site (Bird 2004). They become sedentary and establish a strong relationship with the host plant. They inject secretions from oesophageal glands to induce vascular cells around the nematode's head to become enlarge specialized feeding cells. These are converted into multinucleate 'giant cells' through synchronous nuclear divisions without cell division. Fully differentiated giant cells may contain more than a hundred polyploid nuclei (Caillaud *et al*. 2008). Giant cells act as metabolic sinks that actively transfer nutrients from the host plant to the developing nematodes. Root tissues around the giant cells undergo hyperplasia, and hypertrophy resulting in the characteristic root galls associated with root knot nematode (Dropkin 1989; Caillaud *et al*. 2008). Formation of root galls alters the uptake of water and nutrients and, together with the nematode feeding, reduces plant growth. Nutrients and water transportation from the root to the tip is diminished by infected roots, and as a result, aboveground symptoms such as chlorosis and temporary wilting are prominent during periods of water stress. In addition, some of the plant sugars produced by photosynthesis are diverted to the giant cells to sustain the developing nematodes there by normal root growth is reduced (Dropkin 1989; Nickel 1991; Bleve-Zacheo *et al.* 2007).

Chemical soil sterilisation and the use of other unselective pesticides to control plant parasitic nematodes are common practices against root-knot nematodes. However, the practice of crop rotation using non-host crops, the addition of organic matter to suppress soil nematode population and the selection of natural resistant varieties by conventional breeding are some of the measures in integrated nematode management in Sri Lanka (Ekanayake *et al.* 2003).

The present study was conducted to find out the effect of *Meloidogyne incognita* on the growth of seven tomato varieties cultivated in Sri Lanka and varietal differences of tomato to infestation and population development of *M. incognita*.

## MATERIALS AND METHODS

Infective juveniles of *Meloidogyne incognita* were collected from infested spinach (*Spinacea oleracea*) plants. Identification of the species of nematodes was done using the cuticular perineal pattern of the female nematode. The procedure given by Hopper *et al.* (2005) was adopted. The galled roots were separated, cleaned and teased apart to remove adult females under a light microscope at ×10 magnification. The neck of the female was cut and the interior organs were gently pushed out. The cuticle was placed in a drop of 45% lactic acid on a glass slide. Then the cuticle was cut in half with a needle and the half with the perineal pattern was placed into 45% lactic acid. Then, the perineal pattern was transferred on to a glass slide with a drop of glycerin and was gently covered with a cover slip. The specimen was observed under a light microscope at

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**Table 1** Above ground mean plant measurements (± SE) in Experiments 1 and 2.

| Variety | Experiment 1 | | Experiment 2 | |
|---|---|---|---|---|
| | Plant height (cm) | Stem diameter (mm) | Plant height (cm) | Stem diameter (mm) |
| T245 | 82.5 ± 5.8 | 3.9 ± 0.06 | 81.4 ± 5.8 | 4.24 ± 0.22 |
| Inoculated control | 71.0 ± 1.79 | 3.7 ± 0.7 | 95.2 ± 8.4 | 4.8 ± 0.218 |
| | (NS) | (NS) | (NS) | (NS) |
| B-1 'Ravi' | 87.53 ± 7.36 | 4.27 ± 0.239 | 96.4 ± 2.26 | 4.63 ± 0.36 |
| Inoculated control | 89.3 ± 2.92 | 4.04 ± 0.33 | 108.1 ± 9.6 | 4.9 ± 0.29 |
| | (NS) | (NS) | (NS) | (NS) |
| H T-148-3-11 'Tharindu' | 76.2 ± 0.6 | 4.20 ± 0.25 | 92 ± 4.8 | 3.86 ± 0.147 |
| Inoculated control | 62.9 ± 12.0 | 4.10 ± 0.09 | 120.2 ± 2.8** | 5.42 ± 0.27 |
| | (NS) | (NS) | | (NS) |
| BT-15-1 'Thilina' | 92.9 ± 2.47 | 3.78 ± 0.21 | 90.4 ± 5.4 | 4.56 ± 0.138 |
| Inoculated control | 92.1 ± 10.5 | 4.09 ± 0.19 | 120.5 ± 6.8* | 4.78 ± 0.25 |
| | (NS) | (NS) | | (NS) |
| HT 01 'Rashmi' | 68.8 ± 7.5 | 4.52 ± 0.16 | 84.2 ± 8.25 | 4.75 ± 0.517 |
| Inoculated control | 61.8 ± 3.2 | 4.02 ± 0.06 | 110.8 ± 4.2 * | 4.62 ± 0.25 |
| | (NS) | (NS) | | (NS) |
| HT 01.16.38 'Rajitha' | 87.13 ± 7.47 | 3.92 ± 0.26 | 88.5 ± 12.23 | 4.52 ± 0.286 |
| Inoculated control | 79.8 ± 7.36 | 4.37 ± 0.19 | 116.2 ± 8.0 | 5.25 ± 0.183 |
| | (NS) | (NS) | (NS) | (NS) |
| 'Maheshi' | 76.7 ± 0.9 | 4.23 ± 0.105 | 80.4 ± 8.8 | 4.15 ± 0.269 |
| Inoculated control | 75.03 ± 7.7 | 4.73 ± 0.168 | 88.2 ± 6.2 | 4.96 ± 0.24 |
| | (NS) | (NS) | (NS) | (NS) |

