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Influence of Irrigation Water and Infested Soil with Nematodes on Guava Deterioration in Egypt

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ABSTRACT

Water, particularly irrigation water, is a key source for the transmission of plant-parasitic nematodes (PPNs). The objective of the current study is to assess the influence of infested soil collected from three different counties *i.e*., Adco, Shibin Alqanater and Baltim representing three governorates (Beheira, Qalyubia and Kafr Elsheikh), respectively. Egypt and irrigation water from canals (Mahmudiyah, Bassousia, and Alhilmia) on the decline of guava seedlings *Pasidum guajava* cv. Ameriyah under greenhouse conditions for two seasons (2020-2021). Plant-parasitic nematodes detected in soil and water samples were listed. It was found that guava seedlings grown in soil infested with root-knot nematodes (*Meloidogyne* spp.) and irrigated with contaminated water from canals showed the lowest rate of growth parameters when compared to plants cultivated in sterilized soil and irrigated with tap water, during the two years. However, treatment by Fenamiphos with sterilized soil and irrigated with water from canal showed the least nematode population in the soil. A significant decrease in the number of galls and egg masses was also observed in the presence of the nematicide.

Keywords*:* Guava, *Pasidum guajava* L, Plant-parasitic nematodes, *Meloidogyne* spp., Irrigation water, infested soil.

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INTRODUCTION

Guava, *Pasidum guajava* L., Myrtaceae, is one of the most significant fruits on the globe due to its high nutritional value (Centre of Agricultural Information, 2009). Root-knot nematodes, on the other hand, are a stumbling block to guava production, causing up to 80% damage to guava trees (Sukhakul, 2006). *Meloidogyne javanica*, *M. arenaria*, *M. hapla*, *M. exigua*, *M. graminicola*, *M. microcephala*, *M. naasi*, and *M. thailandica* are some of the species that were found (Moens *et al*., 2009, Chinnasri *et al*., 2012 and Jindapunnapat, 2012) in guava were seedlings and trees.

According to the Ministry of Agriculture, Egypt guava production as of 2019 was 2.7 million tons (FAOSTAT 2020). Lower Egypt (coastal areas) has the most guava cultivations, particularly in Beheira, Damietta, Kafr El-heikh, Alexandria, and Qalyubia governorates. Guava is liable to infection with many species of phytonematodes in Egypt (Ibrahim *et al*., 2000 and Massoud *et al*., 2021). The root-knot nematode causes small knots and tumors on the roots that obstruct plant growth due to blockage of the root vessels (Ashokkumar and Poornima 2019). As a result, the leaves wilt and become yellow and the affected plants are stunted as a result of their inability to grow normally (Dawabah *et al*., 2019). The crust irritates the affected tissues, resulting in the growth of Root-knot like tumors, hence the disease's name.

Free-living nematodes were discovered in drinking water (Doorenbos and Pruitt, 1992; Anonymous, 1993 and Donia, 2008). The reuse of agricultural drainage water is one of the main reasons for the spread of plant-parasitic nematodes from sick fields to clean or newly reclaimed areas. Although data are scarce on the incidence of plant-parasitic nematodes in irrigation water in Egypt, only a few or unusual studies have been conducted in this area since 1992 (Ahmed, 2013).

There is strong evidence that polluted irrigation water is a major, if not exclusive, source of inoculum for plant diseases in a variety of nursery, fruit, and vegetable crops. The plant pathology community faces both difficulties and possibilities as a result of these findings. Water is a factor that all agricultural production has in common. Water and every thing it contains has the potential to be a health hazard. A whole crop might be lost if the water contains harmful pathogens or chemicals. Whether infections are present in the initial source of water or pathogens enter the water along the way of distribution, one effect is that plants are repeatedly inoculated with pathogens (Hong and Moorman, 2005).

The objective of this study is to determine why guava tree production has decreased in some areas as a result of irrigation from main canals that pass through those areas, which are over flowing with nematodes and could be a new source for infection of various crops grown along those canals.

MATERIALS AND METHODS

A: Collection of Soil samples:

Soil samples were collected from guava plantations located in three different counties, *i.e*., Adco, Shibin Alqanater and Baltim representing three governorates, Beheira, Qalyubia and Kafr Elsheikh, respectively. Quantities (60 kg) of soil naturally infested with root-knot nematodes were collected from each county and transported to the greenhouse of Nematode Diseases Department, Plant Pathology Research Institute, Agricultural Research Center, Giza, Egypt.

