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EFFECT OF *Meloidogyne incognita* ON PLANT GROWTH, ABSORPTION AND TRANSLOCATION OF NUTRIENTS AND WATER IN TOMATO PLANTS

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ABSTRACT

The root knot nematodes of the genus *Meloidogyne* infect major crop plants and cause substantial reduction in crop yield and quality. As sedentary endoparasites these nematodes modify vascular cells of host roots for feeding as giant cells. In the formation of giant cells *Meloidogyne* disrupts the vascular tissues, which affects absorption and translocation of nutrients and water in plants. In this study the effect of six different inoculum levels of *Meloidogyne incognita* on the plant growth, absorption and translocation of nutrients and water in tomato c.v. KWR plants were determined in the plant house at 25± 2°C. The growth and moisture content of shoots of tomato plants progressively decreased as the inoculum level of *M. incognita* increased. Significant reductions in plant height, fresh and dry shoot weights, moisture content of shoots were observed at higher population levels (≥5000 eggs and juveniles/kg of soil) of the nematode. Fresh and dry weights of roots had increased significantly with increasing population levels. Significant decrease in the absorption of N and K ions from soil and translocation of N, K and Mg ions from roots to shoots occurred at higher population levels (≥5000 eggs and juveniles/kg of soil). Results of the study conclude that there is a significant effect of *M. incognita* infection on the plant growth, absorption and translocation of water and nutrients in tomato plants. This effect increases with increasing inoculum levels.

KEY WORDS: Tomato, *Meloidogyne incognita*, Plant gro vth, Nutrients, Absorption, Translocation

INTRODUCTION

Almost 95% of food crops grown in Sri Lanka are susceptible hosts of one or more species of root knot nematodes, (*M. incognita*, *M. javanica*, *M. arenaria* and *M. hapla*). These nematodes cause severe yield reduction of many vegetable crops specially in the families of Solanaceae and Cucurbitae. Estimated yield loss of tomato due to *M. incognita* is about 50% (Lamberti *et al.*, 1987).

Meloidogyne feeding causes deformation of the root system of host plants due to the formation of root galls and giant cells in the vascular region of the roots. Vascular tissues are vitally important in physiological activities of the plant such as translocation of nutrients and water and thus affect photosynthesis and transpiration of the whole plant. With the formation of giant cells in the vascular region of host roots, the continuity of phloem and xylem elements are disturbed. In addition to giant cell formation, infected roots form root galls with short and stubby roots with few branch roots and root hairs. This type of damaged roots cannot utilise water and nutrients like normal roots. Vascular elements are blocked and normal translocation of water and nutrients is mechanically hindered. Root inefficiency causes stunting of growth and other symptoms like leaf chlorosis and wilting. Changes in physiology of plant contribute to growth/yield reduction. The plant hormones, Cytokinins and Gibberallins are important for photosynthesis. The production of these hormones in the roots and translocation to above ground parts are inhibited by the infection of *Meloidogyne* spp. by reducing the photosynthesis rate of the plants (Bird, 1969)

Other major factors frequently reducing photosynthesis rate are high moisture retention and deficiencies or imbalance of plant nutrients. The growing plants must take up nutrients via roots from the soil or nutrient solution. Roots that are highly branched with numerous root hairs can absorb sufficient quantities of water and nutrients continuously and effectively. It is clear that the nutrient elements are absorbed with water through the root system and transported through xylem. Plants require a variety of inorganic mineral constituents, materials that are ordinarily supplied to the plant from the soil through the root system. *Meloidogyne* infected plants with deformed vascular tissues cannot absorb available essential nutrients and plant growth is retarded. Studies on nutrient absorption in *Meloidogyne* infected plants revealed that shoot growth and chlorotic foliage on infected plants and that the roots of these plants contained large quantities of minerals than uninfested plants. These evidences show that *Meloidogyne* infection affects absorption and translocation of nutrients and water in plants. However, not much information is available on the effect of *Meloidogyne* infections on the absorption and translocation of inorganic compounds by host plant roots. Therefore, this study was undertaken with the objective of determining the effect of different densities of *M. incognita* on the plant growth, absorption and translocation of water and inorganic nutrients N, P, K and Mg by tomato plant under plant house conditions at 25 ± 2^0C.