NS: measurements are not significantly different from control
$p \leq 0.05$ = *, $p \leq 0.005$ = **: plant height is significantly different from that of control

400X magnification. The method was repeated for 20 specimens and confirmed them as *M. incognita.* Freshly hatched active second stage juveniles were used to inoculate the test tomato plants whenever necessary during this study.

About 75 kg of soil was collected into 10 polythene bags from a natural habitat at the University of Kelaniya premises. Soil-filled bags were tightly closed and exposed to direct hot sunlight continuously for 5 h daily for two weeks to destroy other fauna and their nematode-free status was confirmed by the modified Bearmann funnel technique (Hopper *et al*. 2005). This soil was used to grow tomato plants.

Seeds from seven varieties of tomato, *Lycopersicon esculentus*, namely $T_{245}$, B-1 'Ravi', HT-148-3-11 'Tharindu', BT-15-1 'Thilina', HT-01'Rashmi', HT 01.16.38 'Rajitha' and 'Maheshi' were purchased from the sales outlet of the Horticulture Crop Research and Development Institute, Peradeniya, Sri Lanka.

## Experiment 1: The effect of *M. incognita* on tomato varieties at the dose of 15 nematodes/plant

Seventy polythene bags each 15 cm in diameter and 20 cm in height were filled with about one 1 Kg of soil. They were used as experimental pots. The seven tomato varieties were maintained with 10 replicates each in experimental pots. A single plant was maintained per pot. At the 2nd week from planting, 1 ml of aqueous suspension containing 15 infective juveniles of *M. incognita* was inoculated to the soil around the root system of the plant, with five replicates for each variety. The other five replicates (uninoculated) remained as controls. The pots were arranged in a Complete Randomized Design and were kept for three months in an open area outside the laboratory. The temperature during the study period was 28 ± 2°C. All the plants were watered daily and fertilized regularly using foliar spray and NPK fertilizer as per the recommendation given by the authority of the Department of Agriculture, Sri Lanka. They were checked for other pests and weeds which were removed manually. Plants were supported by wooden pegs. At the 12th week of inoculation, the length of the stem (cm), diameter of the stem (mm), number of total leaves, and number of yellow (chlorotic) leaves were recorded. After the aboveground plant measurements, plant stems were separated at the base, i.e. soil level. Each pot of soil with the root system was split open to expose the roots. The root system of each plant was carefully washed. The root length (cm), wet root weight (g), and the numbers of galls per plant were recorded. The population of *M. incognita* (number of second stage juveniles and eggs) for each 1 g of root was recorded and this was calculated for the total population per plant.

## Experiment 2: The effect of *M. incognita* on tomato varieties at the dose of 30 nematodes/plant

The same tomato varieties were used as for experiment 1. At the 2nd week from planting, a suspension of 30 nematodes per plant was inoculated to five replicates of each variety. The other five replicates remained as controls. Pots were arranged as Complete Randomized Design. Maintenance of experimental pots and post treatment measurements and observations were as in experiment 1.

