Hebron University

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Survey of Plant Parasitic Nematodes Associated with the Rhizosphere of Plants in Nurseries and Intensive Agriculture in the West-Bank

BY

Abdul- Jawwad Anwar Wahbeh Sultan

Supervisor

Dr. Sufian Sultan

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Dedication

To my cherished family especially my father and mother
Who supported me and lightened up my whole life and
ambitions

To my sisters and brothers

To my revered relatives and friends for their matchless
encourage

To my respectful instructors in the college of agriculture.

Abdul- Jawwad Anwar Sultan

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Abstract

This research, focused on the distribution and occurrence of plant parasitic nematodes genera and species in the cultivated crops fields, fruit trees orchards and vegetables in West Bank districts. Also on the existence of plant parasitic nematodes in nurseries and its relation to organic matter; soil texture and soil PH. In addition to the distribution of Root Knot nematodes and their species, populations and reproduction in greenhouses of Cucumber and Tomatoes of some West Bank areas.

The results have proved the existence of 43 species of plant parasitic nematodes belonging to 24 genera and distributed in most West-Bank field crops, fruit trees orchards and vegetables. Species of *Tylenchorhynchus, Helicotylenchus, Criconemoid* and *Meloidogyne* were identified as the most plant parasitic nematodes genera available in all West-Bank areas. On the other hand, the species of *Tylenchorhynchus, Helicotylenchus* and *Criconemoid* were also being discovered with high populations in all West Bank areas.

Correspondingly, results revealed the presence of 15 plant parasitic nematodes genera associated either in single or in combination with the rhizosphere of plants grown in 18 nurseries in the West Bank. Besides, stunt nematode *Tylenchorhynchus spp*. was detected with high populations in most nurseries. But the other fourteen plant parasitic nematodes genera were found distributed with less population than *Tylenchorhynchus* spp. (Table 3.1.1). Thereof, the population of plant parasitic nematodes in nurseries decreases in soils with high organic matter content and in heavy soils, but increase in light soils with low organic matter content. Results also indicated that, when the organic matter increases; the population of

non parasitic (free living) nematodes also boost up, while the parasitic nematodes decrease.

Concerning the root knot nematode, the study demonstrated that; these nematodes were the most destructive ones that inhibit greenhouses of cucumber and tomato. In the same concern, about 21.2% of tomato and cucumber plants grown in greenhouses in West-Bank were infected with Root Knot Nematodes. *Meloidogyne javanica* represents about 58.2%, while Meloidogyne incognita represents 41.8% from the infected roots.

M. javanica was identified in all districts but with high percentage and populations in the hot and moderate climate areas of the West Bank. M. incognita also was distributed allover West Bank areas except hot areas of Jericho, Jordan valley and Tubas. The High populations of *Meloidogyne incognita* were more concentrated in high areas of Hebron and Bethlehem districts.

Chapter1

Literature review

1.1 Importance

Nematodes constitute one of the most important groups of organisms which inhabit the soil around the roots of plants that frequently plays a vital part in their growth and production. However, because most of them live in the soil, they represent one of the most difficult pest problems to identify, demonstrate and control (Stirling et al., 1998). Their effects are commonly underestimated by farmers, agronomists and pest management consultants, but it is inevitable that some 10 percent of yearly world crop production is lost as a result of plant nematode damage (Whitehead, 1998).

It is hard to find a crop free from being attacked, either in fields, orchards, home gardens, or greenhouses. These active slender and wormlike creatures are being found not only in the soil but also in fresh and salt water wherever organic materials exist. At least, 2500 species of plant-parasitic nematodes have been described, characterized by the presence of a stylet used for penetration and feeding on host plant tissue (Sikora and Oostendorp, 1986).

Throughout the years, these interesting organisms have remained little-known groups in the biological complex, mainly because of the technical difficulties encountered in isolation and their preparation for a detailed microscopic examination necessary in the process of identification. They have achieved a small portion of recognition they deserve considered among the problems confronting agriculture only during the last five decades (Ayoub, 1980).

1.2 Damage

Regarding the damage caused by plant parasitic nematodes, it is important to mention that various nematode species in their search for food inflict visible damage mainly in the form of lesions (necrotizing of cortical tissue), swellings, cessation of growth and death of root tips or deformations of the roots system due to root-knot nematode. All these impairments of the feeder roots inhibit their growth and cause their death (Maqbool, 1988).

In addition to the mechanical destruction caused by the direct feeding of plant parasitic nematodes on root cells, the physiology of the root tissue is also altered. Serious concomitant effects are marking disturbances of water and nutrient uptake by the active root system which is in anyway have already being reduced (Sardanelli et al., 2002; Christie, 1959).

The parts of roots that are attacked by nematodes offer venues of entrance by soil borne diseases (fungi and bacteria). These secondary pathogens invade the wounds caused by nematodes and infect the weakened plant more easily at different points. Interactions, mainly with soil-borne fungi such as *Fusarium* spp., *Verticillium* spp., and *Pythium* spp. greatly intensify the damage already caused by the two groups of pathogens. The necroses in fact spread rapidly to the vascular system of the central cylinder of the roots. This directly impedes, and, at an advanced stage, completely abolishes the supply of water and nutrients to the plant. The result is a complete decay of the affected area of the root (Sardanelli et al., 2002; Wick, 1999).

On shoots, the symptoms of damage are much the same for all crops, high population densities of nematodes may cause the following symptoms due to water stress and reduced nutrient uptake: wilted, chlorotic and later necrotic foliage (nutrient deficiency) that lead to the death of entire branches, stunting of shoots, leaves and fruits, deficient fruiting, retarded fruit, ripening, and reduced standing power, a very depressing result that happen due to the weakness of the whole root system (Lahdenpera et al., 1991). However, plant parasitic nemtodes cause irregular growth and different rates of fruit ripening within the same plantation which may create difficulties for harvesting. Even if no direct damage to the aerial parts of the plants is yet apparent, substantial yield losses are often increasing production costs for replanting, additional fertilization and irrigation of the diseased plants as well as control measures to combat subsequent infection by fungal pathogens **(**Kiryanova and Krall, 1980 and Christie, 1959).

Some nematode species have become known as vectors of viruses. For example, *Xiphinema index* which transmits the fan leaf and yellow mosaic viruses are known to inflict severe damage on grapes (Miller, 1980).

When plant roots of vegetables, cereals and fruit plants are attacked by large numbers of plant parasitic nematode, the disease damage can be very serious, some times resulting in total harvest failure. Therefore, in addition to good crop management, the use of effective nematicides is crucially required (Barker and Olthof, 1976).

1.3 Geographical distribution

The Geographical distribution of each plant parasitic nematode species in the agricultural areas is related to several factors that have a dominant influence. Host plant, environmental factors and soil properties are the most important factors that restrict the distribution and population levels (Griffin, 1984).

Cyst nematodes, *Heterodera* spp. were detected in hot sandy soil areas of 1948- occupied region of Palestine as well as in many countries, including Australia, Canada, South Africa, Japan and most European countries (Kort, 1972), India (Sharma and Swarup, 1984; Sikora, 1988) and countries within North Africa and West Asia, including Morocco, Tunisia, Pakistan and Libya (Sikora, 1988), and recently Algeria (Mokabli *et al*., 2001) and Saudi Arabia (Ibrahim *et al*., 1999).

There are four known biotypes of *Tylenchulus semipenetrans* on assorted hosts that can be distinguished by their abilities to parasitize various hosts' rootstocks with worldwide spread (Siddiqi, 1974). However, Oteifa and Shaarawi (1962) mentioned that this species exists according to the distribution of citriculture areas in the entire world.

Four species of *Pratylenchus,* (*P. thornei, P. crenatus, P. neglectus* and *P. penetrans*) were seriously studied and found distributed vastly in the 1948- occupied region of Palestine (Orion *et al*., 1982). These species were found as world widely spread, being found in Syria (Saxena *et al*., 1988; Greco *et al*., 1984), former Yugoslavia, Mexico and Australia (Fortuner, 1977), Canada (Yu, 1997), Morocco (Ammati, 1987), Pakistan and India (Maqbool, 1988), Algeria (Troccoli et al., 1992) and Italy (Lamberti, 1981).

Root knot nematodes *Meloidogyne spp*. are worldwide spread nematodes, as these species are favoring light soils and warm temperatures (Taylor and Sasser, 1978a).

Several species of root knot nematodes were found distributed in cool climates areas, including *M. artiellia, M. chitwoodi, M. naasi, M.*

microtyla and *M. ottersoni* (Sikora, 1988). In warm climate areas, *M. graminicola, M. graminis, M. kikuyensis* and *M. spartinae* are important (Taylor and Sasser, 1978a).

Meloidogyne artiellia has a wide host range including crucifers, cereals and legumes (Ritter, 1972. Di Vito *et al.*, 1985). This nematode was chiefly known from Mediterranean Europe in Italy, France, Greece and Spain (Di Vito and Zacheo, 1987), but also in West Asia (Sikora, 1988), Syria (Mamluk *et al.*, 1983), 1948- occupied region of Palestine (Mor and Cohn, 1989) and western Siberia (Shiabova, 1981).

In tropical and subtropical areas, *M. incognita, M. javanica* and *M. arenaria* were all known for their fierce attack to crops than other root knot nematodes (Swarup and Sosa-Moss, 1990; Abu- Gharbieh 1994). These three species were classified as the most important species of root knot nematode that cause the greatest damage in the world (Franklin, 1965, Barker et al., 1976, Taylor and Sasser, 1978b, Smith *et al.*, 1996, and Abu-Gharbieh, 2004). Moreover, other root knot nematodes were spread vastly in the temperate regions such as *M. hapla* and *M. naasi*, since these species were able to survive in the soils below 0°C (Franklin *et al.*, 1971).

Sasser (1987) investigated the yield loss due to parasitic nematodes, where 371 nematode specialists have participated from 75 countries in the study (Project of Nematode IPM-1975). He estimated that, nematode yield losses represent 12.3% of the annual production in basic crops with an estimated value of about 100 billion dollar. The same study alluded that root knot nematodes represent the most important species causing about 5% yield losses. The most important species in the root knot nematode were *M. incognita* which represents 42.97% of root knot nematode species, followed by *M. arrenaria* 6.65% (Taylor and Sasser, 1982).

Root knot nematodes were found vastly spread either in Jordan or in the west bank especially in irrigated areas (Abu Gharbieh, 1994). However, the first root knot nematode survey in Jordan has been carried out by Abu Gharbieh and Hammo in 1970. They have discovered that more than 20% of all nematode infection belongs to root knot nematodes.

Abu Gharbieh (1982) and Atieh (1986) showed that 75% of root knot nematodes in Jordan was *M. javanica* and located in the hot climate of the south middle Ghour. They have also affirmed that *M. incognita* appeared in North Ghour, Deir alla, Zarka and Jarash.

Abu-Gharbieh and Azzeh (2004) have discussed the existence of plant parasitic nematode over the Arab countries. They have explained that 216 species belong to 65 genera found in all Arab worlds. They also have summarized a final survey done on plant parasitic nematodes in each Arab country (Table 1.1).

Table 1.1: Geographical Distribution of Nematodes in the Arab Countries

Country	Plant parasitic nematode species	Reference
Egypt	*Hirschmaniella oryzae, Nacobbus oberrans, Nothocriconemella mutabilis, pratylenchoides* spp., *Pseudhalenchus anchilispasomus, Rodopholus similes, Rotylenchoides variodes, Tylencholaimus teres* and *Irantylenchus clavedorus.*	(Ibrahim, 2002; Ibrahim *et al.*, 2000)
Jordan	*Ampllimerlinius* spp., *Basiria* spp., *Bidera latipons, Coslenchus* spp., *Crossonema* spp., *Gracilacus micoletzky, Nothcriconema* spp., *Rotylenchus* spp., and **Trichotylenchus** spp.	(Abu Gharbieh, 1987; Yousef and Jacob, 1994; Hashim, 1979)

Continue table 1.1: Geographical Distribution of Nematodes in the Arab Countries

Country	Plant parasitic nematode species	Reference
Morocco	*Boleodorus* spp.	(El Maleh and Edongali, 1995; Ammati, 1987).
Libya	*Dolichodorus* spp.	(El Maleh and Edongali, 1995).
Saudi Arabia	*Subanguina* spp., *Belonolaimus* spp., and *longicaudatus* spp.	(Al- Hazmi *et al.*, 1995).
Sudan	*Paratrophurus lobatus*	(Yassin, 1987).
Egypt+ Jordan	*Criconemoid* spp.	(Mamluk et al., 1984; Ismail, 1997).
Jordan+ Morocco	*Merlinius* spp.	(Yousef and Jacob 1994; Ammati, 1987).
Jordan+ Saudi Arabia	*Boleodorus* spp.	Al- Hazmi *et al.*, 1988; Yousef and Jacob, 1994).