MATERIALS AND METHODS

The experiment was carried out at Horticultural Crop Research and Development Institute (HORDI) at Gannoruwa, Peradeniya. A pure culture of *M. incognita* was maintained on tomato cv KWR in the plant house and eggs and juveniles of the neamtode were extracted using the Sodium hypochlorite method (Hussey and Barker, 1973).

Forty eight clay pots were filled with the steam sterilized potting mixture (sand: Silt: compost: çoir dust; 10: 5: 2: 2). Eighteen-day-old tomato seedlings of variety KWR were transplanted into pots at the rate of one seedling per pot. There were 8 treatments including six different population levels (10, 100, 1000, 5000, 10,000 and 20,000 eggs and juveniles/kg of soil) of the nematode and two control treatments one without adding fertlizer or the nematode and the other without nematode inoculation (no nematodes + no fertilizer and no nematodes + fertilizer). Four days after transplanting, the seedlings were inoculated with the required population levels of *M. incognita* for each treatment by introducing the suspension into 4 holes made in the soil around the base of the plant except in the two control treatments. Equal quantities of fertilzer were applied to plants of all treatments at planting 3 and 6 weeks after transplanting, except for the control plants (No nematodes and fertilizer).

All the pots were arranged on a bench in the plant house according to a completely randomized block design. The plants were maintained in the plant house at 25 $\pm 2^0$C for 50 Days After Inoculation (DAI).

Plant height was measured T 10 day intervals starting on the 10^{th} day after inoculation At the end of the experiment, (50 DAI), the weight of shoot and root system of each plant was recorded and the root systems were rated for galling according to Taylor and Sasser (1978). Dried shoots and roots of each plant were weighed and powdered separately for analysis of N, P, K, and Mg contents. This data was subjected to the analysis of variance and treatment means were compared using least significant difference test at ($p \geq 0.05$) level.

RESULTS AND DISCUSSION

The effect of different population levels of *Meloidogyne incognita* on the mean height of tomato plants at 10 days intervals for a period of 50 days are indicated in table 1. The statistical analysis indicates that there was no significant difference in plant height among different treatments at the early stage of plant growth. At 50 days after inoculation (DAI) height of plants inoculated with higher population densities ($\geq$ 5000 eggs and juveniles/kg of soil) were significantly low ($p \geq 0.001$) than that of plants inoculated with lower populations levels ($\leq$1000 eggs and juveniles/kg of soil) and control treatments (table 1). Plant growth in untreated control pots (without fertilizer) was low compared to the growth of treated control (control plants with fertilizer).

Table 2 indicates the effect of different treatments on the mean fresh and dry weights of tomato plants 50 DAI. Fresh shoot weight of plants in control treatment with fertilizer was the highest and lowest was in the treatment with highest nematode level (20,000 eggs and juveniles/kg of soil). No significant differences were observed in fresh shoot weight among control treatments and treatments with lower levels of nematode population (10 to 1000 eggs and juveniles/kg of soil). The fresh shoot weights of plants with higher nematode levels ($\geq$5000 eggs and juveniles/kg of soil) were significantly ($p \geq 0.001$) lower than that of other treatments.

