

**PLANT PARASITIC NEMATODES INFESTING CITRUS
ORCHARDS IN SHARKIA GOVERNORATE,
EAST DELTA, EGYPT WITH SPECIAL
REFERENCE TO *TYLENCHULUS*
SEMIPENETRANS COBB**

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ABSTRACT: Nine genera of stylet-bearing nematodes were found infesting citrus orchards in Sharkia Governorate East Delta, Egypt. *Tylenchulus* occurred in 95.81% of the total examined samples with population density of 1619.66 nematodes/250gm soil. The identified genera varied in their frequency of occurrence and population from one county (district) to another. For instances, number of the citrus nematode *T. semipenetrans* was obviously lower in heavy clay soil of Minet El-Kamh compared to higher numbers in light sandy soil of Abou-Hammad, Belbies and Fakous. On the other hand, occurrence and population density of the identified genera infestation navel orange were compared under three irrigation systems namely. drip, sprinkler and surface irrigation systems. The citrus nematode, *T. semipenetrans* was found with high value of percent frequency of occurrence in sprinkler followed by drip and surface irrigation system. On contrary, high population density was detected in drip system, followed by sprinkler and surface irrigation systems.

Seasonal population density of *T. semipenetrans* infestation navel orange in sandy soil revealed that there were two peaks or suitable periods for development and reproduction of the nematode. The first peak was situated in February, while the second one was took place in November. The peak of November was very high as compared to that of in February. Moreover, vertical and horizontal distribution of *T. semipenetrans* infecting navel orange under drip and surface irrigation systems showed that as the soil depth increased from 0-20 to

20-40 and 40-60 cm numbers of citrus nematode were significantly decreased under the two irrigation systems. Vice versa was true in horizontal distribution , since as the distance from tree trunk increased from 0-50 to 50-100 and 100-150 cm . Numbers of citrus nematode were significantly increased under the two irrigation systems, except slight increase was noticed when distance increased to 100-150 cm in drip irrigation system.

Key words: Plant parasitic nematodes, *Tylenchulus semipenetrans*, citrus, Sharkia Governorate, survey, irrigation systems.

INTRODUCTION

Great measurements are being proceeded in land reclamation particularly in Sharkia Governorate for needs of fast growing population in Egypt. Citrus and grapes are the most widespread fruit crops in newly reclaimed sandy areas. Egyptian citrus production increased from 420.000 tons annually in 1980s to an average of 1.6 million tons in 1990s (Yossef, 2000). On the other hand, the total area cultivated with citrus in Sharkia Governorate was estimated at 63678 feddans produced 335,555 tons in 2007 (Anon, 2007).

Nematological surveys available indicated that more than 200 species of plant parasitic nematodes were found to attack the root system of citrus trees. The citrus nematode, *Tylenchulus semipenetrans* Cobb is the most important one. Yield losses due to this nematode was estimated to be

in the range of 10-13% depending on level of infestation . This species of nematode infests a large proportion that ranged from 53 to 89% of citrus growing area in Florida and about 8-12% of the total world citrus growing area (Tarjan & O'Bannon, 1984; Noling & Duncan, 1988; Duncan & Cohn, 1990 and Duncan, 1999).

In Egypt, surveys of the major citrus growing areas revealed the presense of 7-16 genera of plant parasitic nematode, including *Tylenchulus* which was detected with high frequency of occurrence and population density (Oteifa *et al.*, 1965; Anwar, 1985; Mahrous *et al.*, 1985; Abd-Elgawad, 1995; El-Deeb, 1995; Refaei *et al.*, 2001 and Korayem and Susan, 2005). Ecological studies are very important for designing successful programs against damage caused by plant parasitic nematodes. Therefore, the objectives of this paper are to estimate frequency of occurrence and population density

of plant parasitic nematodes infesting citrus orchards in one of major producing area in Sharkia Governorate under different irrigation systems. Moreover, this study is extended to investigate seasonal population behavior, vertical and horizontal distribution of *T. semipenetrans* on navel orange.

