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DIVERSITY OF PLANT PARASITIC NEMATODES ASSOCIATED WITH SOME VEGETABLES IN SINAI PENINSULA, EGYPT

El-Nuby, Ahmed S.M.[1*], Sayed A. Montasser[2] and Ismail A. El-Khadrawy[1]
[1]Department of Plant Protection, Desert Research Center, El-Matareya, Cairo, Egypt
[2]Department of Zoology and Nematology, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt
[*]E-mail: ahmedelnuby.drc@gmail.com

A survey for plant parasitic nematode (PPN) fauna in Sinai Peninsula, Egypt was carried out. A total of 607 soil and root samples was collected, at growth seasons during the period from 2016 to 2017 at both governorates; North Sinai (in which few surveys were accomplished) and South Sinai for the first time. The nematode survey was based on collecting soil and root samples around the roots. In the two governorates, 13 genera in 9 families, belonging to 3 orders of phylum Nematoda were observed. These orders were Dorylaimida, Triplonchida and Tylenchida. Three genera viz., *Meloidogyne*, *Rotylenchulus* and *Tylenchorhynchus* belonging to order Tylenchida were found to represent the highest plentiful numbers (18891, 3528 and 3316, respectively) in Sinai Peninsula. *Meloidogyne* was the most abundant and dominant genus in all surveyed districts. Nematodes in North Sinai were more diverse than South Sinai, since they possessed 3 orders, 8 families and 13 genera (*Belonolaimus, Criconema, Criconemoides, Helicotylenchus*, *Hoplolaimus, Meloidogyne*, *Pratylenchus, Rotylenchulus, Tetylenchus, Trichodorus, Tylenchorhynchus, Tylenchus* and *Xiphinema*) versus 2 orders, 5 families and 6 genera viz., *Criconema, Meloidogyne*, *Pratylenchus, Rotylenchulus, Trichodorus* and *Tylenchorhynchus* in South Sinai. Species diversity peaked in Rafah district, whereas in South Sinai, peak was recorded in Ras-Suder district. Reviewing the previous investigations carried out in Sinai for recording plant parasitic nematode, it was found that the last 6 genera recovered from South Sinai were the first records, based on the present survey is considered the first nematological study carried out in this governorate. Also, this study will pay the growers attention, to control infestation by PPN.

Keywords: diversity, plant parasitic nematodes, survey, vegetables, Sinai Peninsula

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Plant parasitic nematodes (PPN) are considered the main constrain for many crops, especially vegetables. Losses due to PPN are estimated at USD $130 billion without considering other losses indirectly by interactions with other pathogens, also they are higher in developed countries compared to that of developing ones (Shakeel et al., 2012 and Becker 2014). Out of all PPN, root-knot nematodes (RKN), *Meloidogyne* have been reported as the most highly distributed ones all over the world and found in all terrains of all ecosystems, and in any soils have temperature more than 3°C. They are considered the most economically important group of phytoparasitic nematodes due to their severe damage occurred for plants, particularly to vegetable crops and for their small-holder growers (Ibrahim et al., 2000; Ibrahim et al., 2010; Anwar and Mckenry, 2012; Shakeel et al., 2012; Adamou et al., 2013a and b; Korayem et al., 2014; Singh and Khanna, 2015; Kumar et al., 2017; Tariq-Khan, 2017 and Vindhyarani, 2017).

Vegetable crops are widely cultivated in Egypt and are common, which highly consumed by the peoples in all countries. Furthermore, small holder farmers in Sinai Peninsula depend on these crops production for consumption and improving their income.

Diversity of nematode fauna in agroecosystems and their relationships to soil processes were studied by Yeates and Bongers (1999), they used the soil nematode diversity as biomarkers for ecosystem. They suggested that nematodes were potential bioindicators and they found that changes in nematode diversity shown by values of the Shannon-Wiener index (H') often reflect environmental differences. They concluded that morphologically distinct groups or families may be useful within regions or soil types but fail to provide a universal indicator. Previous investigations in Egypt have shown the presence of about 54 genera and 160 species of PPN associated with different plants (Oteifa et al., 1997; Ibrahim et al., 2000; Ibrahim and El-Sharkawy, 2001 and Ibrahim et al., 2010). The association of PPN with vegetables was confirmed in Northern Egypt by other authors (Mokbel et al., 2006) as they found 9 genera of PPN in vegetable fields.

Although Sinai Peninsula has a strategic importance, there is little information about distribution of PPN associated with vegetable crops in this area, so the necessity of knowing phytonematodes diversity become urgent, in particular after selecting it as a part of national project for cultivation 1.5 million feddans. Few investigations were carried out in Sinai (confined in North Sinai only) as two surveys were accomplished by Ashoub (2010) and Korayem et al. (2014). However, successful production of vegetables in Sinai has been retarded by nematodes, particularly root-gall nematodes (RGN). Information concerning the occurrence and distribution of plant- parasitic nematodes in Egypt is important to assess their potential to cause economic damage to plants.

The objectives of this study were; identifying plant parasitic nematodes (PPN) associated with vegetable plants in Sinai Peninsula (Egypt), determination the frequencies of occurrence and population densities of nematodes in relation to locality and host species, using the diversity indices for measuring their distribution patterns in vegetable cultivation in Sinai. Documentation the presence and abundance of dominant genus or genera was illustrated in GPS- based map.

MATERIALS AND METHODS

1. Sampling

Nematological surveys were done in Sinai Peninsula, which including two governorates viz., North and South Sinai, besides Sahl El-Teina region (which irrigated from El-Salam canal) during 2016 to 2017. A total of 607 soil and root samples of vegetable crops were collected from the rhizosphere region at a depth of 15-30 cm. Samples were randomly collected for each crop by making a zig-zag pattern across each field with soil auger at 20-cm approximately depth. For plots up to 10 square meters in area, 2-3 sub-samples (cores) were taken per composite sample, the soil was then bulked in plastic bags, mixed carefully, and about 1000 g for each sample was placed in an ice box during collection and was transported, then stored at 4°C until processed in the lab. All samples were taken during the cropping growth season, March to October.

2. Nematode Extraction and Identification

Each soil sample was thoroughly mixed by shaking the plastic bags, then an aliqot of 250 cm^3 sub-sample was used for extraction PPN genera using sieves (Sieve series of 100, 200 and 325 mesh-US Standard with openings of 149, 74 and 45 µm, respectively) following Cobb sifting and gravity method (Cobb, 1918). Light microscope was used for identification and enumeration of nematodes. Identification of nematodes genera, which fixed in 2% hot formaldehyde solution by binocular microscope, was based on the morphological characters of adult and juvenile forms according to different references (Goodey, 1963; Tarjan, 1973; Mai and Lyon, 1975; Anderson and Mulvey 1979 and Mekete et al., 2012)

3. Nematode Estimation

Data registrations were based on two parameters viz. frequencies of occurrence (FO) and population densities (PD) per 250 cm^3 soil. The FO% of the PPN was determined from the relationship among the numbers of samples (e) in which the genus was found divided by the total number of samples taken (E) from that location or crop, multiplied by 100 to express as a percentage [(FO = e/E) X100] according to (Sawadogo et al., 2009). PD of nematode species was calculated as the averages of the total number of nematodes recorded for those samples in which a nematode species was found (summation of individuals of specific nematode genus in all samples/total number of samples containing the same genus) as described by Norton (1978).