Table 1. Effect of different population levels of *Meloidogyne incognita* on mean height of tomato plants at different time of intervals for 50 days after inoculation

Treatments	*Nematode eggs & juveniles /kg soil*	*Mean Shoot Height (cm)* 10 DAI	20 DAI	30 DAI	40 DAI	50 DAI
No nematode + No Fertilizer–T-1	00 a	24.8 a	48.5 a	70.5 a	107.6 a	114.0 ab
No nematode + Fertilizer-T-2	00 a	24.0 ab	44.2 abc	68.6 ab	105.5 ab	119.8 a
Nematode + Fertilizer-T-3	100	22.9 abc	45.8 ab	68.0 ab	102.5 ab	110.2 bc
-do-T-4	500	20.9 bcd	42.3 bcd	63.0 ab	105.5 ab	109.8 bc
-do-T-5	1,000	20.2 cd	31.3 cde	57.8 bc	89.7 b	105.1 cb
-do-T-6	5,000	20.8 bcd	37.9 de	61.2 bc	84.6 c	103.2 c
-do-T-7	10,000	19.4 b	36.3 e	57.6 c	84.3 c	103.8 c
-do-T-8	20,000	19.5 b	30.3 f	44.5 d	85.5 c	101.7 c

Values followed by the same letter in each column are not significantly different at $p \geq 0.001$ in Least Significant Difference Test

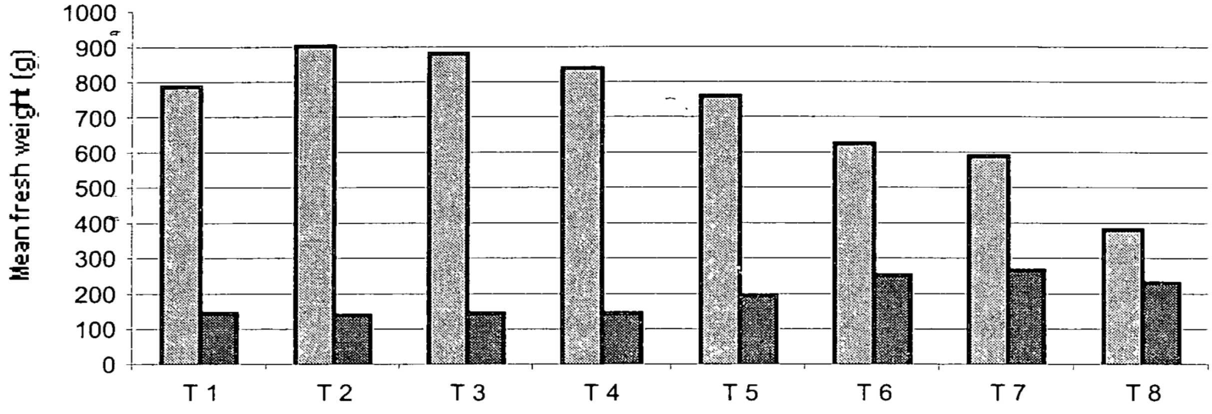
Table 2. Effect of different population levels of *Meloidogyne incognita* on mean fresh and dry weights of shoots and roots of tomato plants 50 days after inoculation.

Treatment	*Shoot Weight (g)*		*Root Weight (g)*	
	Fresh	*Dry*	*Fresh*	*Dry*
T-1	7.96 ab	25.81 a	153 cd	8.92 cd
T-2	905 a	25.52 a	145 d	8.56 d
T-3	883 ab	24.13 ab	148 cd	9.12 cd
T-4	845 ab	24.12 ab	147 d	9.45 cd
T-5	767 b	22.8 b	201 bc	11.5 a
T-6	630 c	20.35 c	254 ab	11.25 ab
T-7	596 c	18.56 c	273 a	9.58 cd
T-8	384 d	15.10 d	233 ab	9.63 bc

Values followed by the same letter in each column is not significantly different at P=0.001 in Least Significant Difference Test.

Highest fresh root weight was observed in plants inoculated with 10,000 eggs and juveniles/kg of soil and differences in fresh root weight among treatments (≥5000 eggs and juveniles/kg of soil) was not significant (p≥0.001). Deformation of roots at the highest nematode level (20,000 eggs and juveniles/kg of soil) has caused poor growth of the root system. Figure 1 clearly shows the variation in fresh root and shoot weight of plants of all the treatments. Pattern of variation in shoot weight and root weight is contradictory. Shoot weight has decreased with increasing population level while root weight has increased with