B: Collection of water samples:

Three canals (Mahmudiyah, Bassousia and Alhilmia) run in the three above-mentioned governorates were sampled for water. The best size of sampling (10 Liters) from each irrigation canal was placed in plastic containers-dipped in water (Faulkner and Bolander, 1970; Smith and Van Mieghem, 1983; Hong and Moorman, 2005). The number and amount of samples are determined by the detection threshold, which can be found by trial and error (Hopper *et al*., 2005). From spring through summer 2020 and 2021, samples of irrigation water sources (IWS) were collected every 10 days.

C: Identification of nematode genera in soil and water samples:

Soil nematodes were extracted using sieving and modified Baermann technique (Goodey, 1957). Whereas irrigation water was sampled for nematodes by simply dipping a container in the water. According to El-Ashry and Abd El-Aal (2019), the nematodes were concentrated where the water is passed through sieves with different pore widths. Nematodes were retrieved in a small volume of water using a combination of the sieving and modified Baermann approach. One mL of nematode solution was pipetted into a Hawksley counting slide for nematode identification, and nematodes were inspected under 100X magnification using anatomy microscope. Nematodes were recognized according to Siddiqi (1986) based on the morphology of adult and juvenile forms.

D: Experimental design:

Experiments were conducted over two years under greenhouse conditions (2020-2021). Sixty plastic pots (20-cm-d), each was filled with 3 kg. soil naturally infested with nematodes collected from guava plantations located in three counties (Adco, Shibin Alqanater and Baltim), representing three different governorates (Beheira, Qalyubia and Kafr Elsheikh), Egypt, respectively. Initial population for root-knot nematode, *Meloidogyne* spp. (the major genus found in soil samples) was recorded. Every twenty plastic pots represented one area, whereas, another thirty-five plastic pots (20-cm-d) were filled with steam-sterilized soil.

Plastic pots filled with naturally infested soil collected from each county were divided into two parts, the first part was irrigated with water collected from Mahmudiyah, Bassousia or Alhilmia canals, each alone whilst the second part was irrigated with tap water. Six-week-old seedlings of guava (*P. guajava*) cv. Ameriyah were each transplanted in plastic pot.

Fenamiphos as a conventional nematicide was used at a rate of 6mL/100L.water for steam-sterilized soil and naturally infested soil whether irrigated from tap water or canals, irrigation is performed three times each week, at a rate of 250 mL per pot. The pots were then placed in a greenhouse in a randomized complete block configuration with five replicates and watered as needed. As a result, the treatments listed below were used:

- **A-** Steam-sterilized soil + irrigation with tap water,
- **B-** Steam-sterilized soil + irrigation with (canal water from Mahmudiyah, Bassousia, or Alhilmia) each alone + Fenamiphos,
- **C-** Steam-sterilized soil + irrigation with canal water,
- **D-** Naturally infested soil collected from (Adco, Beheira; Shibin Alqanater, Qalyubia; and Baltim, Kafr Elshekh) + irrigation with tap water + Fenamiphos,
- **E-** Naturally infested soil + irrigation with tap water,
- **F-** Naturally infested soil + irrigation with canal water + Fenamiphos, and
- **G-** Naturally infested soil + irrigation with canal water.

The roots of the plants were cleaned sixty days following nematode inoculation to remove any adherent dirt. The fresh and dried shoots' weights, as well as the lengths of the shoots and roots, were all calculated. The nematodes were extracted from the soil using sieving and the modified Baermann technique (Goodey, 1957). Roots were stained with 0.01 acid fuchsine in lactic acid (Byrd *et al*., 1983) and inspected under a stereomicroscope for nematode counts, Galls, and egg masses were counted. Root galling or egg masses were rated from 0 to 5, with 0 indicating no galls or egg masses, 1 indicating 1-2 galls or egg masses, 2 indicating 3-10 galls or egg masses, 3 indicating 11-30 galls or egg masses, 4 indicating 31-100 galls or egg masses, and 5 indicating more than 100 galls or egg masses per root system (Taylor and Sasser, 1978).