The data were analyzed statistically by LSD and means compared to the control by a Student's *t*-test or between them by Duncan's multiple range test. Mean data values were followed by ± standard error obtained by descriptive statistics.

# RESULTS

All seven tomato varieties were affected by *M. incognita* but to different degrees.

## Above-ground plant measurements: Experiment 1

The mean plant height and stem diameter for inoculated plants at the end of the experiment were almost similar or slightly different compared to the control plants. They were not significantly different to each other (**Table 1**). The results revealed that the percentage chlorotic leaves of BT-15-1 increased significantly when tested using 15 nematodes per plant (**Fig. 1**).

## Above-ground plant measurements: Experiment 2

A significant reduction in mean plant height was evident in HT-148-3-11 'Tharindu', BT-15-1 'Thilina' and HT 01 'Rashmi' when tested with the dose of 30 nematodes per plant (**Table 1**). However, stem diameter was not statistically different from controls. A significant difference in the percentage chlorosis was evident in tomato varieties, except for 'Maheshi' (**Fig. 2**).

## Below-ground plant measurements

There were no significant differences in mean root length and mean root weight when tested using 15 nematodes per plant (**Table 2**). However, a significant reduction of the mean root length in BT-15-1, HT 01, HT.01.16.38 and 'Maheshi' and mean root weight in HT-148-3-11, HT.01.16.38, and 'Maheshi' were observed when tested using 30 nema-

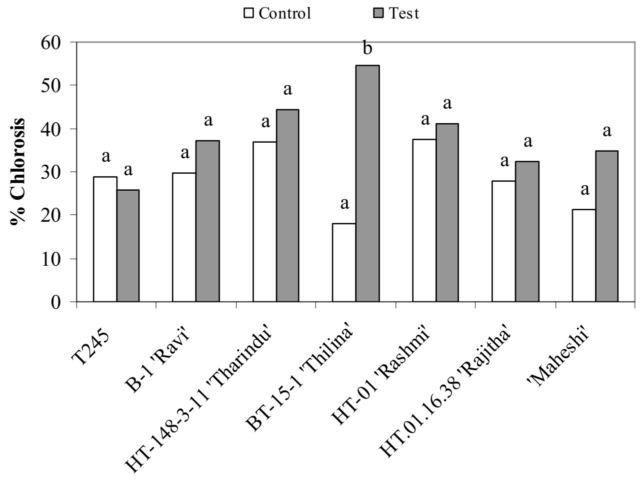


**Fig. 1 The percentage of chlorosis in seven tomato varieties at the dosage of 15 nematodes per plant (±SE).** % chlorosis on a given variety followed by the same letter are not significantly different according to Duncan's Multiple Range test at p≤0.05.

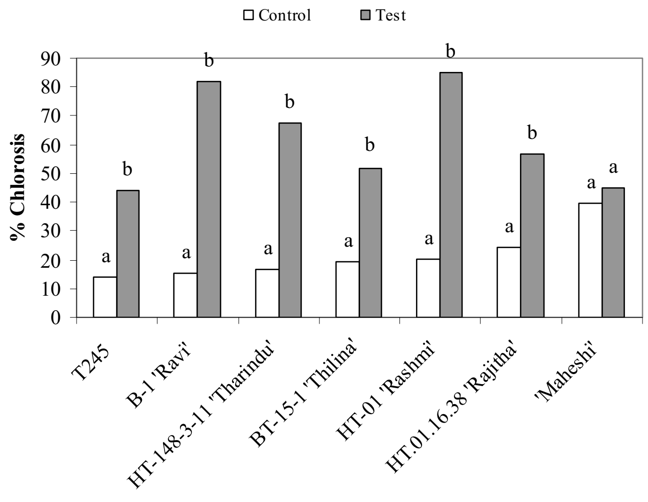


**Fig. 2 The percentage of chlorosis in seven tomato varieties at the dosage of 30 nematodes per plant (±SE).** % chlorosis on a given variety followed by the same letter are not significantly different according to Duncan's Multiple Range test at p≤0.05.

todes per plant (**Table 3**).

