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Sensitivity of sixteen tomato cultivars to root-knot nematode, *Meloidogyne incognita* under greenhouse conditions

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Abstract

Tomato, *Solanum lycopersicum* L. a globally cultivated vegetable crop, faces significant challenges from the root-knot nematode, *Meloidogyne* sp., causing detrimental impacts on crop yield and quality. Sixteen tomato cultivars were screened for their reactions to the root-knot nematode, *M. incognita* to evaluate the ability of nematodes to reproduce and influence vegetative growth under greenhouse conditions. Results indicated that, on all of examined cultivars were categorized into four levels of susceptibility: moderately resistant (cvs. VFNT, 010, 350, 013, 023 and 023 Modified) with a number of galls between 6 and 20; lightly susceptible (cvs. Edkawy and Floradade); moderately susceptible (cvs. 380, Caieer, Peto86, Super mar mand and Castle Rock) with a number of galls between 119 and 185 galls /plant. While highly susceptible Super Strain B,136 and 186 with a number of galls between 161 and 332 galls /plant. These results highlight the potential of using resistant cultivars as a sustainable nematode management strategy. Planting cultivars like VFNT, 010, 013, 023and 023 Modified could significantly reduce nematode populations and gall formation, leading to improved crop health and minimized yield losses.

Keywords: tomato, root-knot nematode, *Meloidogyne incognita*, screening, susceptibility.

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1. Introduction

Tomato, *Solanum lycopersicum* L. (Family: Solanaceae) stands as one of the most widely cultivated vegetable crops globally, valued for its nutritional richness and versatile applications (Patra and Nayak, 2019). Africa and Asia collectively contribute to over 80% of the global tomato cultivation area, yielding approximately 70% of the world's total output (FAO, 2012). Highlighting Egypt's ranks the fifth-largest producer of tomatoes globally; the country boasts an annual production of approximately six million tons, cultivated across 350 thousand acres. The reduced yield can be attributed to a range of abiotic and biotic factors, including bacteria, fungi, viruses, and especially nematodes, all of which contribute to a decline in the quality and quantity of tomatoes. Root-knot nematodes pose a significant challenge to tomato cultivation worldwide (Seid *et al.*, 2019). Unremitting efforts are paramount to boosting vegetable crop yields, given their critical role as a staple food source for millions globally. Employing high-yielding and high-resistance cultivars stands as a pivotal strategy to achieve this yield enhancement (Montasser *et al.*, 2019). Motivated by the significant impact of root-knot nematodes on tomato production, this study aimed to evaluate the resistance of sixteen tomato cultivars to this pest under controlled greenhouse conditions.

2. Materials and methods

2.1 Preparation of nematode cultures

A pure stock culture of the root-knot nematode *M. incognita* was prepared from naturally infected tomato roots collected from an infected field in Nobaria province, Egypt. Individual egg-masse with their mature females removed from root tissue. Each egg-mass is placed in a small glass capsule containing fresh water. The females from which egg-masses were taken preserved in 4% formaldehyde solution in glass capsules for nematode identification. Each egg-mass was transferred to a 25 cm pot filled with steam sterilized sandy loam soil and grown with a seedling of eggplant variety (Balady). Inoculated pots were placed in a greenhouse and watered when needed. After two months of inoculation, infected roots were then chopped and used as sources of inoculation for other series of clean cv. Strain-B tomato seedling. By repeating this procedure, enough quantities of inoculation from stock cultures were obtained on eggplant variety (Balady) (Taylor and Netscher, 1974).

2.2 Identification of Meloidogyne species

Meloidogyne sp. was identified on basis of perineal pattern system of mature females. It was accomplished by placing individual mature females in a drop of heated lactophenol solution on a slide. Using a sharp razor blade, the rear end of every adult female was removed, and the remaining portion was trimmed down to reveal the pattern. According to Taylor and Netscher (1974), slides were carefully sealed with fingernail polish and coated with a fresh cover slip. An oil immersion lens was used to examine each preparation under a microscope. *Meloidogyne* sp. identity was determined by consulting the morphological traits provided by Sasser and Carter (1982), Taylor and Sasser (1978), Hartman and Sasser (1985), and Chitwood (1949).

