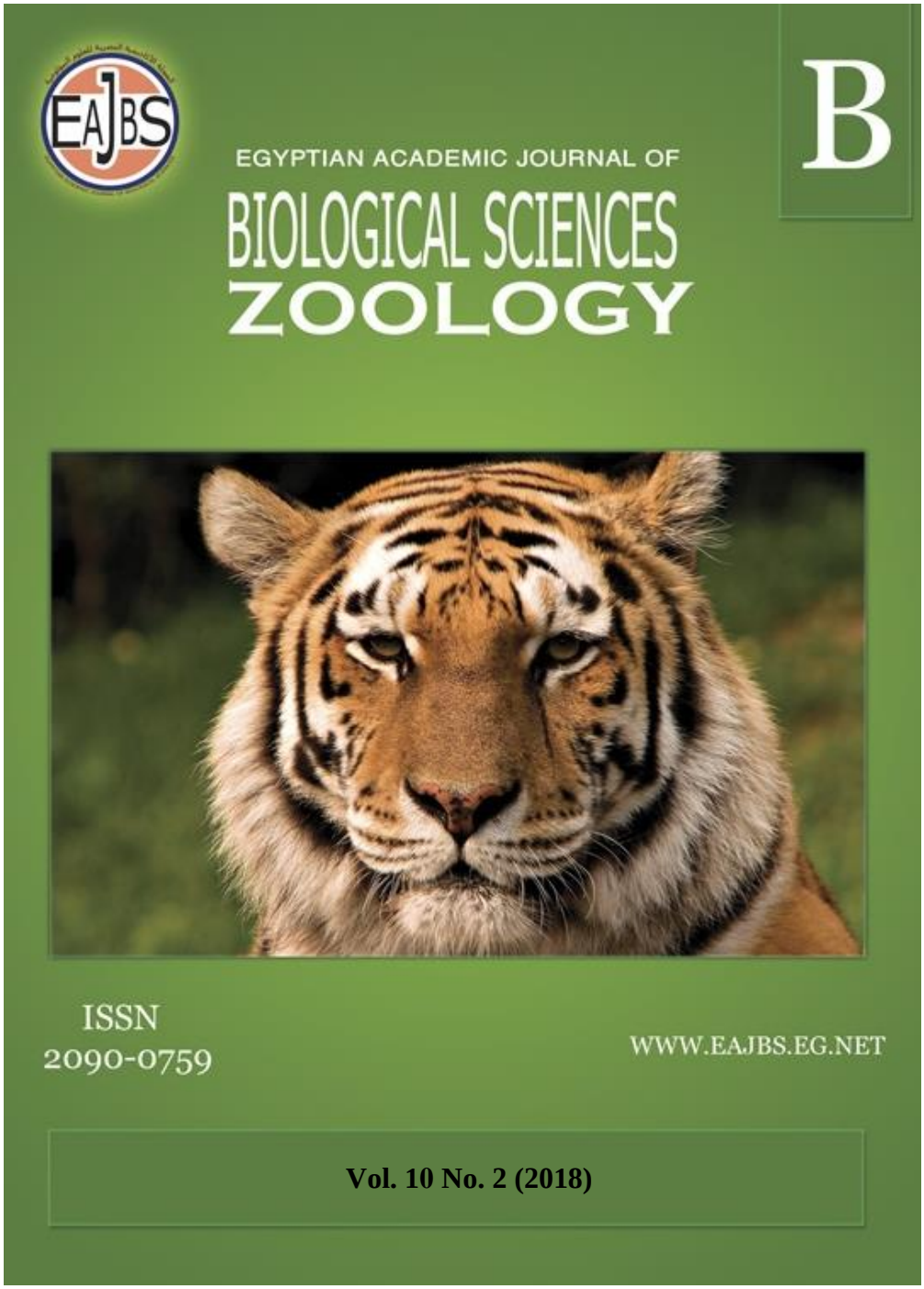

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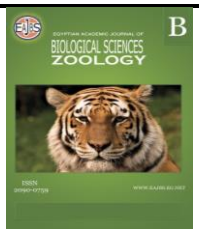

Abundance and Distribution of Plant Parasitic Nematodes Associated With Some Different Plant Hosts