## Formation of galls, reproductive rate of root-knot nematodes and categorization of varieties

Mean gall formation at the low nematode dose was not significantly different between varieties but was significant at the higher nematode dose (**Table 4**). Three varieties, HT-148-3-11, BT-15-1 and HT 01 showed significantly higher number of galls with a high reproductive rate of the nematodes. Thus, HT-148-3-11, BT-15-1 and HT 01 are highly susceptible to *M. incognita* (**Table 4**). Among them, BT-15-1 produced large galls that measure about 1.8 mm in diameter (**Fig. 3A**) compared to those of other varieties (**Fig. 3B, 3C**). Four varieties, $T_{245}$, B-1 'Ravi', HT.01.16.38 and 'Maheshi' produced significantly fewer galls and nematode reproduction in these four varieties was significantly less. The mean root weight and mean root length of HT.01.16.38 and 'Maheshi' were significantly reduced (**Table 3**) indicating that these two varieties are susceptible to infection by

**Table 2** Below ground mean plant measurements (± SE) in experiment 1.

| Variety | Root length (cm) ±SE | Root weight (g) ±SE |
|---|---|---|
| T245 Inoculated | 15.50 ± 2.91 | 4.15 ± 0.31 |
| Control | 11.76 ± 0.94 (NS) | 2.45 ± 1.19 (NS) |
| B-1 'Ravi' Inoculated | 13.40 ± 2.12 | 4.55 ± 1.60 |
| Control | 13.23 ±1.41 (NS) | 2.43 ± 1.19 (NS) |
| H T-148-3-11 'Tharindu' Inoculated | 16.93 ± 2.71 | 5.23 ± 2.09 |
| Control | 15.83 ± 3.36 (NS) | 4.13 ± 0.55 (NS) |
| BT-15-1 'Thilina' Inoculated | 9.80 ± 0.32 | 2.84 ± 0.08 |
| Control | 12.13 ± 1.62 (NS) | 2.91 ± 0.32 (NS) |
| HT 01 'Rashmi' Inoculated | 10.40 ± 1.60 | 1.04 ± 1.5 |
| Control | 10.20 ± 1.13 (NS) | 2.21 ± 0.49 (NS) |
| HT 01.16.38 'Rajitha' Inoculated | 11.90 ± 1.65 | 4.81 ± 1.92 |
| Control | 8.83 ± 0.81 (NS) | 3.11 ± 0.77 (NS) |
| 'Maheshi' Inoculated | 12.20 ± 0.80 | 3.2 ± 0.44 |
| Control | 14.23 ± 2.5 (NS) | 2.85 ± 0.47 (NS) |

NS measurements are not significantly different from that of control

**Table 3** Below ground mean plant measurements (±SE) in experiment 2.

| Variety | Root length (cm) ±SE | Root weight (g) ±SE |
|---|---|---|
| T245 Inoculated | 8.94 ± 1.96 | 1.59 ± 0.77 |
| Control | 13.64 ± 1.25 (NS) | 2.86 ± 0.39 (NS) |
| B-1 'Ravi' Inoculated | 11.96 ± 1.71 | 1.75 ± 1.60 |
| Control | 16.64 ± 2.13 (NS) | 2.84 ± 0.52 (NS) |
| H T-148-3-11 'Tharindu' Inoculated | 12.84 ± 0.66 | 1.99 ± 0.39 |
| Control | 15.74 ± 1.72 (NS) | 3.93 ± 0.49 * |
| BT-15-1 'Thilina' Inoculated | 12.06 ± 1.07 | 2.18 ± 0.27 |
| Control | 16 ± 1.06 * | 2.82 ± 0.19 (NS) |
| HT 01 'Rashmi' Inoculated | 7.86 ± 1.19 | 1.35 ± 0.41 |
| Control | 16.4 ± 1.31 ** | 2.15 ± 0.27 (NS) |
| HT 01.16.38 'Rajitha' Inoculated | 9.08 ± 1.15 | 1.20 ± 0.45 |
| Control | 14.58 ± 1.29 (NS) | 2.65 ± 0.26 * |
| 'Maheshi' Inoculated | 5.82 ± 0.59 | 1.31 ± 0.32 |
| Control | 13.62 ± 1.22 ** | 3.37 ± 0.74 * |

NS measurements are not significantly different from that of control
Value is significantly different from that of control: * $p \leq 0.05$, ** $p \leq 0.005$