MATERIALS AND METHODS

Survey of Plant Parasitic Nematode Genera Infesting Citrus Orchards in Sharkia Governorate

An extensive survey of plant parasitic nematodes associated with citrus orchards in Sharkia Governorate was undertaken during the period from March 2005 to February 2007. A total of 310 soil and root samples were collected from different localities in the major citrus growing areas. These localities were selected in four districts viz. , Abou-Hammad (66 samples), Belbies (113), Fakous (50) and Meniet El-Kamh (81). The first three counties represent newly reclaimed sandy soil type, while the last one represents old land with heavy clay soil type. Samples were collected from navel orange, *Citrus sinensis* (119 samples); Valencia orange *C. sinensis* (69); mandarin,

C. reticulata (73) and lime, *C. aurantifolia* (49).

A handful of soil and feeder roots were collected using a shovel to a depth of about 15-25 cm from a single spot beneath the canopy of 10 trees in the sample area of about one feddan. Each sample was made of 10 subsamples which were mixed together to form composite sample of about 1 kg. From each composite sample an aliquot of 250 gm soil was processed for nematode extraction by sieving and modified Beermann funnel according to Goodey (1963). Replicated aliquots, each of 1 ml were pipetted into Hawksely counting slide . Nematode identification was based on morphology of adult and juveniles forms according to Siddiqi (1986). For each genus frequency of occurrence in percentage and population density were calculated according to Norton (1978) as follows:

% Frequency of occurrence (%FO)=

$$\frac{\text{Number of samples containing a genus}}{\text{Number of collected samples}} \times 100$$

Population density (PD) =

$$\frac{\text{Total number of individuals of a genus}}{\text{Number of samples containing this genus}} \times 100$$

Frequency of Occurrence (FO) and Population Density (PD) of Nematodes Associated with Navel Orange Orchards under Different Irrigation Systems

Soil and root samples were collected from more than 15- years old navel orange orchards under three irrigation systems. All samples were obtained from newly reclaimed sandy areas in Belbies county. Number of samples obtained from drip irrigation system were 116 samples, while those of surface irrigation and sprinkler irrigation were 91 and 22 samples, respectively, since sprinkler irrigation is used in small scale compared to drip and surface irrigations which are used in large scale. Nematodes were extracted and identified and counted as mentioned before.

Seasonal Population Dynamics of the Citrus Nematode *T. semipenetrans* Infesting Navel Orange in Sharkia Governorate

Seasonal population behavior of the citrus nematode *T. semipenetrans* was studied in more than 15-years old navel orange orchard of about one feddan located in Basateen Barakat locality, (Belbies county), during one year started from January and lasted to December

2006. The experimental orchard is characterized by sandy soil and surface irrigation system. It was divided into five plots each of about 1/5 feddan. At monthly intervals, soil samples were randomly obtained from ten trees root areas of each plot to form composite sample. All samples were taken one day after irrigation to a depth of about 15-25 cm. Nematode extraction and identification were accomplished as mentioned before. Data concerning air temperature during the period of study were obtained from Abou-Kpper Meteorological Station.

Vertical and Horizontal Distribution of *T. semipenetrans* Infesting Navel Orange Orchards under Drip and Surface Irrigation Systems

This experiment was carried out in two navel orange orchards located in Salhia locality (Fakous county) and Basateen Barakat locality (Belbies county). The first orchard is irrigated by drip system while the second one is irrigated by surface (flooding) irrigation. Samples were taken one day after irrigation during summer 2007. Five trees were randomly chosen in each orchard . Five soil subsamples were taken , using an auger, from

each tree root area at three strata namely, 0-20, 20-40 and 40-60 cm. On the other hand, samples of horizontal distribution were also taken from another five trees in each orchard. Far from the tree trunk samples were taken at horizontal distribution of 0-50, 50-100 and 100-150 cm at depth of about 15-25 cm. Five subsamples were mixed together to form composite sample. Number of *T. semipenetrans* were counted in aliquot samples of 250 gm/soil. Data were statistically analyzed using F test at 0.05% (Duncan, 1955).