3. Diversity Indices

To evaluate the diversity, three biological indices were used (e.g. Shannon-Wiener index, evenness index, and the Simpson dominance index). Typically, Shannon's (H') index is sensitive to rare taxa, however Simpson's λ index weights common taxa (Boyle et al., 1990), the utilization of richness, evenness and diversity indices cannot be separated. Evenness indices can be considered as relative diversity indices or normalizations of diversity indices (Peet, 1974 and Kvalseth, 1991). In addition, species richness (S) or species abundance represents the simplest biodiversity index and it does not consider any characteristic of taxon or their relative abundance.

Taxonomical diversity of phytoparasitic nematode communities was estimated by: (a) the total number of nematode in each district (N); (b) the species richness (S) represent the total number of taxa in a community; (c) the Shannon-Wiener diversity index (H') according to Shannon and Wiener (1949) using the formula: $H' = - \Sigma[(pi) \times 1n\ (pi)]$, where pi is the proportion of individuals (n/N) in each species, i that counted the local diversity [H′ ranged from 0 to ln (S)], H max= the maximum of Shannon index (Maximum diversity possible); (d) the Simpson index (Simpson, 1949) or dominance index (D) and can actually refer to any one of 3 closely related indices. There are two versions of the formula for calculating using formula, either of them is acceptable;

$D = \Sigma\ (Pi)^2$ or $\Sigma\ (n/N)^2$ and $\Sigma\ n(n-1)/N(N-1)$, the last were used, the value of D ranges between 0 and 1. With this index, 0 represents infinite diversity and 1, no diversity, i.e. the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to overcome these problem, two modifications in D can be used: first; (**1-**D**)** the value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity, secede; (1/D) the higher the value of this index means that greater diversity are found, also the maximum value is the number of taxa. and (e) the evenness or equity index that are considered also as relative diversity indices or normalizations of diversity indices that assess the uniformity of taxa distribution within the community, value of E can be calculated according to Pielou (1975) by this formula;

$E = H'/Hmax = H'/lnS$, ln(S) i.e. natural logarithm of total number of taxa, species, found (E ranged between 0 and 1).

RESULTS

Survey results of phytoparasitic nematodes associated with different vegetable crops in different districts of Sinai are shown in (Tables 1-4). Data in table (1) reveal that 13 genera of stylet-bearing nematodes (*Belonolaimus,* *Criconema, Criconemoides, Helicotylenchus*, *Hoplolaimus, Meloidogyne*, *Pratylenchus, Rotylenchulus, Tetylenchus, Trichodorus, Tylenchorhynchus, Tylenchus* and *Xiphinema*) were isolated from 404 samples collected from North Sinai governorate. *Meloidogyne* was more frequent in all districts than other genera, followed by *Tylenchorhynchus*, which was found in five districts. FO of *Meloidogyne* peaked in Rafah and El-Sheikh Zuweid (77.9 and 65.1%, respectively). The maximum PD of *Meloidogyne* was present in El-Arish and El-Tina plain (3400 and 3050 individuals/250 cm^3 soil, respectively).

The diversity of PPN was greater in Rafah district compared with others. *Belonolaimus* and *Xiphinema* were confined to Rafah district only and were not observed in any vegetable fields, and their frequencies were the lowest compared to other PPN genera in Rafah district as also were found in all district in North Sinai government, besides *Criconema* and *Tylenchus* (0.25%). El- Hassana district was the lowest one in the nematode diversity, since it had one *Meloidogyne. Tetylenchus* recovered once from Al Arish is similar to *Tylenchus* from El-Tina plain. Collective data of North Sinai revealed that *Meloidogyne* was the most abundant genus (44.8%) and also possessed the maximum population density (1330), followed by *Rotylenchulus* (7%), *Trichodorus* (3.5%), *Tylenchorhynchus* (2.7%), *Helicotylenchus*, *Hoplolaimus* and *Pratylenchus* (2.5%) and *Criconemoides* (1.5%), whereas the minimum frequent genera were *Belonolaimus*, *Criconema*, *Tetylenchus*, *Tylenchus* and *Xiphinema* (0.25%).

From South Sinai governorate, a total of 203 samples was collected from vegetable crops, of which six PPN genera were found (*Criconema, Meloidogyne, Pratylenchus, Rotylenchulus, Trichodorus* and *Tylenchorhynchus*) as presented in table (2). *Meloidogyne* and *Rotylenchulus* were found in all districts. The highest FO in all governorates was recorded by *Meloidogyne* (34.5%), followed by *Rotylenchulus* (10.3%) and *Tylenchorhynchus* (7.4%), whereas *Criconema* and *Pratylenchus* were the least frequent genera (0.5%). Nuweiba and Ras Suder included more nematode genera than other districts. Similar to North Sinai, the most dominant genus was *Meloidogyne*; its highest FO of 72.0 and 47.0% were recorded in Ras Suder and Abo Zenima, respectively. Whereas the lowest frequency (16.2%) was observed in Saint Katherine. *Meloidogyne* was found in greater population densities in El-Tour and Nuweiba (1848 and 1125 individuals, respectively). *Rotylenchulus* was recorded in maximum frequency at El-Tour (33.3%), however density peaked in Saint Katherine (700 individuals). *Tylenchorhynchus* was more frequent than the rest recovered genera, since it was recorded in three districts.

Results listed in table (3) show that PPN community in North Sinai varied according to the vegetable hosts. It was observed that favorable hosts of Solanaceae plants were tomatoes and eggplants. It was noticed that tomato plants harbored the maximum number of nematode genera (12) followed by eggplant (8), however pepper possessed the lowest number of genera (4). The highest PO and FO of *Meloidogyne* were observed in eggplant rhizosphere (2265 individuals/250 cm^3 soil and 55.6%, respectively), followed by tomato (825 individuals and 37.3%), the pepper came in the last category (806 individuals and 34.3%). Within Cucurbitaceae plants; cucumber and watermelon harbored the highest number of nematode genera (8), followed by squash (6), whereas cantaloupe possessed the lowest number of genera (4). *Meloidogyne* genus peaked in its frequency with watermelon, followed by cucumber (61.9 and 57.1%, respectively), but the maximum density was gained by cantaloupe (1333 individuals/250 cm^3 soil). It was noticed that sedentary endo and semi endo-parasitic genera; *Meloidogyne* and *Rotylenchulus,* respectively, were found in all vegetable hosts of both families (Solanaceae and Cucurbitaceae).

Data presented in table (4) show that PPN fauna in South Sinai were different from host plant to another. Tomatoes were bearing four PPN genera, *Meloidogyne* was found at high frequency (37.3%) and density (1374 individuals), compared to other PPN genera. Cucumber harbored the maximum density (1163 individuals) and frequency (44.4%) of *Meloidogyne*, also cucumber bore the highest density of *Tylenchorhynchus* (6600 individuals). The last genus was recorded in all vegetable hosts, expect cantaloupe, whereas *Meloidogyne* came secondly. Squash recorded the lowest densities, especially for *Meloidogyne* and *Rotylenchulus* (200 individuals), but the frequency was the highest with *Meloidogyne* (50%) and equal in *Rotylenchulus*, *Trichodorus* and *Tylenchorhynchus* (25%). Watermelon associated with only *Tylenchorhynchus,* achieving the maximum frequency (50%).

Data in table (5) reveal that morphological and morphometric studies of diagnostic characters confirmed the identification of 3 orders, 8 families and 13 genera of PPN (*Belonolaimus, Criconema, Criconemoides, Helicotylenchus*, *Hoplolaimus, Meloidogyne*, *Pratylenchus, Rotylenchulus, Tetylenchus, Trichodorus, Tylenchorhynchus, Tylenchus* and *Xiphinema*) associated with vegetable crop soils in Sinai Peninsula. Among them root-knot, reniform and stunt nematodes were the most abundant.