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ABSTRACT

Our survey conducted to study the distribution and abundance of plant parasitic nematodes associated with different vegetation in Shoubra El-Kheima. Nematode infection had not been surveyed before in this area. The data showed the presence of ten plant parasitic nematode genera, which were: *Meloidogyne* sp., *Helicotylenchus* sp., *Criconema* sp., *Pratylenchus* sp., *Rotylenchulus*, *Tylenchorhynchus* sp., *Tylenchulus*, *Paratylenchus* sp., *Tylenchus* sp., and *Xiphinema* sp. Nematodes were extracted by using modified burmman funnel and identified using identification keys. Results showed that *Meloidogyne* was the most common plant parasitic nematode. Data demonstrated that, 10 genera of plant parasitic nematodes were recorded to be associated with the examined crops. The highest and lowest frequency of occurrence (FO %) of nematodes in vegetable hosts were represented by *Meloidogyne* and *Paratylenchus* (26.0% and 10.5% respectively). While, the genera *Criconemella*, *Xiphinema*, and *Tylenchulus* didn't record in the examined vegetable plants. On the other hand, data of fruits recorded that: Highest and lowest Fo% of nematodes were *Meloidogyne* and *Criconemella* (53.3% and 7.8% respectively). Ornamentals showed that, highest FO% was *Meloidogyne* (27.0) and lowest was *Tylenchus* and *Tylenchorhynchus* equally (1.7). Conclusion: *Meloidogyne*, and *Pratylenchus* were the widest genera in distribution. Moreover, tomato, grapes, and *Ficus carica* were highly susceptible.

INTRODUCTION

Plant parasitic nematodes consider as one of the essential biotic constriction in world agriculture causing economic losses which estimated to be about $70 billion in1987 which equal around 12%/ year (Sasser and Freckman, 1987), reaching up to 20% in some plant crops (Koenning *et. al.*, 1999).While it was about US$125 billion in 2003 (Chitwood, 2003). Certainly, the current losses may be more than this. In Egypt, plant-parasitic nematodes have been recorded as important plant pests since 1901. Many studies in Egypt reported the presence of large numbers of genera of plant-parasitic nematodes associated with many crops, grasses and weeds in different localities, (Abou-Elnaga, 1989; Ibrahim and El- Sharkawy, 2001; Ibrahim *et al.*, 2000; Oteifa *et al.*, 1997) Such as, *Meloidogyne* sp., *Rotylenchulus* reniformis, *Pratylenchus* sp., and *Tylenchulus semipenetrans*, which are considered as constricting factors to

their plant hosts production (Korayem and Mohamed, 2010). The practice of using local plant cultivars and continuous cropping cause survival and rapid build-up of nematode populations in the soil (Abou- Elnaga *et al.*, 1985; Ibrahim, 1990; Ibrahim *et al.*, 1988; Oteifa 1987). Plant parasitic nematodes in Egypt, such as root-knot (*Meloidogyne*), citrus (*Tylenchulus*), dagger (*Xiphinema*), cyst (*Heterodera*), lesion (*Pratylenchus*), ring (*Criconema*), stunt (*Tylenchorhynchus*) and spiral (*Helicotylenchus*) (Ibrahim, 2011). Nmatodes when occuring in large numbers may cause economic damage to several plant crops (Ibrahim and El-Sharkawy, 2001; Oteifa, 1964; Oteifa *et al.*, 1997; Abou-Elnaga, 1989; Ibrahim, 1990).

This work represents an important approach to study the abundance, and distribution of plant-parasitic nematode genera, and their hosts in Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Egypt, which considered as an important area, it represents a research destination for many different disciplines, where research is conducted for undergraduate students, graduate studies and researches in various disciplines. Therefore, it was important to conduct this research study.

Moreover, to complement a list of associated nematode plant hosts from previously published research in Egypt especially that the nematode infection had not been surveyed before in the Faculty of Agriculture Ain Shams University. Our survey should help in determining if the plant-parasitic nematodes are involved in some of the plant disease problems in the faculty or no. Moreover, the results will help when planning effective management strategies in the faculty area.