RESULTS AND DISCUSSION

Survey of Plant Parasitic Nematode Genera Infesting Citrus Orchards in Sharkia Governorate

Nine genera of stylet-bearing nematodes were found in association with citrus orchards in Sharkia Governorate. These genera were *Helicotylenchus*, *Macroposthonia*, *Meloidogyne*, *Pratylenchus*, *Rotylenchulus*, *Tylenchorhynchus*, *Tylenchus*, *Tylenchulus* and *Xiphinema* (Table 1). In terms of nematode prevalence in citrus orchards, *Tylenchulus* occupied the first rank among other identified

genera as it occurred in 95.81 % of the total examined samples. Whereas, members of *Tylenchorhynchus*, *Helicotylenchus*, *Meloidogyne*, *Pratylenchus* and *Xiphinema* came in the second rank with percent frequency of occurrence reaching 44.84, 44.19, 37.42, 34.52 and 34.19%, respectively. The genera *Tylenchus*, *Rotylenchulus* and *Macroposthonia* represented the third rank with least values of percent frequency of occurrence as they were 18.06, 9.68 and 4.84 % respectively. Concerning population density of the identified genera it was evident that the highest value of 1619.66 nematodes per 250 gm/soil sample was detected with *Tylenchulus* followed descendingly by *Helicotylenchus* (138.73), *Meloidogyne* (107.72) and *Pratylenchus* (106.50). Other genera were determined with a relatively lower values of population density they ranged between 53.82 to 19.87 nematodes per 250 gm soil.

The identified genera varied in their frequency of occurrence and population density from one county to another. For instance, *Tylenchulus* was detected in all samples of Miniyet El-Kamh, while it was found in 93.9, 95.5 and 92% of samples collected from Abou-Hammed, Belbies and Fakous,

Table 1. Frequency of occurrence in percentage (FO%) and population density (PD) of plant parasitic nematodes infesting citrus orchard root system in four counties of Sharkia Governorate

Nematode genera	Abou-Hammad	Belbies	Fakous	Miniet El-Kamh	Total collected samples
<i>Helicotylenchus</i>					
FO%	18.1	61.9	32.0	48.2	44.19
PD	85.8	216.4	41.3	34.2	138.73
<i>Macroposthonia</i>					
FO%	6.1	1.7	6.0	7.4	4.84
PD	15.0	29.0	28.3	15.8	19.87
<i>Meloidogyne</i>					
FO%	31.8	36.2	30.0	48.2	37.42
PD	39.2	253.7	32.2	20.1	107.72
<i>Pratylenchus</i>					
FO%	10.6	43.3	56.0	28.4	34.52
PD	71.4	155.9	70.7	55.3	106.50
<i>Rotylenchulus</i>					
FO%	0	24.7	2.0	1.2	9.68
PD	0	39.6	20.0	20.0	38.30
<i>Tylenchorhynchus</i>					
FO%	25.8	49.5	58.0	45.7	44.84
PD	26.9	45.1	41.8	72.3	53.82
<i>Tylenchus</i>					
FO%	27.2	24.7	8.0	7.4	18.06
PD	37.0	39.1	48.7	23.3	37.45
<i>Tylenchulus</i>					
FO%	93.9	95.5	92.0	100.0	95.81
PD	4704.4	1159.5	692.9	398.4	1619.66
<i>Xiphinema</i>					
FO%	30.3	35.4	28.0	39.5	34.19
PD	38.7	32.9	21.4	13.3	26.59

respectively. On contrary, mean population density of this nematode was obviously lower in Miniet El-Kamh (398.4 nematodes per 250 gm/soil) as compared to Abou-Hammad which harbored the highest value (4707.4) followed by Belbies (1159.5) and Fakous (692.9). On the other hand mean population density of the genera *Pratylenchus*, *Helicotylenchus*, *Meloidogyne*, *Xiphinema* and *Tylenchus* was relatively lower in Miniet El-Kamh as compared to the other three counties. While the opposite was true for the genus *Tylenchorhynchus*, since it was found with 72.3 nematodes per 250gm soil samples in Miniet El-Kamh samples compared to 45.1, 41.8 and 26.9 in Belbies, Fakous and Abou-Hammad, respectively.