Table (1). Population densities and frequencies of occurrence of plant parasitic nematodes genera associated with some vegetable crops in different localities of North Sinai.

Nematode genera	Al- Arish (31)		Beir al- Abed (109)		El-Hassana (22)		El- Sheikh Zuweid (43)		Nekhel (20)		Rafah (86)		Rommana (60)		El-Tina Plain (33)		Total (404)	
	PD	FO%	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %
Belonolaimus	-	-	-	-	-	-	-	-	-	-	200	1.20	-	-	-	-	200	0.25
Criconema	-	-	-	-	-	-	-	-	-	-	-	-	200	1.7	-	-	200	0.25
Criconemoides	-	-	-	-	-	-	300	4.7	-	-	200	4.7	-	-	-	-	233	1.5
Helicotylenchus	-	-	-	-	-	-	-	-	-	-	240	11.6	-	-	-	-	240	2.5
Hoplolaimus	-	-	-	-	-	-	-	-	-	-	365	11.6	-	-	-	-	365	2.5
Meloidogyne	3400	38.7	1089	24.8	1422	40.9	1250	65.1	107	40.0	769	77.9	1645	36.7	3050	24.2	1330	44.8
Pratylenchus	-	-	200	0.9	-	-	-	-	-	-	311	10.5	-	-	-	-	300	2.5
Rotylenchulus	-	-	200	0.9	-	-	-	-	333	15.0	474	31.4	200	1.7	-	-	494	7.0
Tetylenchus	200	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	0.25
Trichodorus	200	3.2	450	3.7	-	-	-	-	-	-	322	10.5	-	-	-	-	350	3.5
Tylenchorhynchus	600	3.2	200	0.9	-	-	600	7.0	-	-	416	5.8	-	-	200	3.0	409	2.7
Tylenchus	-	-	-	-	-	-	600	2.3	-	-	-	-	-	-	-	-	600	0.25
Xiphinema	-	-	-	-	-	-	-	-	-	-	200	1.2	-	-	-	-	200	0.25

PD= Population Density/250 cm^3 soil, FO%= Frequency of Occurrence %, Number between parentheses ( ) represented number of samples taken.

Table (2). Population densities and frequencies of occurrence of plant parasitic nematodes genera associated with some vegetable crops in different localities of South Sinai

Nematode genera	Abo –Reideis (15)		Abo-Zenima (17)		El-Tor (67)		Nuweiba (49)		Ras-Suder (18)		Saint-Katherine (37)		Total (203)	
	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %	PD	FO %
Belonolaimus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Criconema	-	-	-	-	-	-	-	-	200	5.6	-	-	200	0.5
Criconemoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helicotylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoplolaimus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meloidogyne	533	40.0	657	47.0	1848	31.3	1125	32.7	896	72.0	1100	16.2	1195	34.5
Pratylenchus	-	-	-	-	-	-	800	2.0	-	-	-	-	800	0.5
Rotylenchulus	400	6.7	400	11.8	250	33.3	371	14.3	200	7.1	700	5.4	324	10.3
Tetylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichodorus	-	-	-	-	-	-	-	-	400	11.1	-	-	400	0.98
Tylenchorhynchus	500	13.3	-	-	300	2.9	500	40.0	-	-	-	-	1013	7.4
Tylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xiphinema	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PD= Population Density/250 cm^3 soil, FO%= Frequency of Occurrence %, Number between parentheses ( ) represented number of samples taken.

Table (3). Population densities and frequencies of occurrence of plant parasitic nematodes genera with host plant species in North Sinai.

Nematode genera	Solanaceae						Cucurbitaceae							
	Eggplant		Pepper		Tomato		Cantaloupe		Cucumber		Squash		Watermelon	
	PD	FO	PD	FO	PD	FO	PD	FO	PD	FO	PD	FO	PD	FO
Belonolaimus	-	-	-	-	-	-	-	-	-	-	-	-	200	4.8
Criconema	-	-	-	-	200	1.2	-	-	-	-	-	-	-	-
Criconemoides	333	3.5	-	-	200	2.4	-	-	-	-	200	4.0		-
Helicotylenchus	300	23	200	3.1	200	6.3	-	-	200	4.7	400	4.0	200	4.8
Hoplolaimus	350	47	-	-	500	2.4	-	-	300	4.7	-	-	317	14.3
Meloidogyne	2265	55.8	806	34.4	825	37.3	1333	33.3	1092	57.1	655	44	839	61.9
Pratylenchus	300	1.2	-	-	300	2.4	400	11.1	400	4.7	200	8.0	200	4.8
Rotylenchulus	356	8.1	200	12.5	1000	7.2	600	5.6	450	9.5	520	20	533	14.3
Tetylenchus	-	-	-	-	200	1.2	-	-		-	-	-	-	
Trichodorus	400	3.5	300	6.3	1100	4.8	-	-	400	2.4	200	4.0	250	19
Tylenchorhynchus	467	3.5	-	-	627	4.8	400	5.6	500	4.8	-	-	600	4.8
Tylenchus	-	-	-	-	600	1.2	-	-	-	-	-	-	-	-
Xiphinema	-	-	-	-	-	-	-	-	200	2.4	-	-	-	-

PD= Population Density /250 cm^3 soil, FO%= Frequency of Occurrence%.

Table (4). Population densities and frequencies of occurrence of plant parasitic nematodes genera with host plant species in South Sinai.

Nematode genera	**Solanaceae**						**Cucurbitaceae**							
	Eggplant		**Pepper**		**Tomato**		**Cantaloupe**		**Cucumber**		**Squash**		**Watermelon**	
	PD	**FO%**	**PD**	**FO%**	**PD**	**FO%**	**PD**	**FO%**	**PD**	**FO%**	**PD**	**FO%**	**PD**	**FO%**
Belonolaimus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Criconema	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Criconemoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helicotylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoplolaimus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meloidogyne	1142	48.9	1700	22.2	1374	37.3	200	25	1163	44.4	200	50	-	-
Pratylenchus	-	-	-	-	220	2.4	-	-	200	3.7	-	-	-	-
Rotylenchulus	533	6.1	400	22.2	464	4.8	-	-	393	57.9	200	25	-	-
Tetylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichodorus	-	-	-	-	-	-	-	-	400	3.7	400	25	-	-
Tylenchorhynchus	1200	4.8	310	22.2	714	8.4	-	-	6600	37	400	25	800	50
Tylenchus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xiphinema	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PD= Population Density /250cm^3 soil, FO%= Frequency of Occurrence %

Table (5). Nematode community diversity indices based on the numbers of nematodes associated with vegetable cultivations in Sinai during 2016-2017 Dorylaimida.