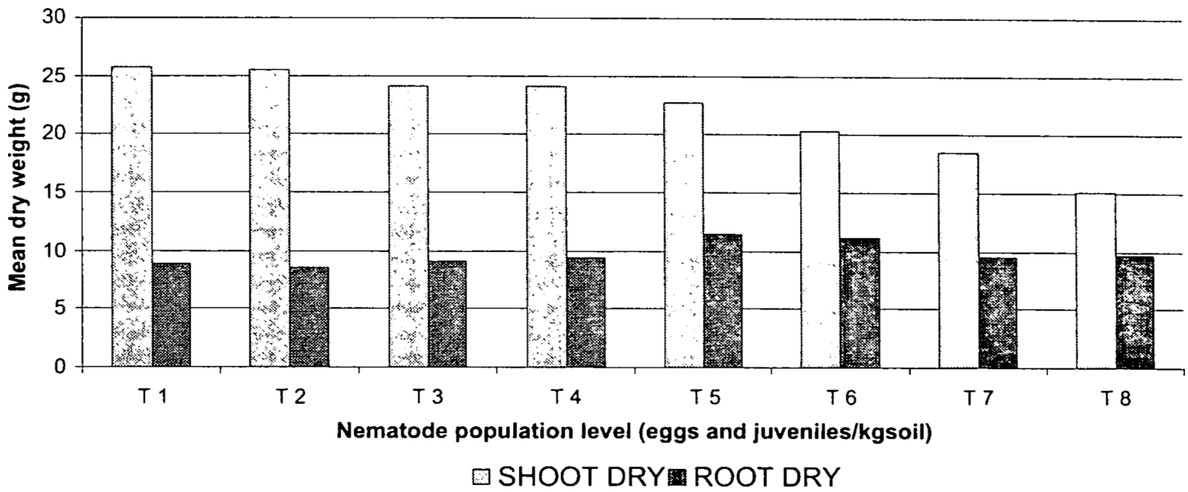
Figure 1. Effect of different population levels of *Meloidogyne incognita* o n mean fresh weight of shoots and roots of tomato plants 50 days after inoculation.



increasing nematode level except for the highest nematode level (figure 1). This explains the effect of nematode level on the plant growth and also the changes and deformation of root growth due to root galling and giant cell formation in the root systems. Galling and giant cell formation inhibits the translocation of water and available nutrients from root to shoot and this results in poor growth of the plant inoculated with the nematode

The mean dry weight of shoot at 50 DAI has decreased when the population level increases (table 2 and figure 3). This pattern of variation was not observed in mean dry root weight of all the treatments. No significant differences were observed in dry weights of roots among all the treatments. Highest dry root weight was observed in plants treated with 10,000 eggs and juveniles/kg of soil. This is due to the formation of new roots to compensate the damage ones due the invasion of nematodes. However, at higher nematode population levels (≥5000 eggs and juveniles/kg of soil) the mean dry root weight has decreased with increasing nematode level. This is due to the deformation of root system and inhibition of the development of lateral roots due to the damage caused by large number of nematodes.

Figure 2. Effect of different population levels of *Meloidogyne incognita* on mean dry weight of shoots and roots of tomato plants 50 days after inoculation.



Fifty DAI, the mean root knot indices were significantly increased ($P \leq 0.05$) with increasing population levels of *M. Incognita* (table 3). Highest root knot index (5) was indicated in plants treated with 10,000 and 20.000 eggs and juveniles/kg of soil. Root systems of untreated plants showed fairly well developed, while with higher population levels, the root systems were deformed with stubby galled roots. Moisture content of shoots has decreased with increasing population levels of the nematode. However, this trend was not observed in moisture content of roots (table 3). Differences in moisture contents of roots among control plants and plants treated with low population levels (≤1000 eggs and juveniles/kg of soil) were not significant. The highest moisture content of roots was observed in plants treated with 10,000 eggs and juveniles/kg of soil. The formation of conspicuous root galls due to the development of large number of female nematodes inside root tissues resulted increased moisture content of roots at higher population levels.