MATERIALS AND METHODS

A total of 504 rhizosphere soil and root samples were collected from the selected area in three groups as follows: first group represents vegetable plants included: tomato, *Solanum lycopersicum* (30 samples); Cauliflower *Brassica oleracea* var. botrytis (20 samples); eggplant, *Solanum melongena* (26 samples); sweet pepper, *Capsicum annuum* (30 samples); common bean, *Phaseolus vulgaris* (26 samples); squash, *Cucurbita pepo* (20 samples); Lettuce *Lactuca sativa*(18 samples) *;* Strawberry *Fragaria ananassa*(20 samples)*;* Jew's mallow *Corchorus olitorius*(24 samples). The second group represents fruit plants included: Grapes *Vitis spp.* (30 samples)*;* Banana *Musa sp.* (30 samples); Apples *Malus domestica* (20 samples)*;* Peach *Prunus vulgaris* (30 samples); Lemon *Citrus limon* (20 samples)*;* Fig *Ficus carica* (20 samples). The third group represents ornamental plants included: Rose *Rosa* (30 samples); *Arabica* Jasmine *Jasminum grandiflorum* (20 samples); Bird of paradise *Strelitzia reginae* (20 samples); Acacia *Acacia sp.* (20 samples); Fig *Ficus decora* (30 samples); Pink Cassia *Cassia nodosa* (20 samples).

Collection of Samples:

Samples were collected as described by Coyne *et al.* (2007), samples were randomly collected at the depth of 20-30 cm at each site. Soil was collected from where the fibrous roots emerged from the main roots and close enough to the trunk to ensure identification of the roots with a specific tree. Samples were put in plastic bags and transferred to the laboratory for the nematode extraction at Agricultural Zoology Lab., Fac. of Agric., Ain Shams Univ. 250 cm^3 of each soil sample was taken for nematode extraction using the modified burmman funnel method (Ayoub, 1980). The root samples were washed with tap water to remove soil particles. Roots were cut into smaller pieces and examined. The roots were washed and placed in the mist chamber to extract the nematodes.

Nematode Identification:

Plant-parasitic nematode genera were identified at the generic level (Mai *et al.*, 1964; and Bongers, 1988) based on the morphological characters of adult forms as described by Goodey and Goodey (1963), Mai and Lyon (1975), and Taylor and Sasser, (1978) and counted using counting slide under a compound microscope.

Nematode Estimation:

Communities of the detected nematodes were analyzed using; frequency of occurrence (FO) (No. of samples containing a given genus/no. of whole samples collected X100), relative abundance (RA), and population density (PD) were calculated and recorded for all genera *Mean density soil*: [(total number 250cm^3 soil)/number of fields positive for genus) (Norton, 1978).

RESULTS AND DISCUSSION

Two hundred fifty soil samples were collected from the rhizosphere of different plants, through the growing season of 2018; plant species were selected to examine because they were common to the area (Table 1).

Table 1: the examined host plants of Faculty of Agriculture Ain Shams University:

Type of host plant	Common name of Hosts	Scientific names	Families
Vegetables	Tomato	*Lycopersicon esculentum*	Solanaceae
	Sweet pepper	*Capsicum annuuum*	Solanaceae
	Eggplant	*Solanum melongena*	Solanaceae
	Cauliflower	*Brassica oleracea* var. *botrytis*	Cruciferae
	common bean	*Phaseolus vulgaris*	Leguminosae
	Squash	*Cucurbita pepo*	Cucurbitaceae
	Lettuce	*Lactuca sativa*	Compositae
	Jew's mallow	*Corchorus olitorius*	Tiliaceae
	Strawberry	*Fragaria ananassa*	Rosaceae
Fruits	Grapes	*Vitis spp.*	Vitaceae
	Banana	*Musa sp.*	Musaceae
	Apples	*Malus domestica*	Rosaceae
	Peach	*Prunus vulgaris*	Rosaceae
	Lemon	*Citrus limon*	Rutaceae
	Fig	*Ficus carica*	Moraceae
Ornamentals	Rose	*Rosa arabica*	Rosaceae
	Jasmine	*Jasminum grandiflorum*	Rosaceae
	Bird of paradise	*Strelitzia reginae*	Strelitziaceae
	Acacia	*Acacia sp.*	Fabaceae
	Fig	*Ficus decora*	Moraceae
	Pink Cassia	*Cassia nodosa*	Leguminosae