Eissa (1974) detected 15 genera of plant parasitic nematodes infesting citrus orchards in Southern Tahrir. El-Morshedy (1980) identified 12 genera in certain localities of Behera, Menoufia, Qalyobia and Sharkia Governorates. *T. semipenetrans* was the most dominant species, while *Helicotylenchus*, *Tylenchorhynchus* and *Pratylenchus* were less important. Anwar (1985) reported that *T. semipenetrans* occurred in 95.5% of total samples, compared to

Helicotylenchus, *Pratylenchus*, *Criconemoides*, *Tylenchorhynchus*, *Longidorus*, *Rotylenchulus* and *Haplolaimus* which were detected with less frequency of occurrence ranged between 22.2 to 1.5%. El-Deeb (1995) showed that nine genera of plant parasitic nematodes were found in associated with citrus orchards in Sharkia Governorate. *T. semipenetrans* was the most dominant one. Also, Refaei *et al.* (2001) detected nine genera in Dakahlia Governorate, where *Tylenchulus* was the predominant genus followed by *Meloidogyne*, *Tylenchorhynchus* and *Helicotylenchus*. Finally, Eid (2005) identified nine genera associated with citrus trees in Rafah county, North Sinai, where *Tylenchulus* was the predominant genus compared to other genera.

Concerning occurrence and population density of plant parasitic nematodes associated with citrus in sandy soil of Abou-Hammad, Belbies and Fakous compared to clay soil of Miniet El-Kamh, our results are confirmed with those reported by El-Morshedy (1980) who showed that occurrence of *T. semipenetrans* was relatively higher in sandy soil compared to clay soil. Moreover, Ismail (1992) revealed that population density of *T. semipenetrans* was much higher in sandy soil of Belbies than those in

clay soil of Miniet El-Kamh, results here are relatively similar and confirmed the present obtained data.

Occurrence and Population Density of Plant Parasitic Nematodes Infesting Navel Orange under Different Irrigation Systems in Sharkia Governorate

Data in Table 2 revealed that nine genera of plant parasitic nematodes were detected in navel orange orchards irrigated by drip or surface irrigation systems as compared to seven genera founded in samples of sprinkler irrigation system. The genera *Tylenchorhynchus* and *Rotylenchulus* were not detected in samples of sprinkler system and this may be attributed to low number of samples collected from this irrigation system.

The genera *Helicotylenchus*, *Meloidogyne*, *Pratylenchus*, *Tylenchulus* and *Xiphinema* were found with a relatively higher values of percent frequency of occurrence in samples of sprinkler irrigation as compared to drip and surface irrigation systems. Since frequency of occurrence for these genera in sprinkler system were 68.2, 63.6, 50.0, 95.4 and 45.5%,

respectively, while the parallel values in drip and surface systems were 24.1 (60.4)*, 31.0 (29.7)*, 30.2 (41.8)*, 93.1 (94.5)* and 29.3 (33.0)* %, respectively. On the other hand, the genera *Rotylenchulus*, *Tylenchus* and *Tylenchorhynchus* were more frequently occurred in samples of surface irrigation compared to drip irrigation. However, frequency of occurrence for *Macroposthonia* was the highest in drip system (6.0%) followed by sprinkler irrigation (4.6%) and surface irrigation (1.1%).

Regarding population density of the identified genera of soil nematodes, it was found that a relatively higher value of *Tylenchulus* was found in drip irrigation (2995.8 nematodes per 250 gm soil) followed descendingly by sprinkler (1546.4) and surface (1078.5) irrigation systems. On the other hand, population density of the genera *Helicotylenchus*, *Meloidogyne*, *Pratylenchus* and *Xiphinema* was the highest in samples of sprinkler followed by surface and drip irrigation systems. Numbers of these genera per 250 gm soil under sprinkler were 730.5, 625.9, 443.6 and 55.8 nematodes, respectively,

()* Values represent % frequency of occurrence for the m. a genera under surface irrigation system.

Table 2. Frequency of occurrence and population density of plant parasitic nematodes infecting navel orange under different irrigation