**Table 4** Mean number of gall formation and the reproductive rate of root-knot nematodes in the tested varieties in experiment 1 and 2 (Ex- 1 and Ex- 2).

| Variety | Mean № of galls Ex-1 | Mean nematode population Ex-1 | $P_f P_i$ value Ex- 1 ($x10^2$) | Mean № of galls Ex-1 | Mean nematode population Ex-2 | $P_f P_i$ value Ex-2 ($x10^2$) |
|---|---|---|---|---|---|---|
| T245 | 32 ± 18.5 a | 8,217 | 5.478 | 42 ± 10.7 a | 59,906 ab | 19.968 |
| B-1 | 26.6 ± 8.19 a | 17,137 | 11.424 | 46 ± 7.35 ab | 61,160 ab | 20.386 |
| HT-148-3-11 | 51 ± 33.5 a | 42,248 | 28.165 | 85 ± 4.63 c | 71,000 c | 23.666 |
| BT-15-1 | 21.7 ± 13.2 a | 24,221 | 16.147 | 89 ± 21.9 c | 73,360 c | 24.453 |
| HT 01 | 32.3 ± 12.3 a | 37,569 | 25.046 | 77.6 ± 16.3 c | 87,706 c | 29.235 |
| HT. 01. 16. 38 | 14.6 ± 1.2 a | 13,696 | 9.13 | 31.2 ± 9.69 a | 23,053 a | 7.684 |
| 'Maheshi' | 14 ± 5.6 a | 13,479 | 8.986 | 46.6 ± 15.6 ab | 45,440 ab | 15.146 |

Data indicated in the 5th column by the same letters are not significantly different at p = 0.05, according to Duncan's multiple range test ($P_f$ final population, $P_i$ initial population)

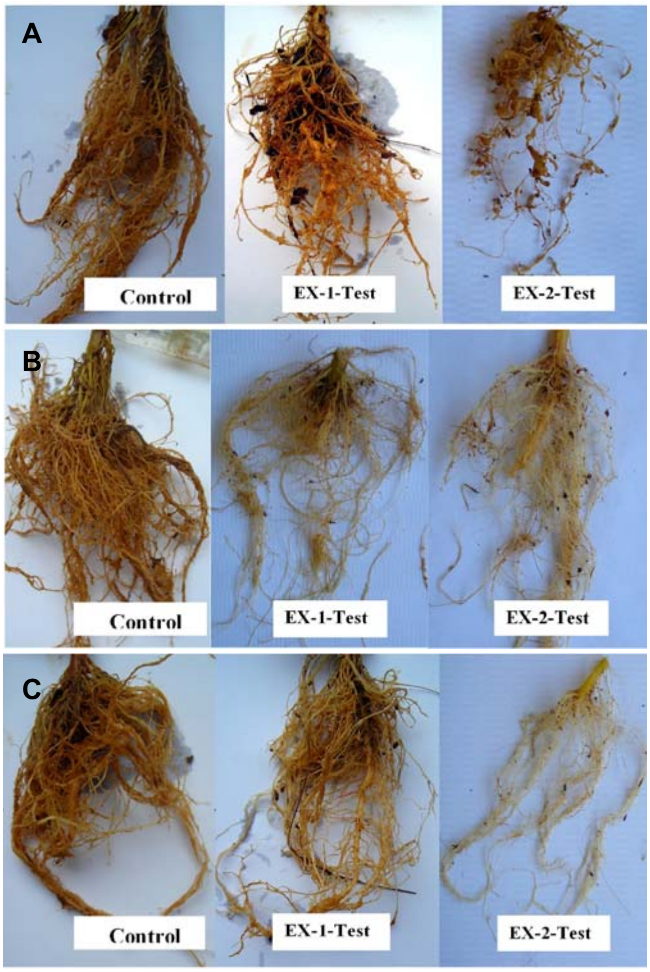


**Fig. 3** (**A**-**C**) Appearance of the root system of tomato varieties affected by *M. incognita* compared to the root system of control plants at the end of experiment (Ex) 1 and 2. (**A**) BT-15-1 'Thilina'; (**B**) T 245 and B-1 'Ravi'; (**C**) HT.01.16.38 'Ragitha' and 'Maheshi'.