Order	Family	Genera	# Taxa in location													
			North Sinai								South Sinai					
			1N	2N	3N	4N	5N	6N	7N	8N	1S	2S	3S	4S	5S	6S
Tylenchida	Hoplolaimidae	*Belonolaimus*	0	0	0	0	0	0	200	0	0	0	0	0	0	0
Tylenchida	Criconematidae	*Criconema*	0	0	0	0	0	0	0	200	0	0	0	0	200	0
Tylenchida	Criconematidae	*Criconemoides*	0	0	0	300	0	0	200	0	0	0	0	0	0	0
Tylenchida	Hoplolaimidae	*Helicotylenchus*	0	0	0	0	0	0	240	0	0	0	0	0	0	0
Tylenchida	Hoplolaimidae	*Hoplolaimus*	0	0	0	0	0	0	365	0	0	0	0	0	0	0
Tylenchida	Heteroderidae	*Meloidogyne*	3400	1089	1422	1250	3050	1075	769	1645	533	657	1848	1125	896	1100
Tylenchida	Pratylenchidae	*Pratylenchus*	0	200	0	0	0	0	311	0	0	0	0	800	0	0
Tylenchida	Hoplolaimidae	*Rotylenchulus*	0	200	0	0	0	333	474	200	400	400	250	371	200	700
Tylenchida	Tylenchidae	*Tetylenchus*	200	0	0	0	0	0	0	0	0	0	0	0	0	0
Triplonchida	Trichodoridae	*Trichodorus*	200	450	0	0	0	0	322	0	0	0	0	0	400	0
Tylenchida	Belonolaimidae	*Tylenchorhynchus*	600	200	0	600	200	0	416	0	500	0	300	500	0	0
Tylenchida	Tylenchidae	*Tylenchus*	0	0	0	600	0	0	0	0	0	0	0	0	0	0
Dorylaimida	Longidoridae	*Xiphinema*	0	0	0	0	0	0	200	0	0	0	0	0	0	0
Abundance [Total individuals for each district (N)]			4400	2139	1422	2750	3250	440	3497	2045	1433	1057	2398	2796	1696	1800
Number of Taxa (species or genera)			4	5	1	4	2	2	10	3	3	2	3	4	4	2
Shannon- Wiener index (H') =-SUM[(pi)xln(Pi)			0.75	1.0	0.37	1.08	0.39	0.29	1.93	0.65	0.72	0.50	0.71	1.11	0.82	0.64
*Simpson (dominance index) (D)=SUM(Pi)2 (1-D)			0.380	0.671	0.001	0.687	0.116	0.370	0.878	0.334	0.663	0.471	0.380	0.707	0.638	0.478
*Simpson (dominance index) (D)=SUM(Pi)2 (1/D)			1.61	3.04	1.00	3.19	1.13	1.59	8.17	1.50	2.98	1.89	1.61	3.41	2.78	1.91
Evenness (E)= Evenness = H/Hmax [Hmax= ln(S)]			0.54	0.62	0.0	0.78	0.57	0.41	0.84	0.59	0.66	0.72	0.65	0.80	0.59	0.92

1N= Al- Arish, 2N= Bir al- Abed, 3N= El-Hassana, 4N= El- Sheikh Zuweid, 5N= El-Tina Plain, 6N= Nekhel, 7N= Rafah, 8N= Rommana,
1S= Abo- Reideis, 2S = Abo- Zenima, 3S= El-Tor, 4S= Nuweiba, 5S= Ras-Suder, 6S= Saint-Katherine
pi= proportion of total sample represented by species I (divide no. Of individuals of species I by total number of samples)
S= number of species, = species richness- Hmax= ln(S) Maximum diversity possible. * Simpson diversity index (D) are expressed by (1-D) and (1/D)

The diversity of PPN communities, measured by numbers of nematode individuals for each species in different vegetable plantations, was compared with indices of diversity based on number of H', D, beside E.H' values varied between 0.37 in El-Hassana to 1.93 in Rafah, which was considered the most diversed district in Sinai. The highest evenness value (0.84) was also found in Rafah and equalled to zero (0.0) in El-Hassana. Simpson index also peaked in Rafah in two forms (1-D) or (1/D), 0.878 and 8.15, respectively. In South Sinai, the maximum four diversity indices were found in Newiba; 1.11, 0.707, 3.41 and 0.80 for H, D-1, D/1 and E, respectively.

As *Meloidogyne* was the most abundant and dominant genus all over the surveyed Sinai surveyed locations, the sample positions were determined using GPS device as illustrated in table (6), GPS-based map was fitted to determine the hot spots of this dangerous genus with own population densities (Fig.1).

Table (6). Hot spots of root-knot nematode and their densities associated with vegetables in Sinai determined by GPS.

No.	N	E	PD	Density	Location
1	31° 00′ 0.12′′	32° 31′ 0.53′′	600	Moderate	El-Teina p
2	31° 00′ 0.01′′	32° 31′ 0.29′′	4300	High	El-Teina p
3	30° 54′ 0.20′′	32° 23′ 0.64′′	4500	High	El-Teina p
4	30° 55′ 0.63′′	32° 26′ 0.45′′	2800	High	El-Teina p
5	31° 00′ 0.45′′	32° 39′ 0.87′′	2333	High	Rommana
6	31° 00′ 0.09′′	32° 41′ 0.14′′	600	Moderate	Rommana
7	30° 59′ 0.39′′	32° 43′ 0.71′′	867	Moderate	Rommana
8	31° 00′ 0.66′′	32° 34′ 0.37′′	200	Low	Rommana
9	31° 00′ 0.74′′	32° 33′ 0.89′′	200	Low	Rommana
10	30° 59′ 0.48′′	32° 43′ 0.83′′	600	Moderate	Rommana
11	30° 59′ 0.43′′	32° 43′ 0.68′′	3800	High	Rommana
12	30° 59′ 0.43′′	32° 43′ 0.71′′	200	Low	Rommana
13	30° 59′ 0.44′′	32° 43′ 0.71′′	4200	High	Rommana
14	30° 59′ 0.44′′	32° 43′ 0.73′′	600	Moderate	Rommana
15	30° 59′ 0.40′′	32° 43′ 0.70′′	1000	High	Rommana
16	30° 59′ 0.63′′	32° 55′ 0.51′′	467	Moderate	Rommana
17	31° 02′ 0.06′′	33° 05′ 0.35′′	200	Low	Bir Al-Abed
18	31° 02′ 0.08′′	33° 05′ 0.33′′	200	Low	Bir Al-Abed
19	31° 02′ 0.07′′	33° 05′ 0.33′′	1000	High	Bir Al-Abed
20	31° 02′ 0.03′′	33° 05′ 0.38′′	2300	High	Bir Al-Abed

Table (6). Cont.