Nematode genera	Drip irrigation system		Sprinkler irrigation system		Surface irrigation system	
	FO%	PD	FO%	PD	FO%	PD
<i>Helicotylenchus</i>	24.1	90.0	68.2	780.5	60.4	244.4
<i>Macroposthonia</i>	6.0	20.7	4.6	14.0	1.1	44.0
<i>Meloidogyne</i>	31.0	36.3	63.6	625.9	29.7	60.8
<i>Pratylenchus</i>	30.2	70.9	50.0	443.6	41.8	72.7
<i>Rotylenchulus</i>	0.9	20.0	0	0	30.8	39.6
<i>Tylenchorhynchus</i>	39.7	49.6	0	0	61.5	45.1
<i>Tylenchus</i>	19.0	39.1	13.6	117.0	27.5	29.8
<i>Tylenchulus</i>	93.1	2995.8	95.4	1546.4	94.5	1078.5
<i>Xiphinema</i>	29.3	32.0	45.5	55.8	33.0	25.3

compared to obviously lower population density under drip and surface irrigation systems with values of 90.0 (244.4)*, 36.3 (60.8)*, 70.9 (72.7)* and 32.0 (25.3)* nematodes, respectively. However population density of the genera *Macroposthonia* and *Rotylenchulus* was relatively higher in samples of surface irrigation than in samples of drip irrigation, whereas vice versa was recorded for *Tylenchorhynchus* which was detected with high population density in drip system compared to surface irrigation system.

Mahrous *et al.* (1985) determined percent of frequency of occurrence and population density of plant parasitic nematodes infecting citrus Sifi orange *Citrus sinensis* var. *Valencia* under surface and drip irrigation system in newly reclaimed sandy areas at Sharkia Governorate. They found that ten genera of true plant parasitic nematodes were detected in samples of surface irrigation system, while seven genera in soil samples of drip system. Moreover, frequency of occurrence and population density of the most prevalent genera i.e., *Meloidogyne*, *Trichodorus*, *Tylenchorhynchus*, *Tylenchulus* and *Helicotylenchus*

were more counted in samples of surface irrigation system as compared to drip irrigation system. The only exception was found with *Tylenchulus* which was recorded with high population density in drip system compared to surface irrigation system.

Seasonal Population Dynamics of *Tylenchulus semipenetrans* Infesting Navel Orange Root System in Newly Reclaimed Sandy Soil of Sharkia Governorate

Data in Fig. 1 show that infestation of navel orange orchards with *T. semipenetrans* was differed variations in nematode numbers throughout the whole year months. There were two peaks population of the citrus nematode. The first peak (period of active growth) was found in February while the second one was recorded in November & December. The peak of November & December was very high compared with to that occurred in February, where the highest population densities were counted in November & December with values of 8249.6 - 3554 juveniles per 250 gm soil, respectively, while mean number of the nematode in February was 2371.2

(*) Values represent % frequency of occurrence for the m. a genera under surface irrigation system

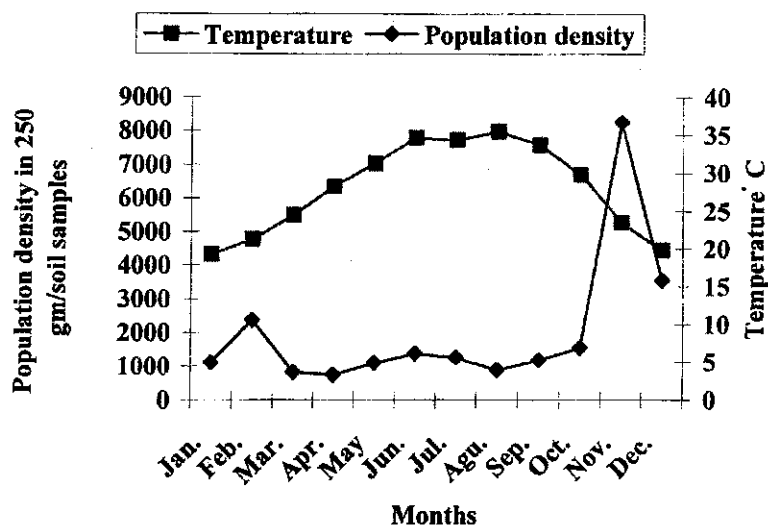


Fig. 1. Seasonal population density of the citrus nematode *T. semipenetrans* infesting root system of navel orange in Belbies county, Sharkia Governorate during 2006

juveniles per 250 gm soil. However, soil population of *T. semipenetrans* was less or more similar during other year months with population density ranged between 744 to 2371.2 juveniles per 250 gm soil.