E: Statistical Analysis:

The obtained data were statistically analyzed using analysis of variance (ANOVA) (Gomez and Gomez, 1984) and Duncan's multiple range tests to compare means (Duncan, 1955).

RESULTS

Survey experimental:

The study was conducted over two years 2020 and 2021, in three locations, the community of plant-parasitic nematodes related to guava plantations was investigated, as well as irrigation water sources polluted with plant-parasitic nematodes and linked crops. Data in Tables (1 and 2) show that nematodes belonging to nine nematode genera were detected from the rhizosphere of guava and irrigation canals at the three locations during the two seasons. These genera were *Meloidogyne*, *Pratylenchus*, *Tylenchulus*, *Tylenchorhynchus*, *Helicotylenchus*, *Hoplolaimus*, *Tylenchus*, *Rotylenchulus*, and *Ditylenchus*.

Data assessed that *Meloidogyne* spp. showed the highest population occurrence within guava plantations and irrigation canals. Soil samples recovered from Shibin Alqanater County showed the highest number of root-knot nematode (1230 juveniles/250g. soil) followed by Baltim county (860J2s /250g. soil) then Adco (560 J2s/250g. soil) in 2020. A similar trend was noticed with irrigation canals where number of *Meloidogyne* spp. at Bassousia canal reached 143J2s /1mL water, then Alhilmia (92 J2s /1mL water), and Mahmudiyah (78 J2s /1mL water). Regards to the second year (2021), the numbers of root-knot nematode in soil sample and water irrigation source were 1102 J2s/250g. soil and 201 J2s /1mL water) in Shibin Alqanater, (672 J2s /250g. soil and 93J2s /1mL water) in Adco and (510 J2s juvenile/250g. soil and 84 J2sjuveniles/1mL water) in Baltin, respectively.

Greenhouse experiments:

A- Plant growth response of guava grown in infested soil collected from Adco County (Beheira governorate) and irrigated with Mahmudiyah canal water and nematode reproduction as well:

For the specified location, the study was done across two years, in 2020 and 2021. Data in Table (3) show guava plant responses to applied treatments, where significant changes in plant growth parameters were identified across treatments compared to healthy plants (sterilized soil + irrigation with tap water) during the two seasons. Treatment with (sterilized soil + irrigation with tap water) had the highest shoot and root fresh weight for seasons 2020 and 2021 (363.5, 31.4; 302.9, and 26.2 g.), respectively, followed by the infested soil + irrigation with tap water + Fenamiphos treatment for the two years (223.7, 24.6; 186.4 and 20.5 g.), respectively. Naturally infested soil collected from Adco county irrigated with water from Mahmudiyah canal had the lowest growth metrics such as shoot and root length for 2020 and 2021 (41.5, 8.3; 33.7, and 6.9 cm.), respectively.

Table (1): Plant parasitic nematodes belonging to various genera associated with guava trees grown in soils of certain counties of three governorates, and irrigation canals at the first Season (2020).

Nematode genera and species	Adco (Beheira)		Shibin Alqanater (Qalyubia)		Baltim (Kafr Elsheikh)	
	No. nematode / 250g. soil	No. nematode in Mahmudiyah Canal / 1mL.	No. nematode /250g. soil	No. nematode in Bassousia canal / 1mL	No. nematode /250g. soil	No. nematode in Alhilmia canal /1mL
Meloidogyne spp.	560	78	1230	143	860	92
Pratylenchus spp.	-	12	17	-	3	17
Tylenchulus spp.	8	20	59	38	27	25
Tylenchorhynchus spp.	14	19	-	19	11	31
Helicotylenchus spp.	3	9	-	17	8	-
Hoplolaimus spp.	-	3	-	7	-	4
Tylenchus spp.	9	-	14	9	21	19
Rotylenchulus spp.	-	9	3	-	-	14
Ditylenchus spp.	13	20	21	10	19	3

Table (2): Plant parasitic nematodes belonging to various genera associated with guava trees grown in soil of certain counties of three governorates and irrigation canals at the second Season (2021).