The microscopic examination of soil and root samples collected from Faculty of Agriculture clarified the presence of 10 genera of plant-parasitic nematodes belonging to eight families, (Species identification was not possible in several samples from the locality because of the limited number of adult specimens and the presence of mostly juveniles). These nematode genera were: ring (*Criconemella* sp.), root-knot (*Meloidogyne* spp.), lesion (*Pratylenchus penetranse*), reniform (*Rotylenchulus reniformes*), stunt (*Tylenchoryhnchus* sp.), dagger (*Xiphinema* sp.*)*, (*Tylenchus* sp.), citrus (*Tylenchulus semipenetranse*), spiral (*Helicotylenchus* sp.), and pin (*Paratylenchus* sp.) nematodes (Table 2).

Data in table (2) indicated that: *Meloidogyne*, was found in all vegetations studied, while *Pratylenchus, Helicotylenchus, and Tylenchorhynchus,* were widespread genera in the most of the examined samples, on the other hand, *Rotylenchulus, Tylenchus*, and *Paratylenchus* showed modest distributions. Meantime, *Xiphinema, Criconemella and, Tylenchulus* are rare inhabitants of the area.

Table 2: Species of plant-parasitic nematodes, which reported in Faculty of Agriculture Ain Shams University and their associated host plants:

Nematode Genera	Families	Hosts
Meloidogyne	Meloidogynidae	*Lycopersicon esculentum, Capsicum annuuum, Solanum melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris, Cucurbita pepo, Lactuca sativa, Corchorus olitorius, Fragaria ananassa, Vitis spp., Musa sp., Malus domestica, Prunus vulgaris, Citrus limon , Ficus carica, Rosa Arabica, Jasminum grandiflorum, Strelitzia reginae, Acacia sp., Ficus decora, and Cassia nodosa*
Pratylenchus	Pratylenchidae	*Lycopersicon esculentum, Capsicum annuuum, Solanum melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris, Cucurbita pepo, Lactuca sativa, Corchorus olitorius, Fragaria ananassa, Vitis spp., Musa sp., Malus domestica, Prunus vulgaris, Rosa Arabica, Acacia sp., Ficus decora, and Cassia nodosa*
Helicotylenchus	Hoplolaimidae	*Lycopersicon esculentum, melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris Cucurbita pepo, Vitis spp., Musa sp., Malus domestica, Prunus vulgaris, Citrus limon , Rosa Arabica, Jasminum grandiflorum, Strelitzia reginae, Acacia sp., Ficus decora, and Cassia nodosa*
Tylenchoryhnchus	Tylenchorhynchidae	*Lycopersicon esculentum, Capsicum annuuum, Solanum melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris, Cucurbita pepo, Lactuca sativa, Corchorus olitorius, Fragaria ananassa, Vitis spp., Musa sp., Prunus vulgaris, Citrus limon , and Acacia sp.*
Rotylenchulus	Hoplolaimidae	*Lycopersicon esculentum, Solanum melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris, Cucurbita pepo, Lactuca sativa, Corchorus olitorius, Vitis spp., Prunus vulgaris, Citrus limon , Ficus carica, Strelitzia reginae, Acacia sp., Ficus decora, and Cassia nodosa*
Tylenchus	Tylenchidae	*Lycopersicon esculentum, Capsicum annuuum, Solanum melongena, Brassica oleracea var. botrytis, Phaseolus vulgaris, Cucurbita pepo, Lactuca sativa, Corchorus olitorius, Fragaria ananassa, Vitis spp., Musa sp., Malus domestica, Prunus vulgaris, Citrus limon , and Cassia nodosa*
Paratylenchus	Tylenchulidae	*Lactuca sativa, Fragaria ananassa, Vitis spp., Malus domestica, Prunus vulgaris, Citrus limon, Jasminum grandiflorum, Strelitzia reginae, and Ficus decora,*
Xiphinema	Longidoridae	*Vitis spp., Malus domestica, Prunus vulgaris, Ficus carica, Rosa Arabica, Ficus decora, and Cassia nodosa*
Criconemella	Criconematidae	*Malus domestica, Prunus vulgaris, Rosa Arabica, Acacia sp., and Ficus decora.*
Tylenchulus	Tylenchulidae	*Vitis spp., Citrus limon, and Ficus decora.*