Continue table 1.1: Geographical Distribution of Nematodes in the Arab Countries		
Country	**Plant parasitic nematode species**	**Reference**
Egypt, Jordan, Saudi Arabia	*Hemicriconemoides* spp.	(Yousef and Jacob, 1994; Al- Hazmi *et al*., 1995; Ibrahim, 2002; Ibrahim *et al*., 2000).
Egypt, Jordan, Sudan	*Psilinchus* spp.	(Yassin 1987; Ibrahim et al., 2000; Hashim, 1979; Abu Gharbieh, 1987).
Wide spread Nematodes	*Anguina* spp., *Ditylenchus* spp., *Helicotylenchus* spp., *Heterodera* spp., *Hoplolaimus* spp., *Longidorus* spp., *Meloidogyne* spp., *Paratylenchus* spp., *Pratylenchus* spp., *Rotylenchus* spp., *Trichodorus* spp., *Tylenchorhynchus* spp., *Tylenchulus* spp., *Tylenchus* spp. and *Xiphinema* spp.	(Ibrahim, 2002; Ibrahim *et al*., 2000; Abu Gharbieh, 1987; Yousef and Jacob, 1994; Hashim, 1979; El Maleh and Edongali, 1995; Ammati, 1987; Al-Hazmi *et al*., 1995; Yassin, 1987).

Little is known about the occurrence of plant parasitic nematodes in Palestine (West Bank and Gaza strip). In the same concern, very limited studies have been done in the West Bank before 1967. However, many studies were carried out by Israeli nematologists in the 1948- occupied region.

Minz *et al* (1960) has reported the presence of *Helicotylenchus* spp. in Jericho and the Jordan Valley. In addition, the presence of *Tylenchorhynchus* spp., *Tylenchus* spp., *Helicotylenchus* spp., *Pratylenchus* and *Xiphinema* spp. was previously recorded and noticed in the West Bank (Gottlieb *et al*., 1986). Cohn and Minz (1961) have confirmed that, *Tylenchulus semipenetrans* were found distributed vastly in all the Palestinian citriculture areas of West Bank, Gaza strip and the occupied region 1948. However, Gottlieb *et al* (1986) indicated that, these species can cause serious economic loss to citrus in the 1948-occupied region.

The first infection with root knot nematode in the West Bank was registered by Abu Gharbieh (1963) on irrigated vegetables in Al Fara'a and Jericho stations.

1.4 Threshold (Economic) level of plant parasitic nematodes

Jacobsen (1997) suggested threshold numbers per 100cc soil sample for the most important root parasitic nematode; stubby-root nematode (*Trichodorus* and *Paratrichodorus*) 50-100, Long nematode (*Longidorus*) 30, Dagger nematode (*Xiphinema*) 50-100, Lance nematode (*Hoplolaimus*) 40-150, Stunt nematode (*Tylenchorhynchus*) 150-300, Spiral nematode (*Helicotylenchus*) 30, Ring nematode (*Criconemella*) 300-600, Root-lesion nematode (*Pratylenchus*) 50-100. Barker *et al* (1976) however, found that, *Pratylenchus* spp. damage level began at

100/100cc soil sample in susceptible hosts such as onion, and up to 600/100 cc on beet. Potter and Olthof (1993) indicated that *Pratylenchus* spp. causes losses in marketable yield that reached about 14% at 67/100 g soil to 71% at 1800/100 g soil. On the other hand, Shafiee and Jenkins (1963) showed that in a study on pepper *Capsicum annuum*, 625/100 cm^3 soil of *Pratylenchus penetrans* have reduced top fresh weight by 84% and root fresh weight by 87%.

Barker and Olthof (1976) in addition to Potter and Olthof (1993) showed that root knot nematode injury symptoms and losses only began when the level of second stage larva reached 200 /100 cc soil. However, another study, Barker et al (1976) showed that economic losses began occurring at a level of 4/100 cc soil.

McElroy (1972) on another study, elucidated that, *Xiphinema* spp. economic losses began at the level of 123/100 cm^3 of soil sample on *Zea mays* (sweet corn).

1.5 Host range of nematodes

Meloidogyne spp., *Heterodera /Globodera* spp., *Pratylechus* spp., *Tylenchulus semipenetrans*, *Trichodorus* spp. and *Xiphinema* spp. are the most dangerous nematodes that attack fruit trees, vegetables, fiber and ornamental crops (Barker and Clayton, 1973; Barker and Olthof, 1976).

Several plant-parasitic nematodes have been found associated with olive trees in a lot of olive orchards in the world, including *Mesocriconema xenoplax* (Raski) Loof & De Grisse (= *Criconemoide xenoplax*)(Luc & Raski), *Helicotylenchus* spp., *Meloidogyne* spp. and *Pratylenchus* spp. Conversely, limited spread is reported about the citrus nematode *Tylenchulus semipenetrans* and the cyst-forming nematode *Heterodera* spp. (Diab and El-Eraki, 1968; Lamberti and Vovlas, 1993).

Abu-Gharbieh and Hammo, 1970 in addition to Hashim (1983) Found that *Tylenchorhynchus clarus, Helecotylenchus digonicus, Meloidogyne* spp., *Pratylenchus penetrans, Rotylenchus macrosomus* and *Xiphinema index* were the most destructive nematode species on olives in Jordan; other species that were associated with olive orchards only caused moderate loss in the production period .

Hashim (1983), studied parasitic nematodes associated with pomegranate (*Punica granatum*) in Jordan. He classified *Helicotylenchus pseudorobustus* as the most dangerous nematode on pomegranate in irrigated orchards. He further indicated that, *Tylenchorhynchus clarus*, *Longidorus* spp., *Meloidogyne* spp., *Criconemella antipolitana*, *Helicotylenchus digonicus, H. Minzi*, *Pratylenchus penetrans, Paratrichodorus tunisiensis, Xiphinima index, X. pachtaicum* and *Criconemoid xenoplax* were also found but with less importance than *Helicotylenchus pseudorobustus*.

Bridge et al (1997) has indicated that the most considerable species of plant parasitic nematode on Banana were *Pratylenchus coffeae*, *Pratylenchus goodeyi* and *Radopholus similes*. He further reported that the two nematodes species. (*P. coffeae* and *R. similes*.) were widely spread and their distribution depended on each other's location and existence.

Franklin (1972) has acknowledged that all varieties of Cabbage *B. oleracea* are good hosts for *Heterodera schachtii*, *Heterodera avenae Heterodera goettingiana*, *Heterodera humuli* and *Heterodera trifolii* with a world-wide distribution. He declared that, oats are considered as primary host for these nematodes, but other cereals and other grasses are good hosts. Williams and Siddiqi (1972) and Norton *et al* (1984) found that *Heterodera trifolii* was the most widespread cyst nematode in North America where it can be detected in grass and grain. However, Gray *et al* (1992) found that *H. schachtii* causes economic losses only in sugar beets; it can attack over 200 plant species in 23 different plant families. Most hosts are found in the *Chenopodiaceae* family and the *Cruciferae* family. In addition to sugar beets, other host crops include turnip, kale, radish, spinach, broccoli, cabbage, cauliflower, tomatoes, Brussels sprouts, table beets, kohlrabi, rhubarb, and other closely related crops.

Table 1.2 some plant parasitic nematode species and its host range:

Nematode species	Host range and reference
Helicotylenchus indicus	Okra, *Abelmoschus esculentus* (Diab and El-Eraki, 1968); cabbage, *Brassica oleracea*; and Carrot, *Daucus carota* (Siddiqui, 2003a).
Tylenchus filiformis	Okra, *A. esculentus*; Mustard, *Brassica campestris;* cabbage, *B. oleracea;* Turnip, *Brassica rapa* (Lamberti and Vovlas, 1993); Carrot, *D. carota*; Tomato, *Lycopersicon esculentum*; Eggplant, *Solanum melongena* (Diab and El-Eraki,1968); Sorghum, *Sorghum vulgar*;, Maize, *Zea mays*; Swingle Lemon, *Citrus aurantifolia*; Blanco Orange, *Citrus reticulate*; and Mango, *Mangifera indica* (Abu-Gharbieh, 1994).
Tylenchulus semipenetrans	Citrus, *C. aurantifolia*; olive, *Olea europaea*; grape, *V. vinifera* (Siddiqi, 1974)
Radopholus simlis	Lemon, *C. aurantifolia;* Blanco Orange, *C. reticulate* (Diab and El-Eraki,1968); (Lamberti and Vovlas, 1993); Banana, *Musa paradisiacal;* and Guava, *Psidium guajava* (Siddiqui, 2003a).
Meloidogyne incognita	Carrot, *D. carota*; Mango, *M. indica* (Lamberti and Vovlas, 1993); Eggplant, *S. melongena* (Diab and El-Eraki,1968); Okra, *A. esculentus*; Turnip, *B. rapa*; Tomato, *L. esculentum;* and Lemon, *C. aurantifolia* (Siddiqui, 2003b).
Rotylenchulus reniformis	Okra, *A. esculentus*; Grapes, *V. vinifera*; Jujube, *Zizyphus jujube* (Diab and El-Eraki,1968); Turnip, *B. rapa;* Carrot, *D. carota* (Lamberti and Vovlas, 1993); Tomato, *L. esculentum*; Eggplant, *S. melongena*; Lemon, *C. aurantifolia*; Blanco Orange, *C. reticulate*; and Guava, *P. guajava* (Siddiqui, 2003a)

Continue- table 1.2:- some plant parasitic nematode species and it's host ranges:

Nematode species	Host range and reference
***Tylenchorhynchus* spp.**	Okra, *A. esculentus*; Turnip, *B. rapa*; Cabbage, *B. oleracea* (Lamberti and Vovlas 1993); Carrot, *D. carota* (Siddiqui 2003a)*;* Tomato, *L. esculentum*; Radish, *Raphanus sativus*; Eggplant, *Solanum melongena* (Diab and El-Eraki 1968); Maize, *Z. mays*; Swingle Lemon, *C. aurantifolia* (Siddiqui 2003b); Mango, *M. indica*; Banana, *M. paradisiaca* (Lamberti and Vovlas 1993)*;* Guava, *P. guaava*; Grape, *V. vinifera*; and Jujube, *Zizyphus jujuba* (Diab and El-Eraki 1968).
Hoplolaimus indicus	Okra, *A. esculentus;* Mustard, *Brassica campestris* (Lamberti and Vovlas 1993)*;* cabbage, *B. oleracea*; Coriander, *Coriandrum sativum* (Siddiqui 2003b); Carrot, *D. carota;* Sesbania, *Sesbania aculeate* (Diab and El-Eraki 1968); Wheat, *Triticum aestivum*; Maize, *Z. mays*; Swingle Lemon, *C. aurantifolia*; Mango, *M. indica*; Banana, *M. paradisiacal*; and Guava, *P. guajava*. (Siddiqui 2003a; Lamberti and Vovlas 1993)
Pratylenchus pratensis, P. neglectus, P. minyus	wide host range of fruit trees and field crops (Norton *et al* 1984)

1.6 Ecology of plant parasitic nematodes

1.6.1 Plant parasitic nematodes in nurseries

Nurseries represent the most important source of plant parasitic nematode. Siddiqui *et al* (1973) has mentioned that, *Xiphinema* spp. are the most important nematode associated with nurseries of commercial crops in California. He further reported that the population of *Pratylenchus* spp. was high in nurseries where weeds were growing.

Peterson (1962) and Ruehle (1975) reported that seedlings of all fruit tree species are susceptible, at least to some degree, to plant-parasitic nematodes. They also confirmed that, the nematodes that were most damaging in nurseries were the root knot nematodes *Meloidogyne* spp., lance nematodes *Hoplolaimus* spp., lesion nematodes *Pratylenchus* spp., stunt nematodes *Tylenchorhynchus* spp., stubby-root nematodes *Trichodorus* spp. and dagger nematodes *Xiphinema* spp. They further emphasized that *Tylenchorhynchus* spp. has the capacity to maintain high population levels in extremely drought conditions.