No.	N	E	PD	Density	Location
21	31° 02′ 0.05′′	33° 04′ 0.96′′	700	Moderate	Bir Al-Abed
22	31° 02′ 0.05′′	33° 04′ 0.94′′	600	Moderate	Bir Al-Abed
23	31° 00′ 0.47′′	32° 56′ 0.14′′	3467	High	Bir Al-Abed
24	31° 04′ 0.53′′	33° 34′ 0.00′′	733	Moderate	Bir Al-Abed
25	31° 02′ 0.51′′	33° 22′ 0.74′′	733	Moderate	Bir Al-Abed
26	31° 02′ 0.52′′	33° 22′ 0.74′′	733	Moderate	Bir Al-Abed
27	31° 02′ 0.53′′	33° 22′ 0.71′′	600	Moderate	Bir Al-Abed
28	31° 04′ 0.30′′	33° 30′ 0.61′′	200	Low	Bir Al-Abed
29	31° 07′ 0.54′′	33° 48′ 0.68′′	533	Moderate	Al- Arish
30	31° 06′ 0.64′′	33° 44′ 0.49′′	3133	High	Al- Arish
31	31° 06′ 0.67′′	33° 44′ 0.48′′	4967	High	Al- Arish
32	31° 14′ 0.12′′	34° 06′ 0.96′′	1175	High	El-Sheikh Z
33	31° 13′ 0.29′′	34° 06′ 0.89′′	1080	High	El-Sheikh Z
34	31° 13′ 0.56′′	34° 06′ 0.46′′	600	Moderate	El-Sheikh Z
35	31° 13′ 0.98′′	34° 06′ 0.24′′	1300	High	El-Sheikh Z
36	31° 13′ 0.99′′	34° 06′ 0.23′′	1340	High	El-Sheikh Z
37	29° 59′ 0.66′′	33° 48′ 0.80′′	1167	High	Nekhel
38	29° 59′ 0.63′′	33° 48′ 0.79′′	800	Moderate	Nekhel
39	30° 43′ 0.06′′	33° 19′ 0.63′′	1422	High	El-Hassana
40	29° 36′ 22.60′′	32° 43′ 21.30′′	350	Low	Ras Suder
41	29° 37′ 28.40′′	32° 42′ 44.90′′	600	Moderate	Ras Suder
42	29° 37′ 36.50′′	32° 42′ 46.60′′	850	Moderate	Ras Suder
43	30° 49′ 00.00′′	32° 23′ 00.00′′	400	Low	Ras Suder
44	31° 18′ 07.00′′	34° 11′ 59.00′′	987	Moderate	Rafah
45	31° 17′ 49.00′′	34° 12′ 06.00′′	713	Moderate	Rafah
46	31° 18′ 08.00′′	34° 12′ 28.00′′	408	Moderate	Rafah
47	31° 17′ 34.00′′	34° 12′ 34.00′′	525	Moderate	Rafah
48	31° 17′ 35.00′′	34° 11′ 46.00′′	756	Moderate	Rafah
49	31° 19′ 18.82′′	34° 13′ 03.29′′	1267	High	Rafah
50	31° 18′ 49.85′′	34° 12′ 25.06′′	960	Moderate	Rafah
51	29° 09′ 0.88′′	33° 04′ 0.05′′	400	Moderate	Abo-Zenima
52	30° 03′ 0.51′′	32° 37′ 0.62′′	950	Moderate	Ras Suder
53	28° 41′ 0.89′′	33° 40′ 0.72′′	500	Moderate	El-Tor

Table (6). Cont.

No	N	E	PD	Density	Location
54	28° 41′ 0.89′′	33° 40′ 0.73′′	550	Moderate	El-Tor
55	28° 16′ 0.86′′	33° 37′ 0.31′′	2900	High	El-Tor
56	28° 16′ 0.84′′	33° 37′ 0.32′′	900	Moderate	El-Tor
57	28° 17′ 0.33′′	33° 37′ 0.41′′	650	Moderate	El-Tor
58	28° 17′ 0.33′′	33° 37′ 0.41′′	200	Low	El-Tor
59	28° 20′ 0.85′′	33° 38′ 0.48′′	4900	High	El-Tor
60	28° 17′ 0.99′′	33° 35′ 0.76′′	1700	High	El-Tor
61	28° 19′ 0.85′′	33° 38′ 0.77′′	1533	High	El-Tor
62	28° 43′ 0.00′′	34° 06′ 0.53′′	1533	High	Siant Kath.
63	28° 40′ 0.66′′	33° 58′ 0.86′′	2200	High	Siant Kath.
64	28° 41′ 0.70′′	33° 56′ 0.85′′	200	Low	Siant Kath.
65	28° 55′ 0.66′′	34° 35′ 0.76′′	350	Low	Newiba
66	28° 31′ 0.60′′	34° 28′ 0.17′′	800	Moderate	Newiba
67	28° 15′ 0.24′′	33° 36′ 0.79′′	800	Moderate	El-Tor
68	28° 42′ 0.51′′	33° 46′ 0.16′′	200	Low	WadiFiran
69	28° 41′ 0.92′′	33° 39′ 0.25′′	200	Low	WadiFiran
70	30° 40′ 44.07′′	33° 30′ 35.88′′	200	Low	El-Maghara
71	30° 35′ 26.71′′	33° 22′ 17.70′′	400	Moderate	El-Maghara
72	30° 27′ 59.78′′	33° 47′ 3.25′′	200	Low	El-Maghara
73	30° 28′ 12.70′′	33° 47′ 0.94′′	600	Moderate	El-Maghara
74	29° 54′ 12.54′′	33° 44′ 3.64′′	300	Low	Nekhel
75	29° 53′ 23.51′′	33° 42′ 14.75′′	200	Low	Nekhel

PD= Population density, N=latitude, E=longitude

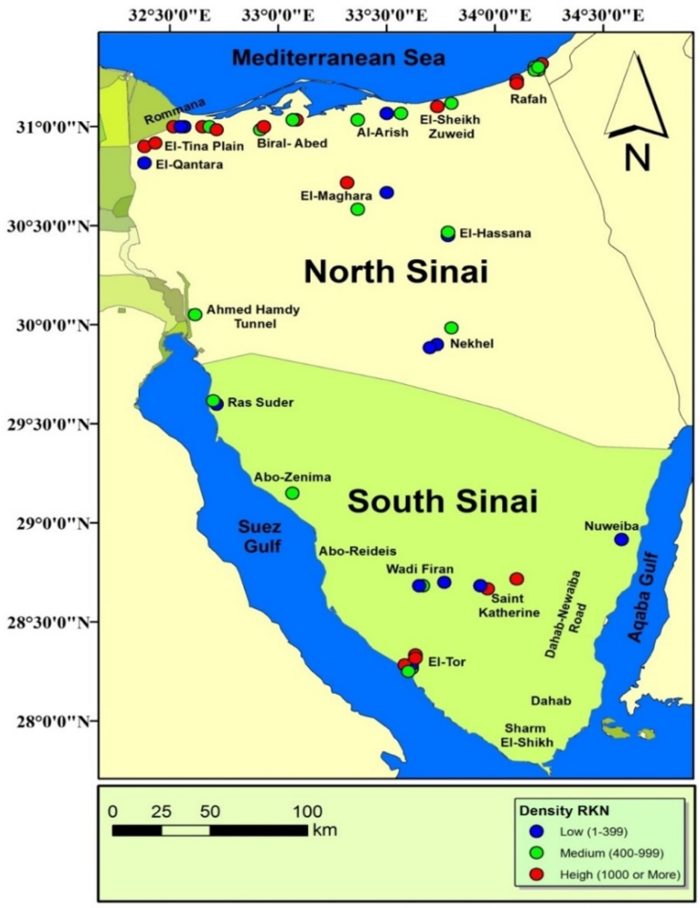

Fig. (1). GPS based map showed distribution of root-knot nematodes associated with vegetables growing in Sinai Peninsula.

DISCUSSION

Phytoparasitic nematodes infect almost all-important agronomical crops, also they constitute a major challenge to the production of many crops, especially in light or sandy soil and newly reclaimed desert lands (Ibrahim et al., 2010). Current survey revealed that thirteen stylet bearing nematode genera were encountered in soil samples collected from different vegetable cultivations in Sinai Peninsula, including ectoparasites (*Belonolaimus, Criconema, Criconemoides, Helicotylenchus*, *Hoploliamus, Tetylenchus, Trichodorus, Tylenchorhynchus, Tylenchus* and *Xiphinema*), endoparasites (*Meloidogyne* and *Pratylenchus*) and semi-endoparasites (*Rotylenchulus*).

Presence of these serious phytoparastic nematodes on vegetables cultivations must be taken seriously by growers, especially they live in warmed areas. The association of these nematodes with vegetable crops has been reported to diminish yields (Anwar and McKenry, 2012). Many investigations were carried out to analyze the parasitic nematode community in several vegetable fields. Another investigator found that seven PPN genera associated with vegetable crops viz. *Helicotylenchus, Meloidogyne, Pratylenchus, Rotylenchus, Scutellonema, Quinisulcius,* and *Tylenchus* in Uganda (Bafokuzara, 1996).