Nematode genera and species	Adco (Beheira)		Shibin Alqanater (Qalyubia)		Baltim (Kafr Elsheikh)	
	No. nematode / 250g. soil	No. nematode in Mahmudiyah Canal / 1mL.	No. nematode /250g. soil	No. nematode in Bassousia canal / 1mL	No. nematode /250g. soil	No. nematode in Alhilmia canal /1mL
Meloidogyne spp.	672	93	1102	201	510	84
Pratylenchus spp.	4	9	-	20	21	10
Tylenchulus spp.	24	32	41	9	42	17
Tylenchorhynchus spp.	9	14	11	-	50	26
Helicotylenchus spp.	10	8	12	-	-	8
Hoplolaimus spp.	-	7	-	3	-	-
Tylenchus spp.	20	2	38	17	46	25
Rotylenchulus spp.	16	11	-	8	10	-
Ditylenchus spp.	36	13	10	35	26	35

Table (3): Plant growth parameters of guava transplant grown in naturally infested soil collected from, Adco county, Beheira governorate and irrigated with Mahmudiyah canal water during 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	Plant growth parameters							
	First season 2020				Second season 2021			
	Shoot		Root		Shoot		Root	
	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).
Sterilized soil + irrigation with tap water	118.7a	363.5a	46.9a	31.4a	99.5 a	302.9 a	39.1 a	26.2 a
Sterilized soil + irrigation with canal water + Fenamiphos	76.3c	124.3d	20.8c	19.3c	69.4 c	103.7 d	17.2 d	16.1 b
Sterilized soil + irrigation with canals water	68.5d	88.5e	17.8c	16.3d	57.1 d	73.8 e	14.5 e	14.4 c
Infested soil + irrigation with tap water + Fenamiphos	93.2b	223.7b	26.7b	24.6b	76.4 b	186.4 b	22.3 b	20.5 b
Infested soil + irrigation with tap water	62.7d	84.8e	10.7d	7.4e	57.3 d	70.7 e	8.9 f	6.2 d
Infested soil + irrigation with canal water + Fenamiphos	85.9 b	189.8c	22.5b	21.4bc	71.6 c	158.2 c	18.8 d	17.8 b
infested soil+ irrigation with canal water	41.5e	66.9e	8.3d	4.9f	33.7 e	55.8 f	6.9 f	3.9 d
LSD at 0.05	15.6	32.6	4.4	3.5	13.3	27.2	3.6	3.2

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

Data in Table (4) indicate significant changes in nematode final population, number of galls and egg masses/5g root across treatments compared to control treatment (Naturally infested soil + irrigation with canal water) for the first season (2918.2, 522.8 and 343.7) and the second season (3511.8, 627.4 and 412.4), respectively.

The lowest final nematode population/250g soil (182.3, 228.8) as well as the number of galls (39.6, 47.5) and egg masses/5g root (19.4, 23.3) for *Meloidogyne* spp., the major target of study was observed on plants cultivated in steam-sterilized soil irrigated with Mahmudiyah canal water and treated by Fenamiphos, for the first and second seasons, respectively. Naturally infested soil + irrigation with tap water + Fenamiphos) ranked the next which gave 601.3, 109.5 and 68.4 for the first season and 731.5, 131.4, and 82.1 for the second season, respectively. Transplanting in naturally infested soil irrigated with tap water gave a high rate of nematode population 1687.1 J2s/250g soil and 2034.6 J2s/250g, respectively for the two seasons.

Table (4): Reproduction of *Meloidogyne* spp. infecting guava as influenced by infested soil from Adco county (Beheira governorate) and irrigated with Mahmudiyah canal water during 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	First Season 2020			Second Season 2021		
	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root
Sterilized soil + irrigation with canal water + Fenamiphos	182.3e	39.6[f]	19.4 f	228.8 f	47.5 e	23.3 e
Sterilized soil + irrigation with canal water	1182.2c	217.3[d]	138.6 d	1428.6 d	260.8 c	166.3c
Infested soil+ irrigation with tap water + Fenamiphos	601.3d	109.5[e]	68.4 e	731.5 e	131.4 d	82.1d
Infested soil+ irrigation with tap water	1687.1 b	305.2b	198.4 b	2034.6 b	366.2 b	238.1b
Infested soil + irrigation with canal water + Fenamiphos	1517.5 b	264.6[c]	175.4 c	1831.1 c	317.5 b	210.5b
Infested soil + irrigation with canal water	2918.2 a	522.8 a	343.7 a	3511.8 a	627.4 a	412.4a
LSD at 0.05	231.1	41.7	26.9	242.5	50.0	32.4