Plant parasitic nematodes are widespread in grapes (*V. vinifera*) nurseries. Michael and McClure (1999) and Rashid *et al* (1973) found that *Meloidogyne* spp., *Xiphinema* spp., *Pratylenchus* spp. and *Criconemoid* spp. occurs alone or in combination, causing a high degree of damage in grape nurseries**.** But there are several species of parasitic nematode that feed on grape in nurseries as secondary host; Rashid *et al* (1973) reported that *Rotylenchulus reniformis* and *Hoplolaimus indicus* nematodes that inhabit grape nurseries may cause light damage or damage less.

Nicol *et al* (2002) revealed that *Criconemoid xenoplax, Pratylenchus penetrans, Pratylenchus vulnus, Meloidogyne incognita* and *Meloidogyne* *javanica* are the most plant parasitic nematodes species that inhabit the rhizosphere of olive nurseries. On the other hand, they identified that the population of these species ranged between 100- 5000 second stage larva per 100cc soil sample in at least 10 % of olive nurseries in Spain.

Studying the economic nematode that inhabit citrus nurseries, Alam *et al* (1979) stated that *Rotylenchulus reniformis*, *Tylenchus filiformis* can only cause economic damage to citrus nurseries. Abu-Gharbieh and Perry (1970) reported that *Tylenchulus semipenetrans*, *Hoplolaimus indicus* and *Belonolaimus longicaudatus* were the most destructive species in citrus nurseries in Jordan.

Alam *et al* (1979) and Abu-Gharbieh and Perry (1970) have classified citrus as a poor host for root knot nematodes. However, Siddiqui (2004) reported that this can be really problematic just whenever citrus is planted in soils containing high number of eggmasses. In this case, the infection with root knot nematodes may cause poor growth without galling of roots.

1.6.2 Soil texture, depth and temperature-nematode relations

Soil moisture content, temperature and soil texture in 30 cm from surface layer in addition to host plants are entirely considered as the most important factors that play a vital role in nematode activity and population dynamics (Griffin, 1984).

Hagan (1994) has studied soil texture-nematode relationship on peanut; he reported that the root knot nematode *(Meloidogyne arenaria)*, the ring nematode *(Criconemoid ornata)* and the lesion nematode *(Pratylenchus brachyurus)* populations are usually rated highest in light-sandy soils. However, *Pratylenchus* may penetrated host roots better in sandy loam than in silt loam soils (Brown *et al.*, 1980). Otherwise, Noling (2003) and Norton *et al* (1984) indicated that the best soil for *Paratrichodorus allius* and *Radopholus citrophilu*s in terms of spread and reproductively was the coarse sandy soils. Furthermore, Norton *et al* (1984) have shown that the high *Heterodera* and *Pratylenchus* numbers and severe damage occurred in lighter soils. However, Wallace (1959) mentioned that, *Heterodera* spp. populations density are strongly correlated to sand, clay and silt percent in the soil; thereof, population consistently became higher in loamy sand than in sandy clay loam**.**

On the other hand, *Criconemoid* spp. was often noticed at high populations just in mud soils (Goodey, 1951). Griffin (1984) affirmed that a serious problem of heavy attack of *Ditylenchus dipsaci* in cereal crops occurs in heavy soils and high-rainfall areas of about 600 mm or more.

Some nematodes species may differ in their favorite soils, for example *Paratylenchu*s spp. studied by Loof (1974) appeared in vast distribution within fine-textured soils with less damage in sandy soils. He also learned that *Paratrichodorus* nematode can cause damage of poor growth on tap-rooted trees in light soils just in dry seasons.

The vast majority of plant-parasitic nematodes live indeed in the upper 30 cm (one foot) of the soil in response to hot summer conditions and downward growth of primary roots. Certain forms, such as the needle nematodes, move deeper into sandy soil to reach 1 m (Jacobsen, 1997). Anderson and Coleman (1982) however, stressed that nematodes remain at the depth of a constant temperature because of the stop of reproduction and activity occurring at temperature less than 5°C and more than 40 °C.

The soil temperature effect on plant's resistance and susceptibility, was studied on onion (*Allium cepa*) by Ferris (1970) who showed that, *Pratylenchus penetrans* at 7-13 °C and a population of less than 100/ 100 g soil caused in fact a significant root weight reduction, but more than 400/ 100 g soil were needed to produce injury at 16-25 °C, which means that susceptibility varied according to different growing temperatures.

In the same concern, Norton *et al* (1984) stated that *P. pratensis* highest reproduction rate may occur at 10-15 °C. However, Acosta and Malek (1979) showed that reproduction of *P. pratensis* in peppermint was much greater at 30 °C than at 22.5 °C and 15°C. They further showed that the population increase was greatest on potatoes at 16 °C and on corn at 24 °C. According to Norton *et al* (1984), the life cycle of *Paratrichodorus allius* and *Paratrichodorus minor* can be completed in 21-22 days at 22 °C and in 16 - 17 days at 30 °C; the optimum temperature for reproduction was 25°C. Hence, the optimum soil moisture for reproduction was near 10%.

As for Toyler and Sasser (1982), they mentioned that, *M. javanica* was found in the areas with a rainfall less than 500 mm/ year and the probability of *M. incognita* increased only in higher rainfall more than 500mm. However, Abu Gharbieh (1994) indicated that *M. incognita* infection has increased in the Zarqa district of Jordan with a rainfall less than 250 mm/year. He also reported that, *M. javanica* have optimum temperature of 28- 32°C, while *M. incognita* optimum temperature ranges between 23-25°C.

Noling (2003) declared that, *R. citrophilu*s typically destroy 25-30% of the feeder roots within the 30 to76 cm soil profile (depth), and as much as 90% of the roots below 76 cm. He further showed that severe effect on citrus rootstocks was evident in the deep sands more than that of the citrus nematode *Tylenchulus semipenetrans*. He also reported that the burrowing nematodes *R. citrophilus* can move from one tree to another in sandy soils to more faster than that in heavy soils.

Migration and movement of plant parasitic nematodes are the most important factors for distribution and concentration (population) into soils. Some nematodes move rapidly such as *Ditylenchus dipsaci* (10 cm within two hours) (Kort, 1972); others such as *Tylenchulus semipenetrans* spread by tillage practices, rainfall and other mechanical methods (Noling, 2003).

Studying the vertical and horizontal movement of parasitic nematodes and its own force, Siddiqui (2003a) showed that nematodes can move either horizontally or vertically. Also he asserted that the movements from down word are very hard and slow, but the movements vertically from up word are very fast and easy.

Furthermore, Siddiqui (2003a,b) found that crop rotation with several plants with different root zone distances can cause reduction in the populations of plant parasitic nematode. He also studied crop rotation sequences of *Hoplolaimus indicus* were he showed that difference in root zone distances such as tomato- tomato- fallow–fennel (sequence) and sorghum-wheat-sorghum-turnip (sequence) had great influence on the nematode population. He further revealed that deep plough (40cm) has greatly decreased the population build up of *H. indicus* than normal plough (20 cm depth).

Warfield (2002) indicated that, plowing and tillage practices are important factors for nematode movement upword.

Movements of nematodes depend strongly on soil properties that do not affect the reproduction rate. Wallace (1959) showed that, variation of soil textures does not affect on the number of eggs per cyst of *Heterodera* *schachtii*. On the other hand, he found that the moisture content was the most important factor that affected migration of *H. schachtii* juveniles.

1.6.3 Organic matter

Organic matter content in the soil is a very important factor that affects the plant parasitic nematode populations. The addition of organic matter (animal manures) to light textured soils infested with *Meloidogyne* spp. considerably decreased the damage caused by these parasites as much as reducing its populations due to organic acid toxicity, development of predatory fungi and bacteria, antagonistic organisms as well modification of the soil texture by the organic matter that could be considered as a principal factor in the whole process (Akhtar and Alam, 1993).

Hallmann *et al* (1999) showed that applying chitin containing compounds such as crab meal compost was potentially suppressing the root galling and eggmass production of the *Meloidogyne javanica* found in tomato and directly increase the populations of microorganisms which degrade chitin.

Researchers have also shown that high concentrations of urea fertilizer can reduce the populations of plant parasitic nematodes (Huebner *et al*., 1983; Rodriguez-Kabana, 1986).

Furthermore, molasses being added to soil as a fertilizer seem to reduce damage to roots caused by nematodes in terms of severity of root galling induced by *Meloidogyne* spp. in tomato. (Story, 1939; Vawdrey and Stirling, 1997)

Studies by LaMondia and Cowles (2002) were conducted on isolates of the fungus *Trichoderma virens* as potential management agent for plant-parasitic nematodes. One of the tested *T. virens* strains have also shown the suppressed root-knot nematodes in high-organic matter soils on pepper (*Capsicum annuum)*.

Fallowing can be used to increase the organic matter content of soil which reduces the number of nematodes (Noe *et al*., 1991; Floret and Serpantie, 1993; Ferris and Bernard, 1971). In addition, other studies have demonstrated that soil treated with rapeseed green manure and mushroom compost statistically reduced dagger and lesion nematodes (Meyer *et al*., 2002).

Greenhouse trials which evaluated the efficacy of infection by the endophytic fungus *Neotyphodium lolii* for nematode suppression correlated positively organic matter content in the soil of green house vegetables with nematode suppression (Mallozzi *et al*., 2001).

As for the organic soil amendments, it is crucially important to consider its contribution to soil health. Besides, it increases the diversity of nematode communities, and may influence the establishment and/or activity of biocontrol organisms (Mallozzi *et al.* 2001).

1.6.4 Soil pH

Hattar *et al*., (1988), Milestone (2002) and Grau (2003) found that there are direct relations between soil pH and plant parasitic nematode populations.

Grau (2003) found that cyst nematodes population density increased as soil pH increased. He found that the populations of cyst nematodes in fields with soil pH levels value between 7.0- 8.0 were higher than that in areas with soil pH between 5.9- 6.5.

Tucker (1998) found that calcium and magnesium uptake from the soil are related to soil pH which cause more susceptible host plants to plant parasitic nematode at pH levels less than 5.5. However, Melakeberhan *et al* (2004) indicated that *Heterodera glycines* were more pathogenic in the soils of pH level between (4.2- 4.5) than that in the soils of pH between (6.5- 7.5).

The nematicidal effects of pre-planting applications of organic acids were studied by Milestone (2002). He investigated butyric acid and propionic acid against *Meloidogyne* spp. on tomatoes and *Pratylenchus penetrans* on strawberries. He found that 0.1M butyric acid treated plots reduced the pH to 5.5 at planting which reduced *M. hapla* eggs production significantly. He further found that the galling severity demonstrates significant differences between treatments. However, aplying 1.0 and 0.5M butyric acid caused high percent of mortality to the treated plants.

Applying Sulfuric acid at 2000 ppm and Elemental Sulfur at 500-700 ppm has significantly reduced the pH in the soil due to the increase of SO4; sulfur was correlated with significant reduction of root galling and eggmass production of *M. javanica* and *M. incognita* (Hattar *et al*., 1988).

Otherwise, Osseni *et al* (2006) found that high acidity soils (pH from 4.2 to 4.5) are more favorable to the development of *Pratylenchus brachyurus*.

Objectives

The objective of the present study was to:

1- Investigate the occurrence of plant parasitic nematodes in the West Bank in relation to different plant groups.

2- Determine the occurrence of plant parasitic nematodes in various West Bank nurseries.

3- Correlate soil texture, pH and organic matter with plant parasitic nematodes occurrence in West Bank nurseries.

4- Study the occurrence of root knot nematodes Meloidogyne spp. in the West Bank tomato and cucumber greenhouses.

Chapter2

Materials and Methods

2.1 Plant parasitic nematode field survey

2.1.1 Soil samples collection

Seven hundred samples (300 cm^3 each) were collected from eight districts in the West Bank (Jenin, Tulkarm, Qalkelia, Nablus, Ramallah, Tubas, Jericho, Hebron and Bethlehem).

*Cereal and pasture grasses fields (150 samples):

Wheat: Triticum aestivum (30 samples), lentil Lens culinaris (30 samples), corn Zea myze (30 samples), okra: Hibiscus esculentus (20 samples), onion Allium cepa (20 samples) and garlic Allium sativum (20 samples).