The recorded data of plant parasitic nematode genera associated with the examined plants seems to be varied according to the type of the plants (vegetable, fruit, and ornamental plants) as follow: in the examined vegetable host plants (Table 3), the highest and the lowest frequency of occurrence (FO%) of the nematode, represented by *root knot nematodes, Meloidogyne* and *Paratylenchus* (FO =26.0% and10.5% respectively), while, The mean population density (PD) ranged from 8.0 to 76.3 individuals/ 250 cm3 soil, *Tylenchorhynchus* had the highest mean population density (PD = 76.3/250 cm3 soil), *Paratylenchus* recorded the lowest population density (8.0/250 cm3 soil). The highest and the lowest relative abundance (RA) in vegetables also recorded by *Meloidogyne* and *Paratylenchus* (RA = 27.0 and 3.8 respectively). On

the other hand, the genera *Criconemella*, *Xiphinema*, and *Tylenchulus* didn't record in the examined vegetable host plants.

Table 3: Frequency of occurrence (FO), relative abundance (RA), and population density (PD) of plant-parasitic nematodes associated with vegetable hosts in Faculty of Agriculture Ain Shams University, Qalyubia Governorate, Egypt.

	Fo %	Ra	Pd
Meloidogyne	34.2	27.0	56.8
Pratylenchus	30.0	13.9	45.0
Rotylenchulus	17.5	16.2	62.2
Tylenchus	14.5	13.7	62.6
Tylenchorhynchus	26.0	19.9	76.3
Helicotylenchus	18.1	23.8	71.3
Paratylenchus	10.5	3.8	8.0
Criconema	0.0	0.0	0.0
Xiphinema	0.0	0.0	0.0
Tylenchulus	0.0	0.0	0.0

FO% = Number of samples containing a genus/number of total samples
RA = total number of individuals of a particular genus per 250g soil and root sample in all samples/number of samples, including those with zero counts for that genus.
PD = mean number of individuals of a particular genus/number of positive samples

Figure (1) showed that, cauliflower and tomato were highly susceptible to nematode infection that the recorded data for total FO%, total RA, and total PD were: 160,176.7, and 756.1 on cauliflower and 226.3, 214.5, and 569 respectively on the tomato plant. While sweet pepper was less susceptible to nematode infection (96.5, 45.0, 186.3 respectively).

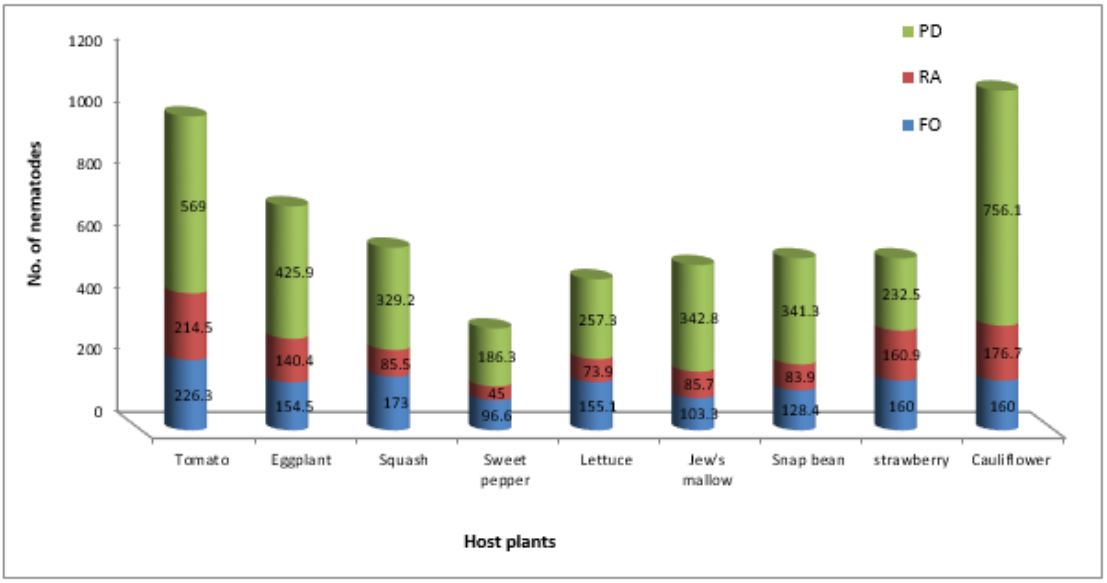

Fig. 1: Frequency of occurrence (FO), population density (PD), and Relative abundance (RA), of plant-parasitic nematode genera found in soil samples collected from Vegetable plants in Faculty of Agriculture Ain Shams University.