*M. incognita.* HT.01.16.38 and 'Maheshi' are thus susceptible. Two varieties, $T_{245}$ and B-1, did not show any other significant damage symptoms other than chlorosis due to nematode infection (**Tables 2, 3**). Therefore, these two varieties could be categorized as less susceptible to *M. incognita*.

## DISCUSSION

Root galling index (GI) and nematode reproduction factor (RF) have been used to assess resistance of a variety of crops to root knot nematodes (Zhou *et al.* 2000; Brito and Rich 2007; Khan and Kim 2007). Ornat *et al.* (2001) reported that the number of egg masses and eggs per egg mass are good indicators of nematode reproduction. The present study was conducted by assessing root galls and nematode reproductive rate (≈RF). Availability of low population of *Meloidogyne* appears to stimulate plant growth by producing auxin during the formation of galls (Wallace 1973). It is difficult to suggest that low levels of nematode population might benefit the plant but it is clear in this study that low levels of nematode population could be tolerated by tomato plants. BT-15-1 produced a significant increase in the number of chlorotic leaves in both experiments. This indicates that this variety is the most susceptible tomato variety to *M. incognita* among the seven tested varieties. This was clearly noticeable by the large size of galls (about 1.8 mm in diameter) present in the root system (**Fig. 3A**). It has been recorded from a study conducted on variability in reproduction of four populations of *M. incognita* on six cultivars of cotton in Pakistan that the most virulent population of *M. incognita* was associated with larger gall size, larger giant cell formation and improved success of juveniles transitioning into reproductive adults (Anwar and Mckenry 2007). The number of galls per plant and the size of galls may directly affect plant growth in most cases. Large numbers of galls allow a large nematode population to develop within the root system, which leads to severe disruption of plant growth and yield (Dropkin 1989). The formation of galls disturbs the normal differentiation of xylem and phloem tissues in roots and declines the transportation of water and nutrient from root to top (Dropkin 1989). Such plants have less ability to cope with water stress and nutrient stress. Also, photosynthesis proceeds at low level leads to reduction of top growth and yield. In addition, the nitrogen fixation bacteria is inhibited indicated by an increase of the yellowish leaves (Dropkin 1989).

Two tomato varieties were susceptible to *M. incognita*: HT.01.16.38 and 'Maheshi'. Both, when tested in experiment 1 showed that there was neither significant growth reduction nor significant difference in the development of the root system between control and test plants. A significant reduction occurs in weight and length of the root system between inoculated and control plants of these two varieties at a high nematode dose. The percentage chlorotic leaves was significant in all varieties, except for 'Maheshi'. The height and development of the root system of $T_{245}$ and B-1 in the presence of *M. incognita* were not significantly different from the control. Root galling was moderate and the galls were small (**Fig. 3B**) and they are similar to that of HT.01.16.38 and 'Maheshi' (**Fig. 3C**). The nematode population present in the root system of $T_{245}$ was comparatively low at a lower dose showing that $T_{245}$ does not favour nematode reproduction within the root system.

Highly susceptible, less susceptible and susceptible tomato varieties for *M. incognita* were found during the study, but no resistant varieties. When soil temperature exceeds 30°C, cultivars may lose their resistance and become susceptible to root knot nematodes (Whitehead 1997; Zacheo *et al.* 1995). Therefore, this phenomenon has to be examined further. However, a study done by Lamberti *et al.* (1993), reported that some tomato varieties such as 'Brech', 'Bush', 'Piersol', and 'VFN 8' are resistant to root-knot nematodes and that the use of resistant varieties is important to control the root-knot nematodes of tomato in Sri Lanka. The present study shows that the economical loss of tomato cultivars, caused by root-knot nematode *M. incognita*, can be minimize by the use of less susceptible tomato varieties. This study also shows that severe plant damage occurs when the nematodes are present at higher levels. Therefore, it is important to adopt management strategies to reduce the initial nematode population of the nematodes in agricultural lands.