*Fruit trees orchards (250 samples):

Stonefruit *Prunus* spp. (30 samples), pomegranate *Punica granatum* (20 samples), quince *Cydonia oblonga* (10 sample), apple *Malus sylvestris* (25 sample), fig *Ficus carica* (20 sample), walnut *Juglans regia* (10 sample), grape *Vitis vinifera* (30 sample), banana *Musa paradisiacal*, date palm *Phoenix dactylifera* (16 sample), citrus *Citrus* spp. (39 sample) and olive *Olea europeae* (50 sample).

*Open field and greenhouse Vegetables (300 sample):

Pepper *Capsicum annum*(20 samples), potato *Solanum tubersum* (25 samples), lettuce *Lactuca sativa* (10 samples), melon *Cucumis melo* (10 samples), common bean *Phaseolus vulgaris* (30 samples), broad bean *Vicia faba* (25 samples), turnip *Brassica rapa*(15 samples), squash *Cucarbita pepo, C. maxima, C. mixa* (25 samples), tomato *lycopersicon esculentum* (45 samples), tobacco *Nicotina tabacum*(15 samples), cucumber *Cucumis sativus* (35 samples), eggplant *Solanum melongena*(25 samples) and spinach *Spinacia oleraceae* (20 samples).

These samples were taken at a depth of 15-30 cm from soil surface. Each sample was divided into three sub samples (100 cc each), and placed in polyethylene bags; bags were then kept in the refrigerator at 4°C.

2.1.2 Plant parasitic nematode extraction

Nematodes were extracted from soil samples by sieve- centrifuge method (Goody 1963).

Centrifuge Method (Goody 1963):-

1) 100cc soil sample free from roots and stones were placed in 500cc beaker and mixed in 200 ml tap water, and left for 30 second.
2) The suspension was sieved in 325 mesh sieve and then centrifuged at 3000 rpm for 4 minutes.
3) Water was then removed and the tubes were filled with sugar solution (484.5 gram sugar/ one liter water) and mixed with the suspension.
4) The solution was rotated at 3000 rpm for one minute.
5) The liquid layer containing the sugar, water and nematodes (suspension) was then sieved in 325 mesh/ one inch and condensated in Petri dish with 5 ml of water for further examination.

2.1.3 Plant parasitic nematode identification

After the extraction of nematodes from soil samples, the suspentions of plant parasitic nematode were placed in Petri dishes. By using micro pipette, plant parasitic nematodes were placed on a slide in a drop of suspension; the nematodes were then killed by passing the microscope slide over a burner flame several times (Ayoub, 1980). By using light microscope, nematode genera and species were thereof identified according to their morphological characteristics such as (stylet type, knobs shape, ovary type, tail shape, vulva site and esophagus shape) according to Thorne (1961), Goody (1963) Taylor and Sasser (1978) and Ayoub (1980).

2.1.4 Plant parasitic nematode quantification

After the identification, the resulting suspension (from extraction) were placed in counting Petri dish and the number of nematodes were counted(per 100 cc soil sample) (Thorne, 1961 and Sultan, 1981).

The mean numbers were recorded.

The occurrence of plant parasitic nematode species (populations) in the rhizosphere of plants grown in the West Bank fields or orchards, greenhouses, and open fields of vegetables were determined. The mean number of plant parasitic nematode species in each district was estimated.

2.2 Plant parasitic nematode survey in nurseries

2.2.1 Soil sample collection

One hundred and fifty five soil samples were collected from 21 Nursery, (three replicate for each sample of transplant from each nursery of grape, olive, almond, apple, guava, loquate, pomegranate, citrus and figs). Samples were collected from private nurseries in the West Bank districts; (Jenin, Tulkarm, Nablus, Qalkelia and Hebron).

Each plant species from each nursery represented one sample (3 pots) with three replicate (one pot each).

Soil samples which were taken from almond pieces were taken at a depth of 15-30 cm from soil surface (300 cc each) and divided into three sub sample 100 cc each.

2.2.2 Soil samples analyses

Soil texture (sand, silt and clay percent), organic matter and pH have been examined for each nursery. Walky-Black method (titration method) to determine organic matter and pipette method for soil texture analysis (Tan, 1995).

2.2.3 Plant parasitic nematode extraction and isolation

Nematodes were thereof separated from sub samples by sieve-centrifuge method (Goody 1963) as in 2.1.2 and and placed in Petri dishes.

2.2.4 Plant parasitic nematode identification

After the extraction, and by using micro pipette, bamboo pick or paintbrush hair, one nematode was placed on slide and then killed by passing the microscope slide over burner flame several times (Ayoub, 1980).

The nematode genera and species were examined and identified by light microscope according to their morphological characteristics (Thorne, 1961, Goody, 1963, Taylor and Sasser, 1978, and Ayoub, 1980).

2.2.5 Plant parasitic nematode quantification

After the identification the resulting suspension (from extraction) were placed in a counting petri dish which represented the extracted nematodes from 100 cc soil sample (the sub samples), and each species were counted as in 2.1.4.

2.3 Root knot nematodes distribution

2.3.1 Plant sample collection

Samples were collected randomly from 260 greenhouses planted with cucumber and tomato and distributed all over the West Bank districts (Hebron, 45 samples;, Bethlehem, 20 samples; Jericho and Jordan Valley, 35 samples; Nablus, 35 samples; Tulkarm, 35 sample; Qalkelia, 30 samples; Jenin, 30 samples and Tubas, 30 samples). Each greenhouse represents one sample; sub samples were taken by randomly uprooting three plants from each greenhouse (roots and its surrounding soil) placed in plastic bags and held in the refrigerator at 4 ^{o}C.

2.3.2 Root knot nematode extraction identification and quantification

Infected roots were removed and carefully washed with tap water, stained with cold Lacto phenol- Acid-Fuchshin and stored in it for not less than 24 hours. Later, these stained roots were cleaned with lactic acid and rinsed in water to remove the excess lacto phenol (Goody 1963).

According to Taylor and Sasser (1978), three females with their eggmasses from fine lateral root for each replicate were detached by using fine needle and dissecting microscope and identified according to the posterior cuticular pattern (Perennial pattern) of adult females.

Numbers of eggs per eggmass were counted by using light microscope. In order to count the number of nematode stages in five grams of infected roots, ten gram of galled (infected) roots were taken and blendered for one minute in blender (Mulinex Type AWY, Model: Depose, OPTIBLEND 2000) with fifty ml of tap water. The suspension of root knot nematodes was collected by 325 mesh sieves into twenty ml solution. Ten ml of homogenized resulting solution were aftermath placed in counting Petri dishes as in 2.4.1 and 2.2.5. Moreover, the number of mature, immature females and larval stages were counted three times, and the mean number of the three replicate was recorded.

Later on, eggmasses were separated from infected fine roots by using the dissecting microscope and fine bladed knife. The numbers of eggmasses per five gram of infected fine roots were counted using the same procedure for counting the number of eggs per one eggmass. Hence, the mean number of three replicate for each sample was taken and the collected data was recorded.

Chapter3

Results and Discussion

3.1 Plant parasitic nematodes distribution in the West Bank soils

The study showed that several species of plant parasitic nematode were found associated in the rhizosphere of cultivated field crops, vegetables and orchards. The results demonstrated that 43 species of plant parasitic nematodes belonging to 24 genera (Table 3.1.1 and 3.1.3) were found distributed in the West Bank open fields (irrigated and non irrigated vegetables and crop fields), orchards and greenhouses.

The results showed that *Helicotylenchus*, *Tylenchorhynchus*, *Criconemoides* and *Meloidogyne* species were the most common nematode genera in the West Bank areas and on wide range of plants and plant groups.

3.1.1 Plant parasitic nematodes distribution in relation to host plant

The survey reveals the occurence of *Helicotylenchus* spp. at high populations in the rhizosphere of all plants except figs, broad bean, lettuce and cabbage (Table 3.1.1 and 3.1.2). Moreover, *Tylenchorhynchus* spp. were found with high populations in the rhizosphere of all plants except melon, cabbage, squash and spinach. The populations of *Tylenchorhynchus* spp. per 100 cc of soil samples were 240 nematodes in citrus orchards, 320 in stonefruit, 310 in vegetables, 320 in olive orchards, 340 in field crops, 350 in grapevine and 360 for both banana and date palm (Table 3.1.2)**.** In addition, *Criconemoides* species were found in high population in stone fruit soils, pomegranate and olive orchards with populations that reached about 350 in stone fruit and pomegranate and 140 per 100 cc soil in olive orchards. *Meloidogyne* species were likewise recorded as second stage larvae in stone fruits (80/ 100 cc soil). Meanwhile, *Meloidogyne* species in intensive agriculture of tomatoes and cucumber greenhouses were found at population mean of 120/ 100 cc soil (Table 3.1.2 and 3.1.3). According to Barker and Olthof (1976), Potter and Olthof (1993), Jacobsen (1997), these numbers were considered lower than the threshold levels.

According to Mamluk *et al* (1984) and Ismail (1997), *Criconemoides* spp. were found distributed in two Arab countries, precisely in Egypt and Jordan only. This survey showed that this species was widely spread in Hebron, Jericho and Jordan Valley as well as Tulkarm areas (Table 3.1.3).

Psilinchus spp. was known to be distributed in three Arab countries Egypt, Jordan and Sudan. (Yassin, 1987. Ibrahim *et al.*, 2000. Hashim, 1979 and Abu Gharbieh, 1987). Correspondingly, this work showed that one species of this nematode (*Psilinchus hilarilus*) had been discovered in one sample of broad bean in the Hebron area.

Yousef and Jacob (1994), Al-Hazmi *et al* (1995) Ibrahim (2002) and Ibrahim *et al* (2000) have all recorded that *Hemicriconemoides* spp. were widely spread in Egypt, Jordan and Saudi Arabia. In parallel, current survey confirmed the existence of *Hemicriconemoides cocophillus* in two samples of citrus in Jenin.

The current survey indicated that *Criconemoides* spp. were found spread in the rhizosphere of stone fruits, pomegranate and quince with a population mean of 350/ 100 cc soil, and with a population mean of 140/ 100 cc soil in olive trees (Table 3.1.3).

Xiphinema spp. were also found associated with the rhizosphere of all plant groups except field crops and vegetables. But it was distributed with high populations in grapevine samples with a population mean of 130/100cc soil.

Longidorus spp. were found with populations of 10, 30, 20, 40, 40 and 10/ 100 cc soil in field crops, stone fruit, grapevine, olive, citrus and vegetable; bananas and date palm soils were identified free from these nematodes. However, results (table 3.1.2) indicated that *Xiphinema* and *Longidorus* spp. were distributed with low populations in vegetables and field crops and with high populations in grape, stonefruit and olive orchards.

Furthermore, the nematode genera *Anguina, Ditylenchus, Helicotylenchus, Hoplolaimus, Longidorus, Paratylenchus, Rotylenchus, Trichodorus, Tylenchorhynchus, Tylenchus* and *Xiphinema* were found common and widely distributed in the West Bank areas, as indicated in (Table 3.1.1). A similar results were found in the arab countries as mentioned by Ibrahim (2002), Ibrahim *et al* (2000) Abu Gharbieh (1987), Yousef and Jacob (1994) Hashim (1979), El Maleh and Edongali (1995), Ammati (1987), Al- Hazmi *et al* (1995) and Yassin (1987).

According to Oteifa and Shaarawi (1962) and Siddiqi (1974), *Tylenchulus semipenetrans* is widely distributed all over world's citriculture areas. Similarely, *T. semipenetrans* was also widely distributed in Hebron, Bethlehem, Tulkarm, Jenin, Jericho and Jordan Valley citriculture areas.

Four species of *Pratylenchus* (*P. thornei, P. crenatus, P. neglectus* and *P. penetrans*) were found vastly distributed in the 1948-occupied region of Palestine (Orion *et al.*, 1982), and in Syria (Saxena *et al.*, 1988 and Greco *et al.*, 1984), former Yugoslavia, Mexico and Australia (Fortuner, 1977), Canada (Yu, 1997), Morocco (Ammati, 1987), Pakistan and India

(Maqbool, 1988), Algeria (Troccoli *et al*., 1992) and Italy (Lamberti, 1981). This study showed that, three species of *Pratylenchus* (*P. thornei*, *P. penetrans* and *P. vulanus*) were distributed in the West Bank areas with populations ranged between 20-70 per 100 cc soil sample and with wide host range that included field crops, fruit trees and vegetables (Table 3.1.1, 3.1.2 and 3.1.3). According to Jacobsen (1997), these levels of population are supposed to be destructive to plants root growth.