Table (4) Data of fruits recorded in table (4) and showed that: The highest and lowest Fo% of nematodes, recorded by *Meloidogyne* and *Criconemella* (Fo = 53.3% and 7.8% respectively). *Rotylenchulus reniformis* had the highest PD, (PD = 98.6/250 cm3 soil), while, *Criconemella* showed the lowest PD (PD =14.8/250 cm3 soil. The highest Ra in fruits recorded by *Meloidogyne* (Ra = 56.5) and the lowest was *Criconemella* (Ra = 3.3).

Table 4: Frequency of occurrence (FO), relative abundance (RA), and population density (PD) of plant-parasitic nematode genera associated with fruit hosts in Faculty of Agriculture Ain Shams Universty, Qalyubia governorate, Egypt

	Fo %	Ra	Pd
Meloidogyne	53.3	56.5	96.8
Pratylenchus	32.2	35.5	81.7
Rotylenchulus	20.0	40.0	98.6
Tylenchus	28.3	21.2	55.1
Tylenchorhynchus	21.1	19.7	62.0
Helicotylenchus	29.5	24.3	63.0
Paratylenchus	15.0	4.6	15.3
Criconema	7.8	3.3	14.8
Xiphinema	17.2	5.8	23.7
Tylenchulus	17.2	33.8	65.5

FO% = (Number of samples containing a genus/number of total samples)
RA = total number of individuals of a particular genus per 250g soil and root sample in all samples/number of samples, including those with zero counts for that genus.
PD = mean number of individuals of a particular genus/number of positive samples

Figure (2) showed that, grapes and lemon showed the highest susceptibility to nematode infection that they recorded 340.0, , and 451.7, 956.6 for total FO%, total RA, and total PD on grapes while lemon plant recorded 290.0, 381.2, and 730.7 respectively. On the other side, fig (Ficus carica) recorded the lowest susceptibility to nematode infection (130.0, 84.4, and 243 respectively).

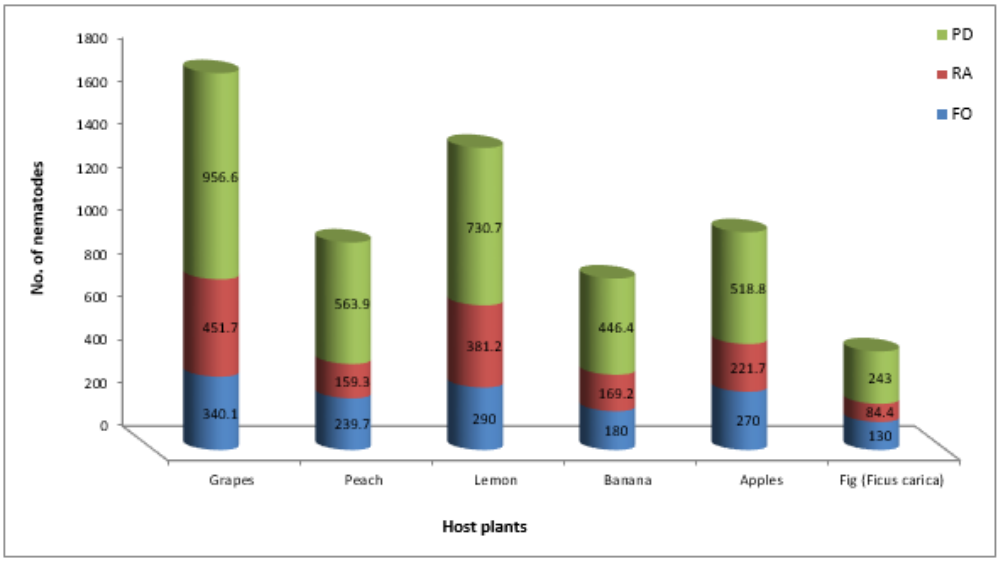

Fig. 2: Frequency of occurrence (FO), Relative abundance (RA), and population density (PD) of plant-parasitic nematode genera found in soil samples collected from fruit plants in Faculty of Agriculture Ain Shams Universty