Table 3. Effect of different population levels of *Meloidogyne incognita* on mean moisture content of shoots and roots and root galling index of tomato plants 50 days after the nematode inoculation.

TREATMENT	*Mean galling index*	*MEAN MOISTURE CONTENT (g)*	
		SHOOT	*ROOT*
T-1	0.0 e	106.9 ab	10.9 bc
T-2	0.0 e	124.4 a	15.5 bc
T-3	1.8 d	123.1 ab	15.6 bc
T-4	2.8 c	116.7 ab	15.1 c
T-5	3.8 c	104.9 b	22.0 ab
T-6	4.3 b	84.7 c	31.1 a
T-7	5.0 a	80.7 c	35.9 a
T-8	5.0 a	48.8 d	29.2 a

Values followed by the same letter are not significantly different p=0.05 in LSD Test.

The effect of different treatments on the contents of N, P, K and Mg in shoots and roots of tomato plants at 50DAI are given in table 4. Mean N and K contents in shoots and roots of plants at higher population levels (≥1000 eggs and juveniles/pot) were significantly (p≥0.05) lower than that of other treatments. No significant differences were observed in P contents of roots and shoots and also Mg content of roots among all the treatments. But the Mg content of shoot of plants treated with higher population levels (p≥0.05) was significantly higher than that of the control treatments and low population levels (≥1000 eggs and juveniles/pot). These results revealed that *M. incognita* infected roots of tomato plants can not absorb N and K and translocate these nutrients from roots to shoots. This effect increases with increasing population level of the nematode. There is no effect of nematode infection on the absorption of P and Mg by roots and translocation of P from roots to shoots of infected tomato plants. However nematode infected roots can not translocate Mg from roots to shoots. These observations indicates that N and Mg absorbed by roots from soil accumulate in the infected root systems without translocating them to shoots and there is no effect on absorption and translocation of P in tomato plants. However, the effect of *M. incognita* on the plant growth, absorption and translocation of water and nutrients (N, K and Mg) is significant. This effect increases with increasing inoculum levels.

Table 4. Effect of different population levels of *M. incognita* on mean N, P, K and Mg contents of shoots and roots of tomato fifty days after inoculation.

Treatment	*N Content*		*P Content*		*K content*		*Mg Content*	
	Shoot	*Root*	*Shoot*	*Root*	*Shoot*	*Root*	*Shoot*	*Root*
T-1	0.64 a	0.25 a	0.21 a	0.05 a	1.20 a	0.26 a	0.19 a	0.03 a
T-2	0.63 ab	0.24 a	0.16 ab	0.05 a	1.16 ab	0.23 a	0.18 b	0.03 a
T-3	0.57 abc	0.18 b	0.15 ab	0.05 a	1.11 ab	0.21 ab	0.17 b	0.03 a
T-4	0.55 bcd	0.14 b	0.15 ab	0.05 a	1.09 abc	0.17 bc	0.17 bc	0.03 a
T-5	0.49 cdf	0.12 bc	0.14 ab	0.04 a	1.00 bc	0.13 cd	0.16 cd	0.03 a
T-6	0.46 def	0.09 cd	0.14 ab	0.04 a	0.91 cd	0.12 cd	0.15 de	0.03 a
T-7	0.44 ef	0.06 d	0.12 ab	0.04 a	0.91 cd	0.10 d	0.15 de	0.03 a
T-8	0.39 f	0.05 d	0.06 ab	0.03 a	0.78 d	0.09 d	0.14 e	0.02 a

Values followed by the same letter in each column are not significantly different at p=0.05 in Least Significance Difference Test.

These findings agree with that of Wallace (1974) who observed the effect of *M. incognita* on the photosynthesis of tomato plants. Results of the present study reveal that when the nematode population was high there was a greater effect on plant growth (fresh and dry shoot weight), extra root development. These changes had increased the fresh root weight and reduced water and nutrient absorption and translocation of the host plant. Ultimately these changes have a greater effect on the photosynthesis and results in reduction of plant growth.

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