As for *Meloidogyne artiellia*, it has been allocated in field crops in the 1948- occupied region of Palestine (Mor and Cohn, 1989). Through the current survey, this species was not found in the West Bank areas. Nevertheless, two species of root knot nematode (*M. incognita* and *M. javanica*) that attack crops in tropical and subtropical areas were detected in all cultivated crops except citrus orchards in the West Bank.

In fruit crops, the results showed that olive, citrus and stone fruit had the highest diversity of plant parasitic nematodes genera and species (Table 3.1.1).

Moreover, the study showed that tomatoes and broad bean have the highest number of plant parasitic nematodes genera and species among vegetables (Table 3.1.1).

Table 3.1.1 Plant parasitic nematodes found associated in the rhizosphere of plant groups

Plant Groups		Nematode Genera and Species
Field Crops	wheat durum, *Triticum aestivum*	*Anguina tritici*, *Helicotylenchus digonicus*, *Paratylenchus* spp., *Pratylenchus thornei*, *Tylenchorhynchus* spp. and *X. pachtaicum*
	Lentil, *Lens culinaris*	*Heterodera goettingiana*, *Pratylenchus thornei*, *Trichotylenchus* spp. and *Tylenchorhynchus* spp.
	Corn, *Zea myze*	*Tylenchus davainii*, *Tylenchus minotus*, *Tylenchus filiformis*, *Pratylenchus thornei* and *Tylenchorhynchus clarus*
	Okra, *Hibiscus esculentus*	*Tylenchus minotus*, *Meloidogyne* spp., *Tylenchorhynchus clarus* and *Tylenchorhynchus dubius*
	Onion, *Allium cepa*	*Ditylenchus* spp., *Helicotylenchus* spp., *Criconemoides* spp., *Heterodera* spp., *Longidorus siddiqi*, *M. javanica*, *M. incognita*, *Pratylenchus thornei*, *Trichodorus* spp. and *Tylenchorhynchus dubius*
	Garlic, *Allium sativum*	*Ditylenchus* spp. and *Meloidogyne javanica*

Continue table 3.1.1

Stone fruits and other Fruit Trees	Stone fruit, *Prunus* spp.	*Aphelenchus avenae, Aphelenchoides* spp., *Criconemoides* spp., *Hoplolaimus* spp., *Helicotylenchus* spp., *Tylenchus* spp., *Tylenchorhynchus* spp., *Xiphinema* spp., *Longidorus* spp., *Meloidogyne* spp., *Paratylenchus* spp., *Pratylenchus* spp. and *Trichodorus* spp.
	Pomegranate, *Punica granatum*	*Helicotylenchus* spp., *Helicotylenchus digonicus, Criconemoides* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Xiphinema* spp. and *X. pachtaicum*
	Quince, *Cydonia oblonga*	*Helicotylenchus pseudorobustus, H.tunisiensis, Pratylenchus thornei, Tylenchorhynchus dubius* and *X. pachtaicum*
	Apple, *Malus sylvestris*	*Longidorus* spp., *Helecotylenchus* spp., *H. tunisiensis, Longidorus* spp., *Paratylenchus* spp., *Tylenchorhynchus* spp. and *X. pachtaicum*
	Fig, *Ficus carica*	*Xiphinema index, X. pachtaicum, Paratylenchus* spp. and *Pratylenchus thornei*
	Walnut, *Junglans regia*	*Helicotylenchus digonicus, Criconemoides* spp., *Meloidogyne* spp., *Pratylenchus thornei, Tylenchorhynchus dubius, Tylenchorhynchus clarus, X. index, X. pachtaicum* and *X. insigne*

Continue; Table 3.1.1

Plant Groups		Nematode Genera and Species
Other Fruit Trees Groups	Grape, *Vitis vinifera*	*Criconemoides informis, Helicotylenchus digonicus, Hemicycliophora* spp., *Meloidogyne* spp., *Tylenchorhynchus clarus, Xiphinema index, X. pachtaicum, X. vuittenezl, Pratylenchus* spp.
	Olive, *Olea europeae*	*Tylenchorhynchus clarus, Tylenchorhynchus dubius, Criconemoides* spp., *Criconemoides informis, X. index, X. insigne, X. pachtaicum, Tylenchorhynchus* spp., *Pratylenchus thornei, Paratylenchus* spp., *M. javanica, M. incognita, Longidorus siddiqi, Helecotylenchus pseudorobustus, H. dihystera, H.tunisiensis* and *Tylenchulus semipenetrans*
	Citrus, *Citrus* spp.	*Helicotylenchus abunaamai, H. pseudorobustus, Hemicriconemoides cocophillus, Hoplolaimus* spp., *Longidorus africanus, L. siddiqi, Macroposthonia xenoplax, Paratrichodorus minor, Paratylenchus* spp., *Pratylenchus neglectus, Trichodorus sparsus, Tylenchorhynchus clarus, Tylenchorhynchus dubius, Tylenchulus semipenetrans, Xiphinema index, X. insigne, X. pachtaicum*
	Banana, *Musa paradisiacal*; Date palm, *Phoenix dactylifera*	*Helecotylenchus pseudorobustus, H. dihystera, H. multicinctus, Hoplolaimus pararobustus, Longidorus laevicapitatus, L. siddiqi, Meloidogyne javanica, X. insigne, Tylenchorhynchus dubius, Pratylenchus thornei*

Plant Groups		Nematode Genera and Species
Vegetables	Pepper, *Capsicum annum*	*Helicotylenchus digonicus, M. incognita, Paratylenchus* spp., *Pratylenchus* spp., *Hemicyclophora obesa, Tylenchorhynchus* spp. and *Xiphinema* spp.
	Potato, *Solanum tubersum*	*Ditylenchus* spp., *Helicotylenchus* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Xiphinema* spp. and *Heterodera restechiensis*
	Lettuce, *Lactuca sativa*	*Tylenchus filiformis , Helicotylenchus digonicus H. dihystera, H. pseudorobustus, Meloidogyne* spp., *Paratylenchus* spp. and *Tylenchorhynchus* spp.
	Melon, *Cucumis melo*	*Tylenchus minotus, Tylenchus davainii, M.incognita* and *M. javanica*
	Common bean, *Phaseolus vulgaris*	*Tylenchus thorni, M. javanica, H. dihystera, H. pseudorobustus, Pratylenchus thornei, Pratylenchus penetranse* and *Trichodorus sparsus*
	Broad bean, *Vicia faba*	*Tylenchus minotus, Tylenchus davainii, Ditylenchus dipsaci, Helicotylenchus digonicus, Helicotylenchus tunisiensus, Heterodera goetlingiana, Psilenchus hilarilus, Pratylenchus thornei, Tylenchorhynchus clarus, Tylenchorhynchus dubius* and *M. javanica*
	Cabbage, *Brassica oleracea*	*Helicotylenchus dihystera, H. pseudorobustus, M. javanica, T. clarus, T. dubius, Pratylenchus thornei, Pratylenchus penetranse*
	Carrot, *Daccus carota*	*Criconemoides* spp., *Helicotylenchus* spp., *Heterodera* spp., *M. javanica, M. incognita* and *Pratylenchus* spp.
	Cauliflower, *Brassica oleracea*	*Criconemoides* spp., *M. javanica, M. incognita* and *Tylenchorhynchus dubius*
	Chard, *Beta vulgaris*	*Paratylenchus* spp., *Pratylenchus* spp. and *Tylenchorhynchus* spp.

Continue; Table 3.1.1

Plant Groups		Nematode Genera and Species
Vegetables	Turnip, *Brassica rapa*	*Helicotylenchus* spp., *Heterodera* spp., *Meloidogyne* spp., *Tylenchorhynchus dubius* and *Tylenchorhynchus clarus*
	Squash, *Cucarbita pepo, C.maxima, C.mixa*	*Meloidogyne javanica*, *Tylenchus davainii* and *T. filiformis*
	Tomato, *lycopersicon esculentum*	*Criconemoides* spp., *Helicotylenchus* spp., *Hemicyclophora* spp., *Heterodera* spp., *Longidorus africanus, L. siddiqi, M. javanica, M. incognita, Paratrichodorus* spp., *Pratylenchus penetrans, Pratylenchus thorni, Rotylenchus reniformis, Trichodorus sparsus, Tylenchorhynchus dubius* and *Xiphinema index*
	Tobacco, *Nicotina tabacum*	*Meloidogyne* spp.,*Pratylenchus* spp. and *Tylenchorhynchus* spp.
	Cucumber, *Cucumis sativus*	*M. javanica, M. incognita, Helicotylenchus* spp., *Hemicyclophora* spp., *Pratylenchus thornei, Paratylenchus* spp. and *Tylenchorhynchus dubius*
	Eggplant, *Solanum melongena*	*M.javanica, M. incognita, Tylenchorhynchus dubius, Pratylenchus thornei, H. pseudorobustus, Hemicyclophora* spp. and *Ditylenchus* spp.
	Spinach, *Spinacia oleraceae*	*Helicotylenchus* spp., *Heterodera* spp. and *Pratylenchus* spp.

Table 3.1.2 Average number of plant parasitic nematodes in the rhizospheres of plant groups

Nematode Genera	Plant Groups						
	A	B	C	D	E	F	G
	Nematode Number/ 100 cc Soil						
Aphelenchus avenae	20	20	20	20	10	20	10
Aphelenchoides spp.	20	10	10	30	0	0	30
Chriconemoides spp.	0	350	0	140	10	10	0
Ditylenchus spp.	70	0	0	0	10	30	30
Helicotylenchus spp.	26	30	37	40	32	34	27
Heterodera spp.	20	0	0	0	0	0	30
Hoplolaimus spp.	0	30	10	10	0	20	10
Tylenchus spp.	50	60	40	50	40	60	70
Tylenchorhynchus spp.	340	310	350	320	240	360	320
Tylenchulus semipenetrans	0	15	35	15	300	0	0
Xiphinema spp.	0	70	130	10	10	40	0
Longidorus spp.	10	30	20	40	40	0	10
Meloidogyne spp.	40	80	30	50	0	60	120
Paratylenchus spp.	10	20	0	0	0	20	20
Pratylenchus spp.	60	30	30	20	30	20	70
Rotylenchus spp.	10	0	0	10	0	20	10
Trichodorus spp.	0	10	10	10	0	10	10

*A: Field crops, B: Stonefruit and other fruit trees (apple, pomegranate, quince, fig and walnut), C: Grapevines, D: Olive trees, E: Citrus, F: Banana, Date palm, G: Vegetables.

*Each number represent the mean number of three replicate.

3.1.2 Plant parasitic nematode distribution in relation to districts (geographical)

Results of determining the existence of plant parasitic nematodes species and their populations in the West Bank areas are recorded in (Table 3.1.3).

The nematodes *Helicotylenchs digonichus*, *Tylenchorhynchus clytoni*, *M. incognita* and *Tylenchulus semipenetrans* were found distributed in Hebron district with high populations (more than 100/ 100 cc soil). Moreover, *Helicotylenchus tunisiensis, Criconemoides xenoplax, Tylenchorhynchus dubius* and *Xiphinema index* were also found distributed at moderate population (25- 100 / 100 cc soil) in Hebron area (Table 3.1.3).

In Bethlehem, *M. incognita* (Table 3.1.3) exists with high populations (more than 100/ 100 cc soil). But, *Helicotylenchus digonichus. H. tunisiensis T. semipenetrans* and *X. index* were found distributed at moderate populations (less than 100 and more than 25/ 100 cc soil).

Furthermore, *Helicotylenchus multicinctus Tylenchorhynchus clarus*, *T. clytoni* and *M. javanica* were found with high populations in Jericho and Jordan valley (more than 100/ 100 cc soil sample). Yet, the following nematodes: *Helicotylenchus volgaris*, *Tylenchorhynchus dubius*, *Tylenchulus semipenetrans*, *Xiphinema index*, *Pratylenchus thorni* and *P. vulanus* were found with populations that ranged between 25 - 100 / 100 cc soil).