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

B- Plant growth response of guava seedling transplanted in infested soil collected from Shibin Alqanater County (Qalyubia governorate) and irrigated with Bassousia canal water and nematode reproduction as well:

Data presented in Table (5) show guava plant responses to applied treatments where significant changes in plant growth parameters were identified across treatments compared to healthy plants (Steam-sterilized soil + irrigation with tap water) during 2020, 2021. which had the highest shoot and root fresh weight reached 324.3 and 19.3 for 2020, 421.6 and 23.2 for 2021, respectively followed by treatment of naturally infested soil + irrigation with tap water + Fenamiphos (214.5, 17.4; 220.9 and 17.9), for the two years, respectively. Plants cultivated in naturally infested soil and irrigated with canal water had the lowest growth metrics where shoot and root length were 35.3 and 6.2 for the first season and 38.8 and 6.8 cm for the second season.

Data (Table, 6) indicate that nematode populations were (347.1 and 300.6J2s/250 g soil), root galling (35.8 and 32.6 galls /5g root) and egg masses number were 25.4 and 32.5 egg masses/5g, Root *Meloidogyne* spp. were greatly reduced in plants grown in sterilized soil, irrigated with Bassousia canal water and treated with Fenamiphos for two seasons, respectively, compared to treatment of naturally infested soil + irrigation with canal water. In addition, guava plants cultivated in naturally infested soil, irrigated with tap water and treated with Fenamiphos ranked the second-best treatment in terms of the decrease in the number of nematodes in soil and roots for two seasons. However, naturally infested soil irrigated with tap water without Fenamiphos gave nematode population (3381.4 and 3059.0 J2/250 g. soil), galls (361.4 and 328.5 galls / 5g. root), and egg masses (231.3 and 210.3 egg mass/5g. root) for the first and the second season, respectively.

Table (5): Plant growth parameters of guava plants grown in naturally infested soil collected from Shibin Alqanater County (Qalyubia governorate) and irrigated with Bassousia canal water at two seasons 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	Plant growth parameters							
	First season 2020				Second season 2021			
	Shoot		Root		Shoot		Root	
	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).
Sterilized soil + irrigation with tap water	99.7a	324.3a	37.7a	19.3a	131.6 a	421.6 a	38.8 a	23.2 a
Sterilized soil + irrigation with canal water + Fenamiphos	67.1c	115.1c	11.6c	9.8c	69.1^{c}	138.1 c	12.1 c	12.7 c
Sterilized soil + irrigation with canal water	59.3c	82.3d	8.6 c	5.4d	71.2^{c}	106.7 cd	11.2 c	5.5^{d}
Infested soil+ irrigation with tap water + Fenamiphos	87.4b	214.5b	20.5b	17.4b	104.9 b	220.9 b	21.2 b	17.9 b
Infested soil+ irrigation with tap water	53.5 c	75.6d	7.5 c	5.1d	58.9^{c}	98.3 d	9.8 c	5.3 d
Infested soil+ irrigation with canal water + Fenamiphos	80.7b	137.6c	10.1c	8.1c	96.8^{b}	165.1 c	12.2 c	9.7 c
Infested soil+ irrigation with canal water	35.3d	60.6e	6.2d	3.0e	38.8^{d}	78.7 d	6.8 d	4.0 d
LSD at 0.05	13.8	28.9	2.9	1.95	16.3	35.1	3.2	2.2

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

Table (6): Reproduction of *Meloidogyne* spp. infecting guava as influenced by infested soil collected from Shibin Alqanater County (Qalyubia governorate) and irrigated with water from Bassousia canal at 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	First Season 2020			Second Season 2021		
	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root
Sterilized soil + irrigation with canal water + Fenamiphos	347.1e	35.8e	25.4e	300.6e	32.6 e	32.5 d
Sterilized soil + irrigation with canal water	2335.1c	260.2c	173.8c	2107.8c	236.6c	158.2 c
Infested soil + irrigation with tap water + Fenamiphos	1135.4d	121.3d	79.6d	1017.2d	110.3d	72.4 d
Infested soil + irrigation with tap water	3381.4b	361.4b	231.3 b	3059.0b	328.5 b	210.3 b
Infested soil+ irrigation with canal water + Fenamiphos	2498.9c	333.7b	219.4b	2256.8c	303.4 b	199.5 b
Infested soil+ irrigation with canal water	5644.6a	5644.6a	412.4a	5116.5a	567.1 a	374.9 a
LSD at 0.05	438.4	49.6	32.6	395.9	45.1	29.9

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

C- Plant growth responses of guava grown in infested soil collected from Baltim County (Kafr Elsheikh governorate) and irrigated with Alhilmia canal water and nematode reproduction as well.