The obtained results agree to certain extent with those reported by many investigators who studied seasonal population dynamics of *T. semipenetrans*. In Egypt, Salem (1980) reported that population densities of *T. semipenetrans* on Baladi sweet orange and Adalia

lemon were the highest during two periods, the first was recorded from March to May while the second reported during October and November. Salem *et al.* (1984) reported that two peak populations were developed during the period of increased root growth which occurred in spring and early autumn. El-Morshedy and Mahrous (1988) found two peaks in May and October. Also, Abd-El gawad *et al.* (1994) recorded that soil population of *T. semipenetrans* peaked in March and being lowest in October.

Finally, Eid (2005) detected two peaks of citrus root nematode, the first in May while the second in November. Last findings of Eid (2005) are more coincide with and confirm the data of the present work Context from the a.m. readings, obviously range of temperature in the present investigation, in relation to population density of *T. semipenetrans* in bounded together.

Most studies reported one peak for citrus nematode per year (Prasad and Chawla, 1966 and Sorribas *et al.*, 2000), two peaks (O'Bannon *et al.*, 1972 and Duncan *et al.*, 1973) or three peaks (Hamid *et al.*, 1988). In general, population growth of *T. semipenetrans* ranged between 20 to 31 °C, with maximum development at 25 °C and very slow development at the extremes (O'Bannon *et al.*, 1966). Low winter temperatures regulate the population growth of the nematode (Duncan and Cohn 1990). Summer temperatures in certain places of deferent countries i.e. Egypt, Texas and Spain approach the upper limit of temperature range and often suppress population of the nematode (Salem 1980, Davis 1984 and Sorribas *et al.*, 2000).

Vertical and Horizontal Distribution of *T. semipenetrans* Infecting Navel Orange Orchards under Drip and Surface Irrigation Systems

Data in Fig. 2 clearly show that as the soil depth increased, mean numbers of *T. semipenetrans* were obviously decrease in two navel orange orchards. In drip irrigated orchards, numbers of *T. semipenetrans* at 0-20, 20-40 and 40-60 cm were 830, 550 and 330 juveniles per 250 gm soil, respectively. Whereas, in surface irrigated one, numbers of *T. semipenetrans* at the same depths were 528, 220 and 108 juveniles per 250 gm soil, respectively. On the other hand, as the distance from tree trunk horizontally increased, mean numbers of *T. semipenetrans* were increased. In drip irrigated orchard, mean numbers of *T. semipenetrans* were significantly increased as the distance increased from 0-50 to 50-100 and 100-150 cm with mean values of 233, 723 and 2300 nematodes /sample, respectively. Whereas, in surface irrigated orchard, mean numbers of *T. semipenetrans* were noticeably increased from 132 to 1316 juveniles per sample as the distance increased from 0-50 to 50-100 cm. However, slight increase with

insignificant variation was detected at 100-150 cm with mean value of 1472 nematodes per sample.

Our results are in harmony with those reported by many authors who determined vertical distribution of *T. semipenetrans*, for instances, the highest numbers of the citrus nematode were detected in the stratum 0-20 cm (Richter, 1969); in the top 15 cm

(Davis, 1984 and Li, 1991), at the depth of 10-20 cm (Tsai and Van Gundy, 1986) and in the top 30 cm (Refaei *et al.*, 2001).

The same uppercase letter in drip irrigation or lowercase letter in surface irrigation indicate no significant differences between distances at $P=0.05$ according to Duncan's multiple range test.