Data in table (5) demonstrated the data of ornamental plants: The highest FO% was *Meloidogyne* (FO%= 27.0) and the lowest were *Tylenchus* and *Tylenchorhynchus* nematodes equally (Fo% =1.7). While the highest PD recorded by *Rotylenchulus reniformis* which had PD = 93.8/250 cm3 soil. *Tylenchus* showed the lowest PD (6.7/250 cm3 soil). On the other side, the highest Ra recorded by *Paratylenchus* (Ra =23.7) and the lowest was *Tylenchus* (Ra = 0.7).

Table 5: Frequency of occurrence (FO), relative abundance (RA), population density (PD) of plant-parasitic nematode genera associated with ornamental hosts in Faculty of Agriculture Ain Shams Universty, Qalyubia Governorate,Egypt

	Fo %	Ra	Pd
Meloidogyne	27.0	18.5	67.1
Pratylenchus	11.7	3.5	13.9
Rotylenchulus	12.2	12.2	93.8
Tylenchus	1.7	0.7	6.7
Tylenchorhynchus	1.7	1.3	13.3
Helicotylenchus	22.7	19.1	84.3
Paratylenchus	12.2	23.7	91.9
Criconema	12.9	4.0	18.1
Xiphinema	14.9	11.4	32.4
Tylenchulus	3.9	2.9	12.7

FO% = (Number of samples containing a genus/number of total samples)
RA = total number of individuals of a particular genus per 250g soil and root sample in all samples/number of samples, including those with zero counts for that genus.
PD = mean number of individuals of a particular genus/number of positive samples

Figure (3) showed that, fig (*Ficus decora*) was highly susceptible to nematode infection that the recorded data was 207.9,200.6, and 703.8 for total FO%, total RA, and total PD respectively. In contrast, jasmine and cacia were less susceptible to nematode infection (70.0, 59.1, and 261.7 on jasmine and 120.0, 34.9, and 187.8 on cacia respectively).

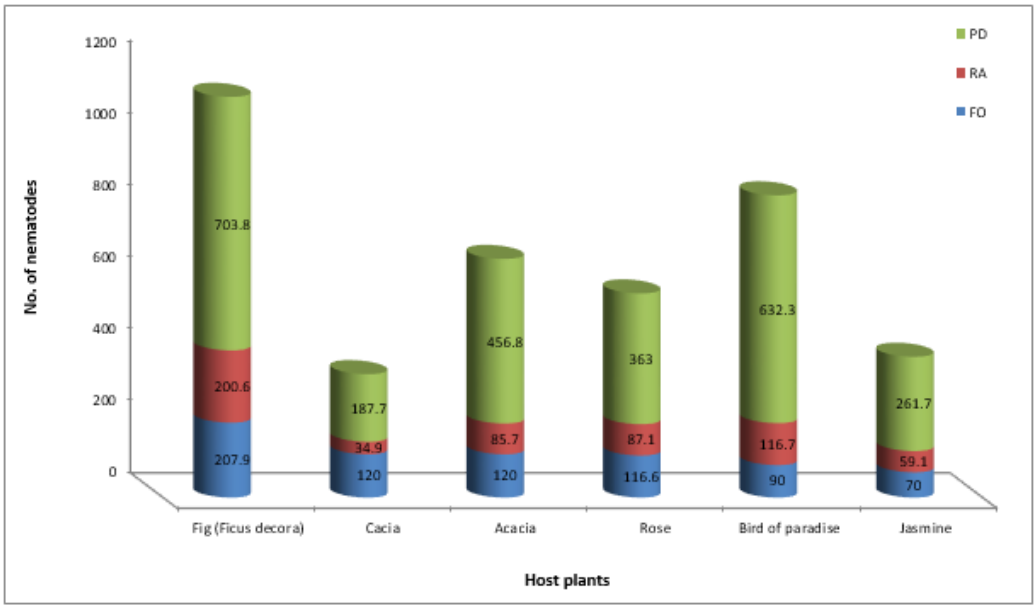

Fig. 3: Frequency of occurrence (FO), Relative abundance (RA), and population density (PD) of plant-parasitic nematode genera found in soil samples collected from ornamental plants in the Faculty of Agriculture Ain Shams Universty.