Helicotylenchus digonichus were notably spread with high population in Ramallah and Nablus (100/ 100 cc soil), but found at moderate population in Jenin and Tulkarm (less than 100 and more than 25/ 100 cc soil sample).

In addition, *Heterodera* spp. were detected in the 1948-occupied region of Palestine, Australia, Canada, South Africa, Japan and most European countries (Kort, 1972), India (Sharma and Swarup, 1984; Sikora, 1988) and countries within North Africa and West Asia, including Morocco, Tunisia, Pakistan. However, the results showed that *H. tunisiensis* was discovered at moderate population intensity in Ramallah and Nablus. As for *Heterodera avenae* and *H. goettingiana*, they are detected at moderate population density in Tulkarm only.

In the same concern, *Tylenchorhynchus clarus, T. clytoni* and *T. dubius* were widely found in Ramallah, Nablus, Jenin and Tulkarm. *T. clarus* and *T. clytoni* were similarly found in Ramallah at population's density less than 25/ 100 cc soil. Besides, *T. clarus* was found across Nablus, Jenin and Tulkarm with a populations' range of 26- 100/100 cc soil. Likewise, *T. clytoni* was located in the same area of Jenin and Tulkarm with same population range. Nonetheless, *T. dubius* was shown to be in same populations (26- 100/100 cc soil) in Ramallah and Nablus.

Respectively, this study also demonstrated that the populations of *Tylenchorhynchus clytoni* and *T. dubius* existed at high levels in Nablus and Tulkarm. Moreover, *M. javanica* and *M. incognita* were widely spread in all West Bank districts (Table 3.1.3). *M. javanica* was found with low populations less than 25 second stage larvae / 100 cc soil sample in Hebron and Bethlehem the but not in Ramallah area. As for Nablus area, *M. javanica* was distributed at a population range of 26-100 second stage larvae / 100 cc soil. However, the high population of *M. javanica* was obvious in Jericho and Jordan valley, Jenine and Tulkarm. On the other hand, *M. incognita* was spread out at high populations in Hebron, Bethlehem and Ramallah, and at moderate populations in Nablus, Jenine and Tulkarm. However, Jericho and Jordan Valley samples were free from *M. incognita*.

Concerning the destribution of plant parasitic nematodes to the districts temperature means; *Helicotylenchus digonichus H. tunisiensis* and *M. incognita* were found in high populations in the cool climate districts (Hebron, Beithlehem, Ramallah and Nablus) with mean yearly temperature mean of 15.5, 16, 17.1 and 17.8 ^{0}C respectively Meteorology directorate-Ramallah (2007).

On the other hand, *Tylenchorhynchus clarus* and *H. multicinctus* was found distributed at high population (more than 100 / 100 cc soil) just in Jericho& J.valley, however *T. clarus* distributed in mid population (25-100/ 100 cc soil) in Nablus Jenin and Tulkarm and in low population in Hebron, Beithlehem Nablus and Ramallah (cool climate districts). *M. javanica* were found distributed in high population in Jericho& J.valley, Jenin and Tulkarm and with mid populations in Nablus.

Pratylenchus thorni was found distributed in the hot areas of Jericho and Tulkarm at a population range of 25- 100/ 100 cc soil, while this ppecies was found at population range 1-25/ 100 cc soil in the other areas of the West Bank. Corresponding, *Trichodorus sparsus* was found distributed in Jericho and Tulkarm at population range of 1-25/ 100 cc soil.

Xiphinema brevicola, *Longidorus laivicapitatus* and *L. braicaudatus* were found distributed vastly in the hot areas of Jericho, Tulkarm, Jenin and Nablus at population range of 1-25/ 100 cc soil, and the cool districts were found free from these nematodes.

Table3.1.3: Mean number of plant parasitic nematodes soecies in West Bank districts

Nematode genera and species	Districts						
	Hebron	Bethlehem	Jericho& J.valley	Ramallah	Nablus	Jenin	Tulkarm
Aphelenchus avenae	*	0	*	0	0	0	*
Criconemoides xenoplax	**	0	*	0	0	0	*
Detylenchus spp.	*	*	0	*	*	0	0
Helicotylenchus Vulgaris	*	*	**	*	*	*	*
H. digonichus	***	**	*	***	***	**	**
H. dihystera	*	0	*	0	*	*	*
H. tunisiensis	**	**	*	**	**	*	0
H. Pseudorabustus	0	0	*	0	0	*	*
H. multicinctus	0	0	***	0	0	0	**
Heterodera spp.							
H. avenae	0	0	0	0	*	*	**
H. goettingiana	0	0	*	0	0	*	**
H. rostochiensis	0	0	*	0	0	*	*
Tylenchus davainii	*	*	*	*	*	*	*
T. filiformis	*	*	0	*	*	0	*
T. minotus	*	*	*	*	*	*	*
T. thorni	*	*	*	*	*	0	0
Tylenchorhynchus clarus	*	*	***	*	**	**	**
T. clytoni	***	*	***	*	***	**	**
T. dubius	**	*	**	**	**	*	***

*(0): Free of nematodes. (*): Low densities (1 - 25 nematodes/ 100 cc soil). (**): Mid densities (26 - 100 nematodes / 100 cc soil). (***): High densities (more than 100 nematode / 100 cc soil sample).

*Each number represents the mean number of 3 replication.

Continue, Table3.1.3: Mean number of plant parasitic nematodes soecies in West Bank districts

Nematode genera and species	Districts						
	Hebron	**Bethlehem**	**Jericho& J.valley**	**Ramallah**	**Nablus**	**Jenin**	**Tulkarm**
Tylenchulus semipenetrans	***	**	**	0	0	*	**
Xiphinema brevicola	0	0	*	0	*	*	*
X. index	**	*	**	*	*	*	*
X. iingens	*	*	0	0	*	*	0
X. pachtaicum	*	*	0	*	*	*	0
Hoplolaimus spp.	0	0	*	0	*	*	*
Longidorus laivicapitatus	0	0	*	0	0	*	*
L. braicaudatus	0	0	*	0	0	*	*
L. veniacola	0	0	0	0	0	*	*
M. javanica	*	*	***	0	**	***	***
M. incognita	***	***	0	***	**	**	**
Paratylenchus minor	0	0	0	0	0	*	*
Pratylenchus penetrans	*	0	*	*	*	*	*
P. thorni	*	*	**	*	*	*	**
P. vulanus	*	*	**	*	0	*	**
Rotylenchus robustus	0	0	*	0	*	**	*
Trichodorus christei	*	0	*	0	0	0	*
T. sparsus	0	0	*	0	0	0	*

0): Free of nematodes. (*): Low densities (1 - 25 nematodes/ 100 cc soil). (**): Mid densities (26 - 100 nematodes / 100 cc soil). (***): High densities (more than 100 nematode / 100 cc soil sample).

*Each number represents the mean number of 3 replication.

3.2 Plant parasitic nematodes distribution in the West Bank nurseries

3.2.1 Plant parasitic nematodes distribution in relation to host plant

The results showed that 15 genera of plant parasitic nematodes were stumbled upon the rhizosphere of plants grown in nurseries in high populations.

The survey indicated that *Tylenchorhynchus* spp. was commonly located in 61 samples out of 155 examined samples; (about 39.4%.) distributed with high populations in the rhizosphere of almond, grapevines, olive, pomegranate, figs, apple, guava and loquat grown in nurseries (18 nurseries out of 21). However, the occurrence of these nematodes may have resulted from the use of infected soils in nurseries. The main source of the soil used in nurseries is orchards and fields in addition to the last reused non sold transplant's soil.

In addition, the tolerance of *Tylenchorhynchus* spp. to drought in nurseries is one of the main reasons for its wide spread in the rhizosphere of the West Bank nurseries as recorded in table (3.1.2 and 3.1.3). The same result was mentioned by Peterson (1962) and Ruehle (1975).

On the other hand, the other fourteen plant parasitic nematodes genera mentioned in table (3.2.2, A – J) (*Xiphinema* spp., *Criconemoides* spp., *Tylenchulus semipenetrans, Longidorus* spp., *Tylenchus* spp., *Trichodorus* spp., *Pratylenchus* spp., *Paratrichodorus* spp., *Paratylenchus* spp., *Helicotylenchus* spp., *Titylenchus* spp., *Rotylenchus* spp., *Psilinchus hilarilus,* and *Meloidogyne* spp.) were discovered in lower numbers than *Tylenchorhynchus* spp. The percent of these nematodes in collected samples were: 17.4%, 24.5%, 12.9%, 7.1%, 7.7%, 9%, 15.5%, 7.1%, 15.5%, 23.9%, 1.9%, 4.5%, 1.3% and 9% (Table 3.2.2, A-J).

Similar results were found by Peterson (1962) and Ruehle (1975) who identified *Meloidogyne* spp., *Hoplolaimus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp and *Xiphinema* spp. as the most damaging nematodes genera in fruit tree nurseries.

However Siddiqui *et al* (1973) suggested that, *Xiphinema* spp. was the most important nematodes associated with the nurseries of commercial crops in California. This current work revealed that *Xiphinema* spp. came in fourth position of occurence after *Tylenchorhynchus*, *Criconemoides* and *Helicotylenchus* species in West Bank nurseries.

Michael and McClure (1999) and Rashid *et al* (1973) mentioned that, *Meloidogyne* spp., *Xiphinema* spp., *Pratylenchus* spp. and *Criconemoid* spp. were found alone or in combination, causing a high degree of damage in grape nurseries. However, this current study showed that, 57% of grape samples (8 of 14 samples) were associated with *Tylenchorhynchus* spp. with population range between 75 -136 / 100 cc soil sample, 35.7% associated with *Xiphinema* spp. with population range between 31.7- 109/ 100 cc soil, 0.7% *Pratylenchus*, *Criconemoid* and *Meloidogyne* spp. with population of 67.3, 75.3 and 22.3 / 100 cc soil.

Rashid *et al* (1973) found that, *Rotylenchulus reniformis* and *Hoplolaimus indicus* attack grape in nurseries. According to the results obtained, grape nurseries were identified as free from *Hoplolaimus* species, but 21.4% of West Bank grape-nurseries samples were infested with *Rotylenchulus reniformis*.

Nicol *et al* (2002) revealed that, *Criconemoid xenoplax, Pratylenchus penetrans, Pratylenchus vulnus, Meloidogyne incognita* and *Meloidogyne javanica* were the most plant parasitic nematodes species that associated in the rhizosphere of olive nurseries. The population range of these species was between 100- 5000 second stage larva per 100cc soil in at least 10 % of olive nurseries in Spain. Although, this curent survey showed that, *Tylenchorhynchus* spp. was the most common nematodes in olive nurseries with 65% (13 nurseries out of 20); 46.7 of these samples had a population range of 100- 275/ 100 cc soil. Twenty % of olive nurseries samples were infested with *Criconemoid* spp.; 10% were with populations of 112 and 156.7 /100 cc soil, and one sample eere found infested with *Pratylenchus penetrans*.

According to Alam *et al* (1979) *Rotylenchulus reniformis* and *Tylenchus filiformis* can cause economic damage to citrus nurseries. However, in this study, citrus nurseries in the West Bank were free from *Rotylenchulus reniformis*, and *Tylenchus* species were only found in one sample with a population of 18.7/ 100 cc soil sample. But, 53.3% of citrus samples were infested with *Tylenchulus semipenetrans*. This agrees with Abu-Gharbieh and Perry (1970) who found that *Tylenchulus semipenetrans, Hoplolaimus indicus* and *Belonolaimus longicaudatus* were the most destructive species in citrus nurseries in Jordan. But, the results obtained confirmed that the citrus nurseries were free from *Hoplolaimus indicus* and *Belonolaimus longicaudatus.*

Alam *et al* (1979) and Abu-Gharbieh and Perry (1970) have both classified citrus as poor host for root knot nematodes, but Siddiqui (2004) confirms the existence of 13% (2 samples of 15) contains root knot nematode with a populations of 19.7 and 20.7 nematodes per 100 cc soil.

By comparing the diversity and the number of plant parasitic nematodes in the rhizosphere of almond plants grown in nurseries land' pieces and in pots, the results proved that the diversity of plant parasitic nematodes were being higher in land' pieces than in pots (Table 3.2.2, A and B); the population were higher in pots than that in land' pieces. However, *Tylenchorhynchus* spp. were found in all examined samples of almond plants grown in land' pieces and the population ranged between 14.7- 51.7 nematodes/ 100 cc soil; 60 % of the examined samples of almond plants grown in pots were investigated, with a population range between 10.9- 119.3 / 100 cc soil (Table 3.2.2, A).