Meloidogyne is by far the most dominant PPN both in North and South Sinai governorates. This widespread distribution of *Meloidogyne* in all agricultural regions is consistent with results from earlier surveys (Ibrahim, 1994; Ibrahim et al., 2000; Korayem and Mohamed, 2010; Korayem et al., 2014). The global distribution of *Meloidogyne* compared with the rest nematode genera, especially in tropical, subtropical and Mediterranean climates, are due to wide and various host ranges that lacking specificity in parasitism (Sasser, 1979 and Anwar et al., 2006). The status of vegetable crops as a good host for *Meloidogyne* has been previously reported (Siddiqi, 2000; Sikora and Fernandez, 2005; Kaskavalci, 2007; Baimey et al., 2009; Chaudhary et al., 2011; Anwar et al., 2013 and Rani, 2017) and this was also supported by the present survey.

All nematode genera found in South Sinai (*Criconema, Meloidogyne*, *Pratylenchus, Rotylenchulus, Trichodorus* and *Tylenchorhynchus)* were firstly recorded in this governorate, as this is the first nematological survey carried out in South Sinai. Seven genera viz., *Belonolaimus, Criconema*, *Criconemoides, Helicotylenchus*, *Pratylenchus, Rotylenchulus,* and *Tetylenchus* also were not reported before the present survey in North Sinai associating with vegetables, whereas Ashoub (2010) reported that only *Meloidogyne* genus associated with vegetable plants., and in the previous survey conducted by Korayem et al. (2014), they found 6 genera (*Hoplolaimus, Meloidogyne*, *Trichodorus,Tylenchorhynchus*, *Tylenchus* and *Xiphinema*) in some North Sinai locations.

In general, the total number of PPN in each district ranged from 1408 (Nekhel) to 3250 (El-Tina Plain) individuals/250-cm^3 soil and in South Sinai from 1075 (Abo-Zenima) to 2796 (Nuweiba). It was found that the highest occurrence was possessed by *Meloidogyne* (44.8%) and the lowest was achieved by *Belonolaimus, Criconema* and *Xiphinema* (0.25%) in North Sinai. *Meloidogyne* also was occupying the top position in South Sinai as its repetition was 34.5%, while the least frequency (0.5%) was recorded by *Criconema* and *Pratylenchus.* Interestingly, *Meloidogyne,* which considered the most damaging genus was detected in all surveyed districts in all Sinai Peninsula governorates. The second repetition rate (7%) in North Sinai was owned by *Rotylenchulus* as it was recovered from four districts only, but it found in all districts of South Sinai with frequency of 10.3%.

The diversity indices, Shannon-Wiener's H', 1-D& 1/D (inverse of Simpson's index) were calculated based on the abundance and frequency of each nematode genus. The 1/D was used to yield larger values for more diverse communities, as well as H' beside E (Evenness). The diversity and spatial patterns of PPN vary according to many factors like; environmental and behavioral factors, plant species, cultivation intensity, monoculture of local varieties, irrigation system and soil type as previously mentioned (Baimey et al., 2009). Also, the probability of species detection is influenced by population density and spatial dispersion properties (Prot and Ferris, 1992). The present results indicated that PPN populations and diversity may increase with higher rainfall and continuous cultivation more than effect of water content and temperature on PPN increases (Govaerts et al., 2007). Earlier findings stated that abundance and population of some nematode species were associated with particular specific soil textures (Jones et al., 1969 and Bongers, 1988). It is also known that populations of some of the nematodes were markedly reduced by soil cultivation and cropping systems (Oostenbrink, 1964 and Jones et al., 1969). It was previously mentioned that soil physico-chemical properties, climate and agricultural practices have a great impact on the diversity of PPN communities. The interaction between phytoparasitic nematode communities and edaphic factors are poorly understood in most agrosystems (Ortiz et al., 2010; Duyck et al., 2012; Godefroid et al., 2013; Kavitha and Vanita Das, 2015 and Godefroid et al., 2017). Organic matter and previous crops can favor the reproduction of certain nematode species. Godefroid et al. (2017) recorded that *Pratylenchus coffeae* was more abundant in regions have a high exchangeable cation content and low organic matter content. Nematode abundances were apparently affected by the previous crops e.g., *Radopholus similis* was particularly abundant in fields where banana or plantain were the previous crops; and *Meloidogyne* were abundant in fields where a market garden was the previous crop. Kumar et al. (2017) observed that sandy loam type favor reproduction of RKN. In contrary, Baimey et al. (2009) found a weak relationship between soil physico-chemical properties and nematode population density.

However, cultivation on Sinai Peninsula, especially in the South Sinai depends on water free of nematodes (rain and wells), *vice versa*; in El-Salam canal, in the north, which feeds El-Tiena plain by irrigated water, helps to distribute nematodes from a place to another and encourage the farmers to cultivate the soil many times yearly. Recent investigations found significant possibilities for increased nematode diversity and greater prevalence of both *Meloidogyne* and *Pratylenchus* with increasing rainfall. Also, climate change, especially temperature. These findings suggest that significant changes in nematode populations were linked to changing climate, cropping systems and agriculture practices (Fleming et al., 2016 and Hamza et al., 2018).

So, these results are beneficial for future planning for managing PPN in Sinai and protect new targeted plantations from plant parasitic nematodes, in particular root knot nematode (RKN) *Meloidogyne* as its hot spots were determined in vegetable cultivation in Sinai Peninsula (Fig. 1). These finding are in harmony with previous finding (Gautam et al., 2014; Korayem et al., 2014; Singh and Khanna, 2015; Myint et al., 2017 and Rani, 2017). In these areas showing severe infestation, especially for the most dangerous nematode (*Meloidogyne*), root-lesion nematode (*Pratylenchus*) and for ectoparasitic genera, which considered a viral vectors (*Trichodorus* and *Xiphinema*), it is advisable to adapt strict integrated disease management strategies for controlling these nematodes. In view of damage potential of these hidden enemies of plants, an urgent need is felt for commencing coordinated efforts at national and regional level pertaining to distribution and dissemination of plant parasitic nematodes, estimating of crop losses and for developing nematode management strategies. Observations and results obtained from this survey clarify that host plants vary in their susceptibility to PPN infection, so cropping sequence may play an important role in phytonematodes management and reducing nematicides use.

CONCLUSION

The present study represents the first survey in South Sinai and one of the few surveys carried out in North Sinai. It was found that 13 plant parasitic nematode (PPN) genera variably distributed in different surveyed localities of vegetable cultivations in Sinai Peninsula. The most predominant genus was the *Meloidogyne*, which was found in all locations under this extensive survey, the frequency of this nematode was varied from district to other. The diversity of nematode fauna was found to be affected by many factors including; plant host, cultivation intensity, soil type, irrigation system and. Current and future studies should put the objective of mapping out of plant parasitic nematodes incidence and impact of cropping sequence in survival, diversity and dynamics of PPN. Finally, any development program on susceptible vegetable plants in these infested areas should include control measures against these nematodes, so this study can be useful for the design of phytoparasitic control programs in vegetable fields.

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REFERENCES

Adamou, H., B. Adamou, H.A. Oumarou, S. Ramatou, D. Seyni and E. Toudou (2013a). Characterization of plant-parasitic nematode communities associated with tomato, eggplant and pepper in the suburban area of Niamey (Niger). Int. J. Agri. Crop. Sci., 5 (20): 2488-2494.

Adamou, H., S. Etienne and D. Ramatou (2013b). Biodiversity of plant-parasitic nematodes associated with pepper in the regions of Diffa and Dosso (Niger republic). Int. J. Farm. Alli. Sci., 2 (15): 482-487.