2.3 Preparation of planting materials for resistance screening

In the normal growing seasons, seeds of the tomato cultivars (Castle Rock, Edkawy, Floradade, Peto86, Super mar mand, Super Strain B, VFNT, 380, 010, 350, 186, 013, 023 Modified, 023, 136 and Caieer) were planted in 30 cm diameter pots containing mixture of clay and sand soil [(1:1) (v:v)] for two weeks. Next, pots were inoculated with approximately 1000 newly hatched juveniles (J2) of *M. incognita* per plant in five holes around the root system. Each treatment was replicated four times. Non inoculated plants served as a control. In the greenhouse, all pots were arranged in a randomized block design at temperature of 30 ± 5°C. After 45 days of inoculation, all plants were harvested and removed gently, washed in water and the root of each plant was stained in lacto-phenol acid fuchsine (Goodey, 1957). Number of juveniles in soil per pot, galls, nematode developmental stages in root, egg-masses per root was counted. Eggs of ten randomly selected egg-masses of each root system were also counted by sodium hypochlorite. The rate of nematode reproduction was calculated. Plant vegetative growth parameters involving length and fresh weight of both roots and shoots were determined. In each parameter, the percentages of reduction were calculated. The reactions of the tested cultivars (host category) were determined based on the nematode reproduction (Pf / Pi) according to Montasser *et al.* (2017).

3. Results and Discussion

3.1 Susceptibility of tested tomato cultivars to Meloidogyne incognita under greenhouse conditions

Sixteen tomato varieties were tested for their susceptibility and resistance to infection of the root knot nematode, *M. incognita* (Table 1). We examined and assessed the suitability of sixteen tomato cultivars (Castle Rock, Edkawy, Floradade, Peto86, Super mar mand, Super Strain B, VFNT, 380, 010, 350, 186, 013, 023 Modified, 023, 136 and Caieer) against *M. incognita*. Cultivars Super Strain B, 136 and 186 were highly susceptible as these cultivars gained the highest values of number of galls, adult female, egg-masses per root, eggs per egg-mass and rate of nematode reproduction. Non-significant differences were found on such nematode criteria on such root cultivars when compared with those of the other tested cultivars. Therefore, the calculated values of rates of nematode reproduction were 282.61, 122.18 and 102.24 folds, respectively. On tomato cultivars Caieer, Castle Rock, 380, Super mar mand and Peto86 supported the moderately values of nematode criteria, however, the calculated numbers of galls per root were 164, 185, 119, 168 and 161 galls respectively and values of rates of nematode reproduction (Rf) were 73.97, 66.74, 60.1, 52.70 and 52.25 folds, respectively. Also, *M. incognita* reproduced and multiplied low on Floradade and Edkawy cultivars with the number of galls per root were 150 and 107 galls respectively and rates of nematode reproduction (Rf) were 43.89 and 39.99 folds, respectively. In the plant cultivars 023 Modified, 023, 013, 350, 010, and VFNT, the nematode's final population per plant either equaled or slightly exceeded its initial population. When compared to other tested cultivars based on these nematode criteria, these root cultivars exhibited notable differences. Specifically, the calculated values for the rates of nematode, the number of galls were 13, 11, 11, 20, 6 and 7 galls, and the rates of nematode reproduction (Rf) were 2.5, 1.9, 1.4, 1.1, 1.04 and 1.02 folds, respectively.

Table (1): Susceptibility of sixteen tomato cultivars to *Meloidogyne incognita* under greenhouse conditions.

Cultivars	Number of galls/root	Nematode final population (Pf)	Rate of nematode reproduction *(RF)	*Host category
Castle	185 [b]	66736	66.74	MS
Edkawy	107 [bc]	39995	39.99	LS
Floradad	150 [b]	43890	43.89	LS
Peto86	161 [b]	52246	52.25	MS
Super	168 [b]	52700	52.70	MS
Super	332 [a]	282625	282.61	HS
VFNT	7 [c]	1020	1.02	MR
380	119 [bc]	60095	60.10	MS
010	6 [c]	1042	1.04	MR
350	20 [c]	1085	1.09	MR
186	205 [b]	102243	102.24	HS
013	11 [c]	1444	1.44	MR
023	13 [c]	2510	2.51	MR
023	11 [c]	1903	1.90	MR
136	161 [b]	122176	122.18	HS
Caieer	164 [b]	73968	73.97	MS

*Host category determined according to Montasser *et al.* (2017) as follows: (Pf / Pi = 0.0) I = Immune host; (Pf / Pi < 0.4) HR = Highly resistant host; (0.5 ≤ Pf / Pi ≤ 0.9) R = Resistant host; (1.0 ≤ Pf / Pi ≤ 4.9) LS = Less susceptible host; (5.0 ≤ Pf / Pi ≤ 14.9) MS = Moderately susceptible host and (Pf / Pi > 15.0) HS = Highly susceptible host. Means in each column followed by the same letters are not significantly different by (p≥0.05) according to Duncan's multiple range test. * Significant at 0.05 level of probability ** highly significant at 0.01 level of probability.