On the other hand, results recorded in table (3.2.2, A and B) shows that about 80% of almond root stocks (stone fruits) land' pieces were infested with *Criconemoides xenoplax* with a population range between 23.3- 47.7 nematode/ 100 cc soil. However, the percentage of infestation in plants grown in pots was about 77% with a population range between 16.3- 257.7 nematode/ 100cc soil.

Helicotylenchus spp. occurred in about 33.3% of nurseries with one or more species and with a population range between 11.3- 16 nematodes / 100 cc soil. Furthermore, the results showed that *Paratylenchu*s spp. were found with high populations in the rhizosphere of almond (pots), apple, guava, pomegranate, citrus and fig nurseries.

3.2.2 Soil texture

The present work clearly reveals that plant parasitic nematode populations correlate positively with the increase of sand percent in the soil. This agrees with previous studies done by Hagan (1994) and Noling (2003). Results (table 3.2.1 and 3.2.2 E) showed that high populations were recorded in grape nurseries samples that contain high percent of sand. *Tylenchorhynchus* spp. population mean numbers in each sample were found 120 per 100 cc soil. But in the samples which contained low sand percent, *Tylenchorhynchus* spp. were found with population range of 55.3 to 97 per 100 cc soil.

Results agree with Loof (1974), Hagan (1994), Norton *et al* (1984) and Noling (2003); they found that the populations of plant parasitic nematodes are usually rated highest in light- sandy soils.

*Paratylenchu*s spp. was found positively correlated with sand percent of soil samples. However, the observation of Loof (1974) indicated that this nematode can only be highly populated in agricultural crops in fine-textured soils whereas its damage was seriously considered less in sandy soils. He also mentioned that this nematode caused destruction and poor growth on tap-rooted trees grown in light soils just in dry seasons. In this case, the population-symptoms relation may appear earlier in heavy-fine soils where the roots growth rate are less (as slow growth rate and low population building up are established on sensitive plants).

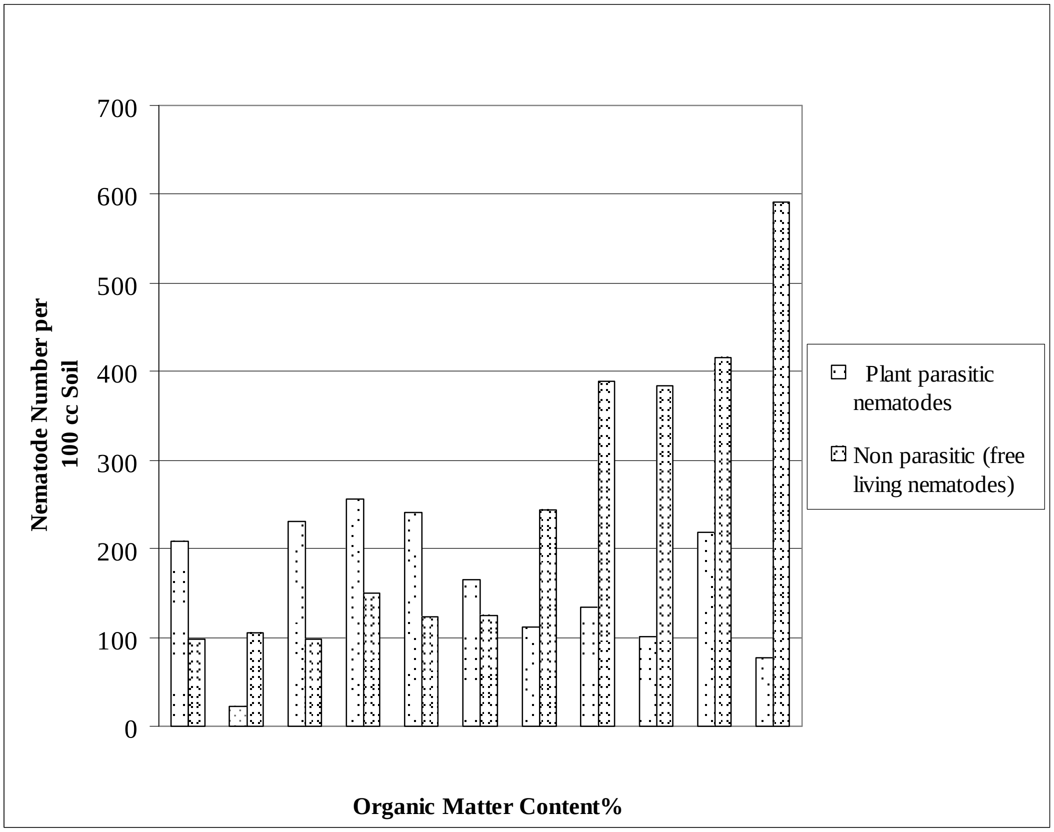
3.2.3 Organic matter content

By comparing the plant parasitic nematodes populations in nursery' samples (Table 3.2.2, A-K) and the soil properties (Table 3.2.1), the current study clearly portray that the plant parasitic nematodes population decrease in the soil with high organic matter content. However, these results agree with that mentioned by Huebner *et al* (1983) and Rodriguez-Kabana (1986). They showed that high concentration of urea fertilizer reduced the populations of plant parasitic nematodes. Also the results of Meyer *et al*. (2002), Floret and Serpantie (1993) and Ferris and Bernard (1971) indicated that the increase of organic matter content of soil reduced the number of plant parasitic nematodes.

Table (3.2.2, D), represents the populations of plant parasitic and non parasitic (freeliving) nematodes in the rhizosphere of apples grown in nurseries. The observation indicated obviously that as the organic matter content increases, the free living nematodes populations also increased, whereas the plant parasitic nematodes populations decreased. Thereof, Fig (3.2.1) showed the relationship between the number of plant parasitic and free living nematodes with organic matter content in the soil samples of apples grown in nurseries. Hence, the populations of plant parasitic nematode appear at the highest level in the soil of 0.47%, 0.5% and 0.19% organic matter content (more than 200 nematodes per 100 cc of soil sample). The low levels of plant parasitic nematodes appeared at organic matter content % of 3.39%, 3.34%, 2.89%, and 2.67%. On the other hand, the population of freeliving nematodes appeared in low levels in soil samples of organic matter content ranging between 0.19- 0.81% and began to increase constantly at the organic matter content of 0.96%. Thereof, the population of free living nematodes reached the highest population (665 nematode/100 cc soil) at the organic matter content of 3.39%.

Results may be due to the presence of free living nematodes and the other natural enemies in the soils at high organic matter contents that cause reduction of plant parasitic nematodes' populations or even for other possible reason related to soil texture. The same results was strongly confirmed by Firris and Bernard (1971), Floret and Serpantie (1993), Malozzi *et al* (2001), Meyer *et al*. (2002), and LaMondia and Cowles (2002). However, they found that high organic matter content can increase the suppression of plant parasitic nematode population building up by increasing the vigor of natural enemies.

Fig 3.2.1: **Plant parasitic and free-living nematode populations/ 100 cc soil sample in relation to organic matter contents in apple nurseries**



3.2.4 Soil pH

Results showed that the pH of soils used in nurseries (Table 3.2.1) ranged between 6.5 and 7.9. The results showed that there was no visible relation between nematode populations in nurseries and soil pH.

Table 3.2.1: Physical and chemical properties of the soils used in nurseries of the West Bank

Nursery Data		Soil Properties				
Nurseries	**Location**	**O.M%**	**pH**	**Sand%**	**Silt%**	**Clay%**
H1	Hebron	2.98	7.2	31.71	10.6	57.69
Q1	Qalkelia	0.47	6.7	82.91	2.64	14.45
H2	Hebron/Halhul	2.98	7.3	29.11	16.28	54.61
Q1	Qalkelia	0.5	7.3	25.908	18.84	55.252
Q2	Qalkelia	0.81	7.3	84.51	2.6	12.89
H3	Seaer	0.19	6.5	85.11	2.6	12.29
T1	Tulkarm	2.67	7.4	74.39	7.64	17.97
T2	Tulkarm	1.21	7.5	75.23	4.16	20.61
Q3	Qalkelia	3.14	7.3	26.55	20.84	52.61
J1	Jenin	1.83	7.2	15.15	31.56	53.29
N1	Nablus	0.5	6.8	86.51	4.56	8.93
N2	Nablus	3.39	7.8	14.59	22.32	63.09
H4	Hebron/Haska	2.05	7.0	40.47	5.04	54.49
T3	Tulkarm	0.4	7.4	84.51	2.6	12.89
T4	Tulkarm	0.5	7.5	66.39	5.08	28.53
H5	Hebron	0.96	7.3	32.75	9.84	57.41
H3/ A	Hebron	3.6	6.9	33.11	13.8	53.09
H2/A	Hebron/Halhool	1.74	7.1	22.15	31	46.89
Q4	Qalkelia	0.19	7	65.79	11.12	23.09
H6/A	Hebron	4.07	7.9	27.95	9.28	62.77
Q5	Qalkelia	0.19	7.1	34.308	42.92	22.772
Q6	Qalkelia	0.34	6.9	75.87	2.12	22.01
J1/ A	Jenin	1.52	7.5	34.31	42.9	22.77

* Each value represents the mean number of three replicates for each nursery.

Table 3.2.2: Plant parasitic nematodes associated with the rhizosphere of plants grown in nurseries / 100cc soil:

A: Groundbeds soil (Almond)												
Nursery number	**Nematode Population/100cc soil**											
	Tr	**X**	**Cr**	**T**	**L**	**Th**	**H**	**Pty**	**Prt**	**Tri**	**Ptr**	R.K.N
H3/ A	33	0	27.7	0	13.7	0	10.3	0	31.7	0	0	0
H4	51.7	0	47.7	0	0	56.3	0	107	0	0	0	31.7
H2/A	32.3	0	27	0	0	33	0	78.3	16.7	0	0	0
H6/A	14.7	0	23.3	0	0	0	6.7	0	0	17.3	0	0
J1/ A	29.3	0	0	38.3	0	0	0	70.7	0	0	42.3	18

B: Pots soil (Almond)												
Nursery number	**Nematode Population/100cc soil**											
	Tr	**X**	**Cr**	**T**	**L**	**Th**	**H**	**Pty**	**Prt**	**Tri**	**Ptr**	R.K.N
H1	23.7	0	72.7	0	13.3		0	0	0	0	0	0
Q1	84	0	91	0	0	42.7	0	0	0	0	0	0
H2	0	19	16.3	0	0	11.7	0	0	0	0	0	12.3
Q2	59.3	0	0	0	0	0	0	0	98.3	0	0	0
T1	23	0	74	0	0	0	0	0	0	0	41	24
T2	0	0	0	50.7	0	0	0	0	0	0	60	0
Q3	10.7	0	0	12.3	0	0	0	0	0	0	9.7	0
N1	0	0	219	0	22.3	0	0	0	0	0	0	0
N2	11.7	0	19.7	0	0	5	0	0	0	0	0	0
T4	49	0	168.3	0	0	0	0	0	0	0	0	0
H5	0	0	44.3	0	0	0	0	0	0	0	0	0
Q4	0	0	257.7	64.3	0	0	0	0	0	0	0	33.3
T2	119.3	0	93	0	0	19.7	0	50.3	74.7	0	0	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, L: *Longidorus* spp., Th: *Tylenchus.* H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Ptr: *Paratrichodorus spp*, R.K.N: root knot nematode

C: Pots soil (Olive)											
Nursery number	**Nematode Population/100cc soil**										
	Tr	**X**	**Cr**	**T**	**Th**	**H**	**Pty**	**Prt**	**Tri**	**Ptr**	R.K.N
H1	33.3	0	37.7	0	0	9	0	0	22.3	0	0
Q1	88.7	0	0	0	0	17.3	0	0	113	0	0
H2	0	0	0	0	0	2.7	0	31	0	0	18.3
H3	100	0	0	51.3	0	0	0	0	0	0	0
T1	241.3	0	112	0	32.7	8.7	0	0	0	0	0
T2	0	0	156.7	0	0	0	0	0	87.7	19	0
Q3	40	0	19.3	4.3	0	0	0	0	0	0	0
J1	41	41.7	0	0	62.7	0	0	25	0	0	0
N1	275	0	0	31.7	16.3	23.7	105.7	0	0	0	0
N2	35	18.3	0	0	0	0	0	0	0	0	0
T4	145.7	0	0	0	0	0	0	0	0	0	0
H5	0	0	0	0	0	3.7	0	0	0	0	0
Q4	180.7	0	0	0	0	0	0	0	0	0	35
Q5	237.3	0	0	33.7	0	0	0	0	0	0	13
Q6	148.3	0	0	0	0	0	0	0	0	0	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, Th: *Tylenchus* spp., H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus penetrans*, Tri: *Trichodorus* spp., Ptr: *Paratrichodorus* spp., R.K.N: Root Knot Nematodes.