The influence of infested soil collected from Baltim County and irrigated with water from Alhilmia canal on plant growth response is illustrated in Table (7). It is evident that guava plants grown in sterilized soil and irrigated with tap water were the best in the rate of growth metrics during the two seasons, followed by treatment with naturally infested soil + irrigation with tap water + Fenamiphos where shoot weight was 228.2 and 286.6 g. and root weight was 27.1, and 33.81g. for the two seasons, respectively. Plants grown in naturally infested soil and irrigated from Alhilmia canal water had the lowest growth metrics where shoot and root weights were (72.4 & 7.1 g.) for 2020 and (86.9 & 8.2g.) for 2021.

Table (7): Plant growth parameters of guava plants grown in naturally infested soil collected from Baltim county (Kafr Elsheikh governorate) and irrigated with Alhilmia canal water at two seasons 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	Plant growth parameters							
	First season 2020				Second season 2021			
	Shoot		Root		Shoot		Root	
	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).	Length (cm).	Fresh Weight (g).
Sterilized soil + irrigation with tap water	116.2a	318.6a	54.3a	37.6a	151.1 a	404.2a	65.2 a	48.8a
Sterilized soil + irrigation with canal water + Fenamiphos	75.6cd	115.3d	21.8d	15.0cd	129.9a	149.9d	28.3d	19.5d
Sterilized soil + irrigation with canal water	83.5b	131.4cd	27.9c	19.7c	108.6b	157.7d	33.5c	33.4b
Infested soil+ irrigation with tap water + Fenamiphos	102.5a	228.2b	36.4b	27.1b	133.3 a	286.6b	50.9b	33.8b
Infested soil+ irrigation with tap water	70.1d	92.3d	16.5e	9.5d	91.1b	119.2e	19.8e	12.4e
Infested soil+ irrigation with canal water + Fenamiphos	92.8b	162.3c	26.3c	18.2c	143.5a	227.2c	36.3c	25.2c
Infested soil+ irrigation with canal water	48.6d	72.4e	10.7f	7.1d	58.3c	86.9f	14.9e	8.2f
LSD at 0.05	17.6	32.0	5.5	3.8	23.3	24.5	7.2	5.3

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

Data in Table (8) illustrate the impact of infested and sterilized soil as well as irrigation water from Alhilmia canal and tap water with or without Fenamiphos on root-knot nematode population in soil and roots of guava plant. Results indicated that plants grown in sterilized soil and irrigated from canal water with Fenamiphos had the lowest nematode population in soil and root in comparison with control (Infested soil + irrigation with water canal) in 2020 and 2021. Results also showed that nematode density was significantly (P≤0.05) reduced in the treatment of naturally infested soil + irrigation with tap water + Fenamiphos) where nematode population recorded (899.0 & 509.3J2s/250g. soil), galls (121.2 & 71.3 gall/5g. root), and egg masses (77.2 & 45.4 egg masses/5g. root) for the two seasons, respectively. Using naturally infested soil + irrigation with tap water gave high nematode population (2540.1 & 1471.2 J2s/250g. soil), galls (335.8 & 197.5 galls/5g. root), and egg masses (221.4 & 130.2 egg mass/5g. root), respectively for the first season (2020) and the second season (2021).

Table (8): Reproduction of *Meloidogyne* spp. infecting guava as influenced by infested soil collected from Baltim county (Kafr Elsheikh governorate) and irrigated with water from Alhilmia canal during 2020 (24±4°C) and 2021 (26±4°C) under greenhouse conditions.