## CONCLUSIONS

The tomato varieties tested in this study could be categorized in to three groups, less susceptible, susceptible and highly susceptible based on the damage caused to the plant by the nematodes, number of galls present in the root system and the reproduction rate of the nematode. Two varieties, $T_{245}$ and B-1 'Ravi' were categorized as less susceptible because they allowed the nematodes to multiply well, but inflicting little damage. Two varieties, HT.01.16.38 'Rajitha' and 'Maheshi' were categorized as susceptible because these two varieties allowed the nematodes to multiply well, but the number of galls present in the root system was low. Three varieties, HT-148-3-11 'Tharindu', BT-15-1'Thilina' and HT 01 'Rashmi' were categorized as highly susceptible because these three varieties inflicted severe damage forming large number of galls and allowing the nematodes to multiply well.

## REFERENCES


**Anwar SA, McKenry MV** (2007) Variability in reproduction of four populations of *Meloidogyne incognita* on six cultivars of cotton. *Journal of Nematology* **39**, 105-110

**Bird DMcK** (2004) Signaling between nematodes and plants. *Current Opinion in Plant Biology* **7**, 372-376

**Bleve-Zacheo T, Melillo MT, Castagnone-Sereno P** (2007) The contribution of biotechnology to root-knot nematode control in tomato plants. *Pest Technology* **1**, 1-16

**Brito KRJA, Rich JR** (2007) Host suitability of selected weed species to five *Meloidogyne* species. *Nematropica* **37**, 107-120

**Caillaud M-C, Dubreuil G, Quentin M, Barbeoch LP, Lecomte P, Engler JdeA, Abad P, Rosso M-N, Favery B** (2008) Root-knot nematodes manipulate plant cell functions during a compatible interaction. *Journal of Plant Physiology* **165**, 104-113

**Dropkin VH** (1989) *Introduction to Plant Nematology* (2nd Edn), Wiley-Interscience, USA, pp 165-340

**Ekanayake HMRK, Nishantha KMDWP, Nugaliyadda MM** (2003) Integrated management of *Meloidogyne* species in vegetable fields in the mid country wet zone of Sri Lanka. *ASDA - Annals of the Sri Lanka Department of Agriculture* **5**, 77-83

**Gheysen G** (2000) Concerted efforts to develop handles for plant parasitic nematode control. *Developments in Plant Genetics and Breeding* **6**, 159-167

**Hooper DJ, Hallmann J, Subbotin SA** (2005) Methods of extraction, processing and detection of plant and soil nematodes. In: Luc M, Sikora RA, Bridge J (Eds) *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture* (2nd Edn) CAB International, Wallingford, UK, pp 53-84

**Jacquet M, Bonglovanni M, Martinez M, Verschave P, Wajnberg E, Castagnone-Sereno P** (2005) Variation in resistance to the root-knot nematode *Meloidogyne incognita* in tomato genotypes bearing the *Mi* gene. *Plant Pathology* **54**, 93-99

**Khan PSDZ, Kim YH** (2007) Evaluation of medicinal herbs for resistance to root-knot nematode, *Meloidogyne incognita*, in Korea. *Nematropica* **37**, 73-77

**Lamberti F, Ekanayake HMRK, Sasanelii N** (1993) Effect of some plant parasitic nematodes on the growth of selected crops in Sri Lanka. *Nematologia Mediterranea* **21**, 27-43

**Nickle WR** (1991) *Manual of Agricultural Nematology*, Marcel Dekker, New York, 1064 pp

**Ornat G, Verdejo-Lucas S, Sorribas FJ** (2001) Population of *Meloidogyne javanica* in Spain virulent to the Mi resistance gene in tomato. *Plant Disease* **85**, 271-276

**Wallace HR** (1973) *Nematode Ecology and Plant Disease*, Edward Arnold Ltd., London, 228 pp

**Whitehead AG** (1997) *Plant Nematode Control*, CAB International, New York, 384 pp

**Zacheo G, Bleve-Zacheo T, Pacoda D, Orlando C, Durbin RD** (1995) The association between heat-induced susceptibility of tomato to *Meloidogyne incognita* and peroxidase activity. *Physiology and Molecular Plant Pathology* **46**, 491-507

**Zhou E, Wheeler TA, Starr JL** (2000) Root galling and reproduction of *Meloidogyne incognita* isolates from Texas on resistant cotton genotypes. *Journal of Nematology* **32 (Suppl.)**, 513-518