Anderson, R.V. and R.H. Mulvey (1979). Plant-parasitic nematodes in Canada Part 1. An illustrated key to the genera. Biosystematics Research Institute, Ottawa, Ontario, Monograph/Research Branch, Agriculture, Canada No. 20.

Anwar, A.S., M.M. Mahdi, M.V. McKenry and A. Qadir (2013). Survey of plant-parasitic nematodes associated with four vegetable crops cultivated within tunnels. Pak. J. Zool., 45 (3): 595-603.

Anwar, A.S., M.V. McKenry and N. Javad (2006). The root-knot nematodes: destructive M.C. pests of crops. Proc. Int. Symp. Sust. Crop Impro. Integ. Manag. Organized by Fac. Agric., Univ. Agric., Faisalabad, Pakistan, September 14-16, p. 216-222.

Anwar, A.S. and M.V. McKenry (2012). Incidence and population density of plant-parasitic nematodes infecting vegetable crops and associated yield losses in Punjab, Pakistan. Pak. J. Zool., 44 (2): 327-333.

Ashoub, A.H. (2010). Community analysis of plant parasitic nematode in North Sinai. Egypt. J. Agronematol., 9 (2): 91-102.

Bafokuzara, D.N. (1996). Incidence of different nematodes on vegetable and fruit crops and preliminary assessment of yield loss due to *Meloidogyne* species in Uganda. Nematol. Bras., 20 (1): 32-44.

Baimey, H., D. Coyneb, G. Dagbenonbakinc and B. Jamesa (2009). Plant-parasitic nematodes associated with vegetable crops in Benin: Relationship with soil physio-chemical prosperities. Nematol. Medit., 37: 227-236.

Becker, J.O. (2014). Plant Health Management: Crop Protection with Nematicides. In: 'Encyclopedia of Agriculture and Food Systems'. Elsevier, London, p. 400-407.

Bongers, T. (1988). In "De Nematoden van Nederland". Natuurhistorische Bibliotheek KNNV. Nr. 46. Pirola, Schoorl The Netherlands.

Boyle, T.P., G.M. Smillie, J.C. Anderson and D.R. Beeson (1990). A sensitivity analysis of nine diversity and seven similarity indexes. Res. J. Water Poll. Control, 62: 749-762.

Chaudhary, K.K., D. Brhane, H. Okube, T. Zaid and E. Dagnew (2011). Distribution, frequency of occurrence and population density of root knot nematode in Hamelmalo – Eritrea, Afr. J. Microbiol. Res., 5 (31): 5656-5661.

Cobb, N.A. (1918). Estimating the nematode population of the soil. [Washington]: United States Department of Agriculture, 1918. 48 pp. (Agricultural Technical Circular, 1).

Duyck, P.F., E. Dortel, P. Tixier, F. Vinatier, P.M. Loubana, C. Chabrier and P. Quénéhervé (2012). Niche partitioning based on soil type and climate at the landscape scale in a community of plant-feeding nematodes. Soil Biol. Biochem., 44: 49-55.

Fleming, T.R., N.E. McGowan, A.G. Maule and C.C. Fleming (2016). Prevalence and diversity of plant parasitic nematodes in Northern Ireland grassland and cereals, and the influence of soils and rainfall. Plant Pathol., 65: 1539-1550.

Gautam, S.K., G. Sahu, B.K. Verma and A.N. Poddar (2014). Status of root-knot nematode (*Meloidogyne* species) disease in vegetable crops of some districts of central plain region of Chhattisgarh state. India. Afr. J. Microbiol. Res., 8 (16): 1663-1671.

Godefroid, M., L. Delaville, S. Marie-Luce and P. Quénéhervé (2013). Spatial stability of a plant-feeding nematode community in relation to macro-scale soil properties. Soil Biol. Biochem., 57: 173 -181.

Godefroid, M., P. Tixierb, C. Chabrierb, D. Djigal and P. Quénéhervé (2017). Associations of soil type and previous crop with plant-feeding nematode communities in plantain agrosystems. Appl. Soil Ecol., 113: 63-70.

Goodey, J.B. (1963). In: 'Soil and Fresh-Water Nematodes'. New York: John Wiley and Sons.

Govaerts, B., M. Fuentes and M. Mezzalama (2007). Infiltration, soil moisture, root rot and nematode populations after 12 years of different tillage, residue and crop rotation managements. Soil and Tillage Research, 94: 209-19

Hamza, M.A., A. Moukhli, Z. Ferji, O. Fossati-Gaschignard, J. Tavoillot, N. Ali, H. Boubaker, A. El Mousadik and T. Mateille (2018). Diversity of plant-parasitic nematode communities associated with olive nurseries in Morocco: Origin and environmental impacts. Appl. Soil Ecol., 124: 7-16.

Ibrahim, I.K.A. (1994). Potentially important phytoparasitic nematodes in agroforesty plantations and the associated host plants. Proc. of the 2nd Afro-Asian Nematol. Symp., Menoufia, Egypt.

Ibrahim, I.K.A. and T.A. El-Sharkawy (2001). Genera and species of phytoparasitic nematodes and the associated host plants in Egypt. Adv. Agric. Res. Egypt, 3 (1): 75-95.

Ibrahim, I.K.A., Z.A. Handoo and A.A. El-Sherbiny (2000). A survey of phytoparasitic nematodes on cultivated and non-cultivated plants in Northwestern Egypt. J. Nematol., 32 (4S): 478-485.

Ibrahim, I.K.A., A.A. Mokbel and Z.A. Handoo (2010). Current status of phytoparasitic nematodes and their host plants in Egypt. Nematropica, 40 (2): 239-262.

Jones, F.G.W., D.W. Larbey and D.M. Parrott (1969). The influence of soil structure and moisture on nematodes, especially *Xiphinema*, *Longidorus*, *Trichodorus*, and *Heterodera* spp. Soil Biol. Biochem., l: 153-165.

Kaskavalci, G. (2007). Effect of soil solarization and organic amendment treatment for controlling *Meloidogyne incognita* in tomato cultivars in Western Anatolia. Turk. J. Agric. For., 31: 159-167.

Kavitha, B. and V. Vanita Das (2015). Characterization of plant-parasitic nematode communities associated with brinjal crops in the Nagole Area of Rangareddy District, Hyderabad, Telangana, India (2011&2012). Int. J. Eng. Sci. Res., 5: 2297-2293.

Korayem, A.M. and M.M.M. Mohamed (2010). High yielding hybrid maize cultivar tolerant to *Pratylenchus zeae* in Egypt. Pak. J. Nematol. 28 (1): 109-114.

Korayem., A.M., M.M.A. Youssef, M.M.M. Mohamed and A.M.S. Lashein (2014). A survey of plant parasitic nematodes associated with different plants in North Sinai. Middle East J. Agric. Res., 3 (3): 522-529.

Kumar, S., C.B. Yadav and A.A. Tiwari (2017). Survey of root-knot nematodes associated with tomato crops in Fatehabad, Agra. Indian Res. J. Gene. Biotechnol., 9 (1): 73-77.

Kvalseth, T.O. (1991). Note on biological diversity, evenness, and homogeneity. Oikos, 62 (1): 123-127.

Mai, W.F. and H.H. Lyon (1975). In: 'Pictorial Key to Genera of Plant-Parasitic Nematodes'. Cornell University Press, Ithaca and London, NY, No. 4th revised, 219 pp.