Treatments	First Season 2020			Second Season 2021		
	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root	Nematode Population /250g. soil	No. of galls /5g. root	No. of egg masses /5g. root
Sterilized soil + irrigation with canal water + Fenamiphos	266.4f	39.9e	23.2f	136.7e	23.5e	13.7f
Sterilized soil + irrigation with canal water	1731.3d	227.3c	149.2d	998.4c	133.7c	87.8 d
Infested soil+ irrigation with tap water + Fenamiphos	899.0e	121.2d	77.2e	509.3d	71.3d	45.4e
Infested soil+ irrigation with tap water	2540.1b	335.8b	221.4b	1471.2b	197.5b	130.2b
Infested soil+ irrigation with canal water + Fenamiphos	2244.8c	296.2b	182.3c	1300.5b	174.2b	107.5c
Infested soil+ irrigation with canal water	4330.8a	576.7a	373.5a	2527.5a	339.2 a	219.7a
LSD at 0.05	344.1	45.6	29.34	198.4	26.8	17.3

The means in each column preceded by the same letter(s) did not differ substantially at P≤0.05, according to Duncan's multiple range test.

DISCUSSION

A large proportion of guava trees are in decline and produce fewer fruits. This investigation was conducted to study the deterioration of guava cultivations in Egypt as a result of transplanting in infested soil with nematodes as well as using contaminated irrigation water from three different canals where it was found that the soil and irrigation water in different areas are infested with different nematodes belonging to genera, *Meloidogyne*, *Tylenchyulus semipentrans*, *Tylenchorhynchus*, *Pratylenchus* and *Ditylenchus* spp.

A number of 26 species of *Pythium*, 17 species of *Phytophthora*, fungi belong to 27 genera of fungi, 10 viruses, 8 species of bacteria, and 13 species of plant-parasitic nematodes were recorded in a review of plant pathogens in water resources (Hopper *et al*., 2005). Phytonematodes such as *Pratylenchus* spp., *Meloidogyne* spp., *Xiphinema index*, and *Criconemoides xenoplax* were found in irrigation water from canals that irrigate grapevine throughout the survey (Hugo and Malan, 2010).

According to some reports, root, and stem rot fungi (Cooke, 1956) such as *Pythium* spp. (Harvey, 1952; Lumsden and Haasis, 1964 and Gill, 1970), *Phytophthora* spp. (Luce, 1953; Klotz *et al*., 1959; McMurtrey 1961 and McIntosh, 1966) and a soil-borne wilt fungus *Verticillium alboatrum* (Easton *et al*., 1969) in addition to plant pathogenic bacteria (Lamichhanea and Bartolican, 2015) as well as phytopathogenic nematodes (Faulkner and Bolander, 1967, Steadman *et al*., 1975) may be recovered from various components of irrigation systems.

It was found that transplanting guava seedlings in infested soil irrigated with contaminated canals water led to a decrease in plant growth as well as an increase in nematode infection. This finding is consistent with El-Ashry and Abd El-Aal (2019), who reported that nematode species obtained from polluted irrigation water from three canals in Egypt's Sharkia, Kafr Elshekh and Menia governorates, survived and reproduced on tomato plants. When used for irrigation in commercial plant nurseries, water becomes polluted by chance. Contamination of wells collected rainfall, lakes, boreholes, ponds, dams, runoff water, rivers, municipal water, irrigation canals and drainage water in soil less cultivation are also a concern (Hugo and Malan, 2010).

Furthermore, agricultural contaminated irrigation water is a source of plant-parasitic nematode infection (Hallmann *et al*., 2005), and nematode virus vectors can be disseminated by irrigation water (Runia and Amsing, 2001).

The adoption of management strategies to prevent the spread of plant-parasitic nematodes via irrigation, as well as awareness of the possibility for nematode contamination, are both important aspects in reducing nematode harm to plants and ensuring agricultural sustainability. In reality, the quantity and spread of plant-parasitic nematodes have both increased, implying that the risk of irrigation water pollution has increased as well. To control nematodes in water resources in the future, new methods must be investigated.

CONCLUSION

Although nematodes are constantly present in agricultural soil, plant-parasitic nematodes must be maintained below detection levels in nurseries. Because water is naturally devoid of nematodes, preventative steps should be taken to maintain it free of nematodes and to reduce the capacity of water to transport plant-parasitic nematodes, which can then contaminate valuable and limited agricultural soils. It is vital to discover techniques for managing water resource pollution.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

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