Generally, the highly susceptible cultivars like Super Strain B, 186, and 136 experienced extensive gall formation, with an average of 267 galls per root, a final nematode population (Pf) of 202548, and a rate of nematode reproduction (RF) of 185.85. In contrast, the most resistant cultivars, including VFNT, 010, and 023 Modified, demonstrated remarkable resistance with an average of only 8 galls per root, Pf values as low as 1042, and RF values as minimal as 1.04. These results are in accordance with findings of Mohamed *et al*. (1999). The strong correlation between gall formation, nematode population, and reproduction rate was evident. For example, Super Strain B, the most susceptible cultivar, displayed 332 galls per root, a Pf of 282625, and an RF of 282.61, while VFNT, the most resistant cultivar, had only 7 galls per root, a Pf of 1020, and an RF of 1.02. These results are in accordance with findings of Abbas *et al*. (2008) and Hassan *et al*. (2021).

3.2 Influence of M. incognita on plant growth of tested tomato cultivars under greenhouse conditions

Plant growth response due to root knot nematode infection was determined through the estimation of the percentage reduction in plant high and fresh weights of shoots and roots (Table 2). Among the tomato cultivars tested, the highest percentage reduction values of shoot length were showed in 023 Modified, 010 and 186 cultivars (36.6, 28 and 20.4%) followed by Peto86, VFNT and 380 cultivars showed the lowest percentage reduction values (6,7 and 7.8%) compared to the uninoculated one, respectively. However, in the root length parameter, the highest percentage reduction values of were showed in Caieer and 023 Modified cultivars (19 and 15.6 %) followed by 010 and 023 cultivars. While Castle Rock, Floradade and Super Strain B cultivars showed the lowest percentage reduction values.

Table (2): Influence of *M. incognita* on plant growth of tested tomato cultivars under greenhouse conditions.

Cultivars	Shoot fresh weight in (g)			Root fresh weight in (g)		
	Infected	Non-infected	Reduction (%)	Infected	Non-infected	Reduction (%)
Castle	6.56	15.6	6.56	4.5	6.6	2.1
Edkawy	10.3	27.8	10.3	5.7	8.1	2.4
Floradad	6.3	14.9	6.3	5.1	6.2	1.1
Peto86	2.9	10.2	2.9	4.9	6.7	1.8
Super	11.3	20.8	11.3	6.2	14.4	8.2
Super	8.2	23	8.2	8	14	6
VFNT	2.7	10.8	2.7	6.2	9.4	3.2
380	30.5	46.7	30.5	13	18.5	5.5
010	8.9	29.7	8.9	11.5	20.2	8.7
350	8.2	22.4	8.2	8.8	11	2.2
186	21.6	39.4	21.6	9.2	14.2	5
013	21	41.6	21	9.7	17.8	8.1
023	11.4	36.7	11.4	17.3	26	8.7
023	23.5	66	23.5	10.1	15	4.9
136	4.4	17.9	4.4	11.1	16.8	5.7
Caieer	4.9	17.7	4.9	9.9	11.5	1.6

On the other hand, the highest percentage reduction values in shoot weight were recorded on 380, 023, 186 and 013 cultivars (30.5, 23.5, 21.6 and 21%), respectively. Followed by 023 Modified and Super mar mand cultivars, the lowest percentage reduction values included VFNT and Peto86 cultivars (2.7 and 2.9%). Meanwhile, in root weight parameter, the highest percentage reduction values were showed in 010, 023 Modified, Super mar mand and 013 cultivars (8.7, 8.7, 8.2 and 8.1%), respectively, followed by Super Strain B and 136 cultivars. The lowest percentage reduction values calculated Floradade, Caieer and Peto86 cultivars (1.1, 1.6 and 1.8%), respectively. Generally, these results are in accordance with findings of Mohamed *et al*. (1999), Abbas *et al*. (2008) and Hassan *et al*. (2022).

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