Mekete, T., A. Dababat, N. Sekora, F. Akyazi and E. Abebe (2012). Identification key for agriculturally important plant-parasitic nematodes. Prepared for the International Nematode Diagnosis and Identification Course 2012 - A manual for nematology. Mexico, D.F.: CIMMYT.

Mokbel, A.A, I.K.A. Ibrahim, M.A.M. El-Saedy and S.E. Hammad (2006). Plant parasitic nematodes associated with some fruit trees and vegetable crops in northern Egypt. Egypt. J. Phytopathol., 34: 43-51.

Myint, N.N., Y.Y. Aye, Y.Y. Aung and S. Bawm (2017). Detection of plant parasitic nematodes in the soil of crop field in Meiktila area, Myanmar. J. Agric. Sci.,1: 258-263.

Norton, D.C. (1978). In: 'Ecology of Plant Parasitic Nematodes'. John Wiley and Sons, New York, 268 pp.

Oostenbrink, M. (1964). Harmonious control of nematode infestation. Nematologica, 10: 49-56.

Ortiz, B.V., C. Perry, P. Goovaerts, G. Vellidis and D. Sullivan (2010). Geostatistical modeling of the spatial variability and risk areas of southern root-knot nematodes in relation to soil properties. Geoderma, 156: 243-252.

Oteifa, B.A., M.M. Shams Eldean and M.H. El Hamawy (1997). A preliminary compiled study on the biodiversity of free-living, plant- and insect-parasitic nematodes in Egypt. Egypt. J. Agronematol., 1: 1-36.

Peet, R.K. (1974). The measurement of species diversity. Annu. Rev. Ecol. Syst., 5: 285-307.

Pielou, E.C. (1975). In: "Ecological Diversity". Wiley, New York, 165 p.

Prot, J.C. and H. Ferris (1992). Sampling approaches for extensive surveys in nematology. J. Nematol., 24 (S): 757-764.

Rani, V.P. (2017). Identification of root-knot nematodes in the selected agro ecosystems of Telangana state. Int. J. Zool. Res., 7: 1-6.

Sasser, J.N. (1979). Economic importance of *Meloidogyne* in tropical countries. In: Lamberti F. and C.E. Taylor (eds). 'Root-knot Nematodes (*Meloidogyne.* Species): Systematics, Biology and Control'. Academic Press, London, p. 359-374.

Sawadogo, A., B. Thio, S. Kiemde, I. Drabo, C. Dabire, J. Ouedraogo, T.R. Mullens, J.D. Ehlersand and P.A. Roberts (2009). Distribution and prevalence of parasitic nematodes of cowpea (*Vigna unguiculata*) in Burkina Faso. J. Nematol., 41: 120-127.

Shakeel, Q., N. Javed, Y. Iftikhar, I.U. Haq, S.A. Khan and Z. Ullah (2012). Association of plant parasitic nematode with four vegetable crops. Pak. J. Phytopathol., 24 (2): 143-148.

Shannon, C.E. and W. Wiener (1949). In: 'The Mathematical Theory of Communication'. University of Illinois Press, Urbana. 117 pp.

Siddiqi, M.R. (2000). In: 'Tylenchida Parasites of Plants and Insects'. Second Ed. CAB International, Wallingford, UK, 848 pp.

Sikora, R.A and E. Fernandez (2005). Nematode parasites of vegetables. In: Luc et al. (eds.). 'Plant Parasitic Nematodes in Subtropical and Tropical Agriculture'. 2nd edition, CAB International, Wallingford, UK, p. 319-392.

Simpson, E. (1949). Measurements of diversity. Nature, 163: 688.

Singh, P. and A. Khanna (2015). Incidence of phytoparasitic nematodes in vegetable crops grown under protected cultivation in Himachal Pradesh. Int. J. Sci. Environ. Technol., 4 (6): 1640-1646.

Tariq-Khan, M., A. Munir, T. Mukhtar, J. Hallmann and H. Heuer (2017). Distribution of root-knot nematode species and their virulence on vegetables in northern temperate agro-ecosystems of the Pakistani-administered territories of Azad Jammu and Kashmir. J. Plant Dis. Prot., 124 (3): 201-212.

Tarjan, A.C. (1973). A synopsis of the genera and species in the Tylenchorhynchinae (Tylenchoidea, Nematoda). Proc. Helminthol. Soc. Wash., 40: 123-144.

Vindhyarani, P. (2017). Species diversity of phytophagous nematodes in selected agroecosystems of Telangana State. Int. J. Zool. Stud., 2: 1-4.

Yeates, G.W. and T. Bongers (1999). Nematode diversity in agroecosystems. Agriculture, Ecosystems and Environment, 74: 113-135.

تنوع النيماتودا المتطفلة نباتيًا المرافقة لبعض الخضر في شبه جزيرة سيناء، مصر

أحمد سليمان محمد محمد النوبي[1]*، السيد عبد العزيز منتصر[2] وإسماعيل عبد الله الخضراوي[1]
[1]قسم وقاية النبات، مركز بحوث الصحراء، القاهرة
[2]قسم الحيوان الزراعي والنيماتودا، كلية الزراعة، جامعة الأزهر

تم إجراء مسح للنيماتودا المتطفلة نباتيًا في زراعات الخضر في شبه جزيرة سيناء، حيث جمعت ٦٠٧ عينة تربة وجذور من ريزوسفير نباتات الخضر المتاحة في موسم النمو خلال عامي ٢٠١٦-٢٠١٧ في كلا المحافظتين: شمال سيناء (أجريت فيها مسوحات محدودة فى دراسة سابقة) و جنوب سيناء (أول مسح يجري فيها). تم تسجيل ١٣ جنس تابع لتسع عائلات تقع تحت ثلاث رتب (orders) تقسيمية هي: Triplonchida ،Dorylaimida ،Tylenchida، وجد أن ثلاثة أجناس فقط (*Meloidogyne*, *Rotylenchulus*, *Tylenchorhynchus*) تتبع لرتبة Tylenchida كانوا أكثر كثافة حيث كانت كثافتهم العددية عالية (١٨٨٩١، ٣٥٢٨ و٣٣١٦، على التوالي) في شبه جزيرة سيناء عمومًا. وجد أن نيماتودا تعقد الجذور من جنس *Meloidogyne* كان أكثر الأنواع كثافة وسيادة في كل المراكز الممسوحة في سيناء. أيضًا أظهرت النتائج أن محافظة شمال سيناء كانت أكثر تنوعًا من جنوب سيناء، حيث إحتوت على ثلاثة رتب وثمانية عائلات وثلاثة عشر جنسًا (*Belonolaimus, Criconema, Criconemoides, Helicotylenchus Hoplolaimus, Meloidogyne*, *Pratylenchus, Rotylenchulus, Tetylenchus, Trichodorus, Tylenchorhynchus, Tylenchus*and*xiphinema*) مقابل ٢ رتبة و٥ عائلات و٦ أجناس في جنوب سيناء *Criconema, Meloidogyne*, *Pratylenchus, Rotylenchulus,*) *Trichodorus*and*Tylenchorhynchus*). التنوع الحيوي وصل إلى قمته في مركز رفح في شمال سيناء، أما في الجنوب فكان مركز رأس سدر الأكثر تنوعًا. بمراجعة المسوحات السابقة في شبه جزيرة سيناء لتسجيل النيماتودا المتطفلة نباتيًا، فقد وجد أن الأجناس الست المعزولة من جنوب سيناء تعتبر أول تسجيل كون أن هذا المسح النيماتودي يعتبر الأول من نوعه في تلك المحافظة. أيضًا هذه الدراسة سوف تلفت إنتباه المزارعين للعمل على مكافحة التلوث بالنيماتودا.