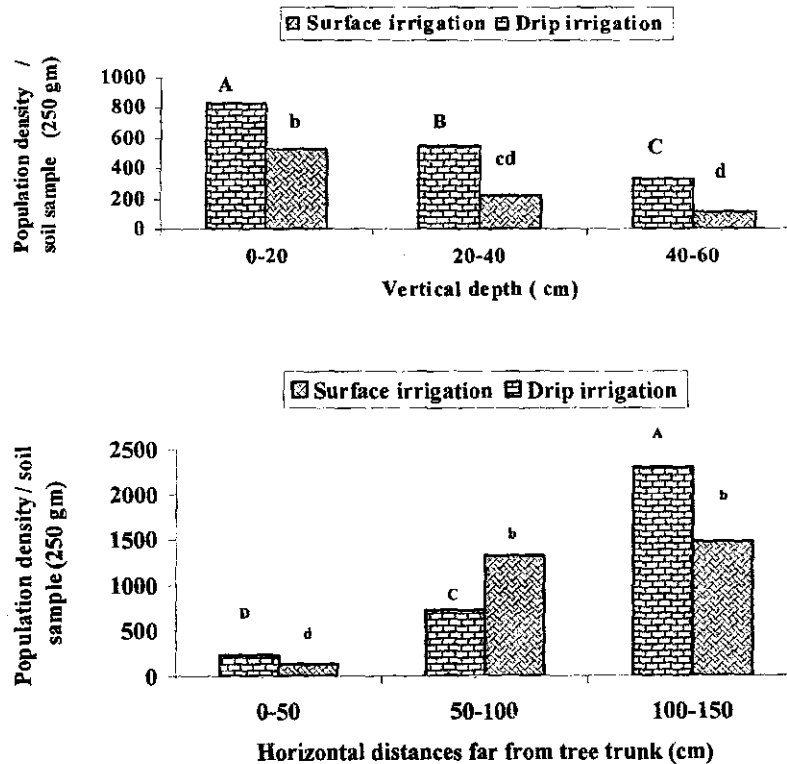


Fig.2. Vertical and horizontal distribution of *T. semipenetrans* in navel orange orchards under drip and surface irrigations during summer 2007

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النيماتودا المتطفلة في بساتين الموالح بمحافظة الشرقية وبصفة خاصة نيماتودا الموالح

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تم تحديد تسعة أجناس من النيماتودا المتطفلة على الجذور في بساتين الموالح بمحافظة الشرقية حيث وجدت نيماتودا الموالح في ٩٥,٨١ % من العدد الكلي للعينات وبكثافة عددية بلغت ١٦١٩,٦٦ فردا / ٢٥٠ جرام تربة ومن ناحية أخرى اختلفت النسبة المئوية لتكرار التواجد وكذلك الكثافة العددية لهذه الأجناس من مركز الي آخر . وجد أن أعداد نيماتودا الموالح كانت منخفضة في الأراضي الطينية الثقيلة بمركز منيا القمح مقارنة بالأراضي الرملية الخفيفة بمراكز أبو حماد و بلبيس و فاقوس، تم مقارنة النسب المئوية لتكرار التواجد والكثافة العددية لأجناس النيماتودا التي تصيب البرتقال بسرة تحت ثلاثة نظم ري مختلفة ، وجدت نيماتودا الموالح بكثافة عالية في نظام الري بالتنقيط متبوعا بنظام الري بالرش ثم الري السطحي في حين كانت النسبة المئوية لتكرار تواجدها هذه النيماتودا عالية في نظام الري بالرش متبوعا بنظام الري بالتنقيط ثم الري السطحي .

كذلك تم دراسة سلوك التعداد الموسمي لنيماتودا الموالح في البرتقال أبو سره وأنضح أن لهذه لنيماتودا ثروتين (قمتين) من النشاط خلال العام في شهر فبراير بينما كانت الثانية خلال شهري نوفمبر و ديسمبر وكانت أقصى زيادة في متوسط تعداد النيماتودا خلال شهر نوفمبر . درس التوزيع الرأسي و الأفقي لنيماتودا الموالح في البرتقال أبو سره تحت نظامين للري هما الري بالتنقيط و الري السطحي وأنضح قلة أعداد نيماتودا الموالح بصورة معنوية بزيادة العمق من صفر-٢٠ سم الي ٢٠-٤٠ سم و ٤٠-٦٠ سم تحت نظامي الري في حين ظهر العكس بالنسبة للتوزيع الأفقي حيث زادت متوسطات أعداد نيماتودا الموالح كلما زادت المسافة الأفقية من جذع الشجرة من صفر-٥٠ الي ٥٠-١٠٠ سم وكذلك ١٠٠-١٥٠ سم وكانت هذه الزيادة معنوية في نظام الري السطحي بين الثلاث مسافات أما في نظام الري بالتنقيط فقد كانت الزيادة في متوسط أعداد النيماتودا معنوية عند زيادة المسافة الأفقية من صفر -٥٠ سم الي ٥٠-١٠٠ سم و غير معنوية عند زيادة المسافة الأفقية الي ١٠٠-١٥٠ سم.