Plant species were selected because of the economic importance or because they showed some disease symptoms. Nematodes feed on cell sap of the infected plants causing damage to their hosts. Some of these nematodes cause dangerous quantity and quality losses to various plants, less information is known about the interaction between the nematodes and their hosts (Vercauteren et al., 2001; Dhandaydham,M., *et. al.,* 2008 Gheysen and Fenoll, 2002) (Lohar and Bird, 2003; Lohar et al., 2004) In Egypt, the amount of damage and economic importance has not studied enough (Ibrahim & El- Sharkawy, 2001 Gad et al., 2018, and Korayem, et. al., 2014). Root knot nematode (*Meloidogyne* sp.) represents one of the most pathogenic nematode, as it distributes in the Egyptian soils (Korayem *et al.,* 2011; Anwar and McKenry, 2012; Baimey et al., 2004; Mokbel, 2014; Abou El- Naga *et al.,* 1985; Oteifa *et al.*, 1997; Ibrahim, 1985 and Ibrahim *et al.,* 2000). Each crop species grown is susceptible to one of *Meloidogyne* species (one or more) (Sasser, 1980). The resistance to nematodes vary between host plants and seems to be either pre- or post-infection, pre-infection resistance (Bendezu and Starr, 2003 and Haynes Jones, 1976), maybe due to the lack of entry into the crop and may be due to some chemical substances in the plant which are antagonistic or toxic to the nematodes (Huang, 1985). Post-infection resistance after the nematode penetration of the plant while in some cases are associated with the hypersensitivity of the plant response in the host (Dhandaydham, M., *et. al.,* 2008). Most of studies clarified that root knot nematode causes a large shortage in yield of vegetable and field crops and the amount of damage, these damages depends on nematode population density, predominant environmental conditions and type of host plant (Youssef and Korayem, 2008; Korayem et al., 2009; (Ibrahim & El- Sharkawy, 2001; Korayem and Bondok, 2013; and Korayem et al., 2012). Many of plant-parasitic nematodes; *Meloidogyne* sp., *Pratylenchus* sp., *Rotylenchulus reniformis*, and *Tylenchulus semipenetrans* are considered limiting factors to their hosts production in Egypt (Korayem and Mohamed, 2010). Also, citrus nematode, *Tylenchulus semipenetrans* and *reniform* nematode, *Rotylenchulus reniformis* are considered economically important nematodes causing damage to their host plants (Ibrahim, 2011) .

Virus-transmitted nematode, *Xiphinema*, was found in some of the examined samples, these nematodes transmit some plant viruses causing some viral diseases to crops (Brown *et al.,* 2004) but their economic importance as vectors of plant viruses in Egypt needs more studies. Other plant-parasitic nematodes were found in the examined samples .

Differences in nematode distribution are not known clearly (Norton, 1978), in our case we can conclude that, the collected samples from this area clarified the distribution of pathogenic nematodes under the same prevalent environmental conditions there and host cover plant could be partially responsible for these differences in distribution and populations of some nematode species. In addition to that, stunt nematodes (*Tylenchorhynchus* spp.), root-lesion nematodes (*Pratylenchus* spp.), dagger nematodes (*Xiphinema* spp.) and ring nematodes (*Criconemella* spp.) are often performing with vegetable crop plants. Such as, *Tylenchorhynchus* spp. which has been detected in several countries such as India and Oman (Waller and Bridge, 1978), and Egypt (Oteifa and El-Shakawi, 1965). The lesion nematodes are important parasites infecting several plant crops which are well known to form disease complexes with many different fungi which cause root rot (Sikora and Fernández, 1990), this damage estimated as a 50% reduction in the weight of tomato roots (Netscher 1970). Ring nematodes are considered as an important factor limiting the plant growth of many vegetable crops (Sikora and Fernández, 1990).spiral nematodes,

Helicotylenchus and was identified in soil from vegetable crops. *Tylenchus* spp. is which feed on fungi mostly in the soil (Sasser, 1989).

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