D: Pots soil (Apple)							
Nursery number	**Nematode Population/100cc soil**						
	Tr	**X**	**H**	**L**	**Pty**	**Prt**	**Free living nematodes**
H1	72.7	12.7	6	16.3	54	56.7	543.7
Q1	92.7	20.3	22.7	25	125.7	106.3	89
H2	0	8	6.7	0	32.3	53.3	501.7
Q2	123	21.3	20.7	0	0	0	124
H3	0	0	22.7	0	0	0	105.7
T1	0	0	13.3	0	93.7	81	448.7
T2	87	0	0	47.3	0	0	388.7
Q3	0	5	11.7	0	0	21.3	605
J1	0	9.7	5	0	0	0	383
N1	232.7	0	24	0	0	0	149.3
N2	37	0	4	8.7	14.7	0	665.3
T4	216.7	24.7	0	0	0	0	122.7
H5	100	0	0	0	0	11.7	244
Q4	209	0	0	0	0	0	98.7
Q5	32.7	0	12	0	0	24.3	107

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., L: *Longidorus* spp., Th: *Tylenchus* spp., H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp.

E: Pots soil (Grape)													
Nursery number	**Nematode Population/100cc soil**												
	Tr	**X**	**Cr**	**T**	**Tityl**	**Th**	**H**	**Pty**	**Prt**	**Tri**	**Ptr**	R.K.N	Rty
Q1	97.3	0	0	0	0	0	15.7	0	33	0	0	0	0
H2	93.7	0	75.3	0	0	0	11.3	0	0	17	0	0	32.3
H3	124.3	0	0	0	0	0	0	0	0	0	0	0	0
T1	0	58	0	0	0	0	15	67.3	0	0	0	0	23
T2	0	0	0	0	0	0	0	0	47	66.3	0	0	0
Q3	0	31.7	0	0	0	25.3	0	0	0	0	0	22.3	0
J1	55.3	0	0	0	0	0	16	0	0	0	0	0	0
N1	136	70.7	0	0	0	0	0	0	0	0	0	0	0
N2	75	0	0	42.7	21.3	0	0	0	0	0	0	0	0
T4	0	109	0	0	0	0	0	0	0	0	0	0	97.7
H5	99.7	74	0	0	0	0	0	0	0	0	0	0	0
Q4	122.7	0	0	0	0	0	0	0	0	0	0	0	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, Th: *Tylenchus* spp., H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Ptr: *Paratrichodorus* spp., Tityl: *Titylenchus* spp., Rty: *Rotylenchulus reniformis*, R.K.N: Root knot nematodes.

F: Pots soil (Guava)										
Nursery number	Nematode population/100cc soil									
	Tr	X	Cr	T	Th	H	Pty	Prt	Tri	Ptr
T4	68.7	75.7	0	55	14.3	0	0	84.3	0	0
Q4	70.7	0	234	77	0	86.7	0	0	76	0
N1	0	85.7	0	0	0	0	75.7	0	0	66

G: Pots soil (Loquate)									
Nursery number	Nematode population/100cc soil								
	Tr	X	Cr	H	Pty	Tri	Ptr	R.K.N	L
Q1 /Loquate	10.3	29		0	12.7	41	0	17.3	25.7
T3	0	0	77.3	179.3	39.3	0	0	0	48.7
H3	0	0	246.7	0	0	0	0	36.7	77.3
T1	0	0	126	0	0	0	0	0	0
Q3	0	0	0	73.3	0	0	35.3	20	0
J1	0	0	57	0	0	0	0	0	0
N2	0	0	69.3	0	0	0	0	0	24
H5	70.3	38.7	0	0	0	0	0	0	0
Q4	0	0	95.3	0	91.3	0	0	0	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, L: *Longidorus* spp., Th: *Tylenchus* spp., H: *Helicotylenchus*. spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Ptr: *Paratrichodorus* spp., R.K.N: Root knot nematodes.

H: Pots soil (Pomegranate)													
Nursery number	**Nematode Population/100cc soil**												
	Tr	**X**	**Cr**	**T**	**Tityl**	**Th**	**H**	**Pty**	**Psyl**	**Prt**	**Tri**	**Ptr**	R.K.N
Q1	0	0	269	0	0	0	22.7	0	0	0	0	67.3	0
Q2	0	0	313	0	0	0	0	0	0	75	0	0	0
T1	0	65.3	0	0	0	0	27.7	0	0	90	0	0	0
Q3	15	0	33.7	0	0	0	4.3	0	0	25.7	0	0	0
J1	0	0	0	0	50.7	0	0	0	0	0	0	0	0
N2	57.7	51.3	80.7	12.3	0	21.7	0	0	0	0	0	0	0
T4	0	79.3	0	0	0	0	0	45.7	0	0	76.7	0	44
Q4	107	0	0	0	70.7	0	0	0	37.7	0	0	0	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, Th: *Tylenchus* spp., H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Ptr: *Paratrichodorus* spp., Tityl: *Titylenchus* spp., Psyl: *Psilenchus hilarilus* R.K.N: Root knot nematodes.

I: Pots soil (Citrus)											
Nursery number	**Nematode Population/100cc soil**										
	Tr	**X**	**Cr**	**T**	**Th**	**H**	**Pty**	**L**	**Prt**	**Tri**	R.K.N
Q1	79.3	0	0	125.3	0	0	0	0	70	0	0
Q2	79	0	0	130.3	0	0	0	0	0	0	0
T1	0	84	101.3	0	0	19	0	0	0	0	0
T2	74.3	0	0	0	0	0	53.7	72.3	0	0	20.7
Q3	0	0	0	37	0	7.3	0	0	0	31.3	0
J1	0	44.3	0	48.3	0	0	0	0	0	0	0
N1	0	0	0	241	0	0	0	0	0	0	0
N2	0	0	0	69	18.7	0	0	0	0	0	0
T4	191	0	0	0	0	0	0	0	37	0	19.7
Q4	253.7	0	68.7	181.3	0	0	0	0	0	34.7	0
Q5	0	0	0	82.3	0	0	0	0	0	64	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, L: *Longidorus* spp., Th: *Tylenchus* spp., H: *Helicotylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Rty: *Rotylenchulus reniformis*, R.K.N: Root knot nematodes.

J: Pots soil (Figs)												
Nursery number	**Nematode population /100cc soil**											
	Tr	**X**	**Cr**	**T**	**Psyl**	**H**	**Pty**	**Prt**	**Tri**	**Ptr**	Rty	R.K.N
H1	0	20.7	51	0	0	0	0	0	0	0	0	23.7
Q1	0	66.3	0	0	0	254.3	76.7	78.7	0	0	0	0
H2	0	12.7	40.7	0	0	0	0	0	0	42.7	15.7	0
Q2	0	53	219	0	0	0	0	0	0	0	0	0
H3	125	0	0	0	0	241	0	0	233	0	0	0
T1	0	0	0	0	0	0	0	0	0	108	0	0
T2	108.3	0	0	75.7	22	0	56.7	0	0	0	0	0
Q3	26.7	0	0	0	0	0	39	0	740	0	0	0
J1	0	0	0	0	0	54	21.7	0	0	0	0	0
N1	0	0	0	0	0	184	0	0	0	139.7	83.7	0
N2	20.3	0	18.3	0	0	10.7	0	21	23.3	0	0	0
T4	0	0	151.7	0	0	0	0	0	0	0	0	0
H5	0	0	0	0	0	0	0	0	0	0	0	0
Q4	97.3	0	0	0	0	122	0	0	0	0	70.3	0
Q5	48.3	0	46.3	0	0	0	0	0	0	0	67.7	0

*Tr: *Tylenchorhynchus* spp., X: *Xiphinema* spp., Cr: *Criconemoides xenoplax*, T: *Tylenchulus semipenetrans*, H: *Helicotylenchus* spp., Pty: *Paratylenchus* spp., Prt: *Pratylenchus* spp., Tri: *Trichodorus* spp., Ptr: *Paratrichodorus* spp., Rty: *Rotylenchulus reniformis* Psyl: *Psilenchus hilarilus*, R.K.N: Root knot nematodes.

3.3 Root knot nematodes distribution

Root knot nematodes (*Meloidogyne* species) are widely spread in most West Bank greenhouses planted with tomatoes and cucumber. The study showed that about 21.2% of tomatoes and cucumber grown in sampled greenhouses were infected with root knot nematodes (55 greenhouse/260 greenhouses visited). Moreover, results showed that *Meloidogyne javanica* represented about 58.2% of root knot nematodes found in the examined infected samples, while *M. incognita* % was 41.8% (Table 3.3.3 and 3.3.4).

The collected information about the history of root knot nematode infections in the greenhouses describes the build up of infestation over time. More than 70% of these infested greenhouses were treated 1-2 times with soil borne-disease fungicides before, which may have contributed in reducing the nematopathogenic fungi which allowed the population, build up of plant parasitic nematodes.

The data recorded in table (3.3.1…3.3.4) represent the occurrence and the number of *M. javanica* and *M. incognita* stages in infected roots of cucumber and tomatoes grown in greenhouses in the West Bank. Data (Table 3.3.3 and 3.3.4) showed that all the examined samples collected from Jericho and Tubas areas were infected with *M. javanica*. In the same concern, *M javanica* was widely distributed all over the West Bank but with more infestation in Jericho and Tubas than that in Tulkarm, Qalkelia, Jenin, Hebron and Nablus. Generally speaking, *M. javanica* infested cucumber and tomato greenhouses intensively in (Tulkarm, Qalqelia, Tubas, Jericho and Jenin), the hot climate areas of the West Bank. But it was found in high populations in two areas of Hebron district (Al-Samo'a and Tarqumia) where temperatures in these areas are usually higher than the other areas of the Hebron district with 4-5 °C.

In addition to that, the result indicated that *M. incognita* dominanted with high populations in the South of the West Bank (Hebron and Bethlehem areas) which represents some of the cool areas of the West Bank (Hebron and Beithlehem, 850 – 1000 m elevation) above sea level, (Meteorology directorate, 2007) (Map 3.3.1, Table 3.3.1, fig 3.3.5, 6, 7 and 8).

Concerning the geographical distribution of *M. Javanica* and *M. incognita* in the West Bank areas especially in the high land areas (cool areas), data were similar to that found in Jordan (Abu Gharbieh, 1994).

In this respect, *M. incognita* were found in the mountain areas were cool and moderate temperature prevail (21- 25°C) (Bethlehem, Hebron and Nablus). However, *M. javanica* were found in the coastal areas as well as in the Jordan Valley (ghour) where the temperatures around 30°C and above Table (3.3.1).

Correspondingly, Fig 3.3.1 to 3.3.8 showed that *M. incognita* and *M. javanica* populations were correlate to the temperature. However, *M. javanica* mature, immature females and eggmasses number/ 5 gram roots (3-4 month age cucumber and tomatoes) in the cool climat areas were 17.8, 23.4 and 19 respectively and in moderate climate areas were 22.5, 49.1 and 28.6 respectively and in hot climate areas were 33.6, 69.8 and 40.6 respectively (Fig 3.3.1). In addition Fig 3.3.2 showed that the number of eggs / one eggmass of *M. javanica* distributed in greenhouses areas in cool climate areas (3-4 month age cucumber and tomatoes) in cool climate areas was 328.7, in moderate climate areas was 395.7 and in hot climate areas was 480.4.

Concerning the *M. incognita* populations in the west bank, in cool areas the mean number of *M. incognita* mature, immature females and eggmasses/ 5 gram roots (3-4 month Age cucumber and tomatoes) in Fig 3.3.5 were 26.8, 45.3 and 23 respectively, in moderate climate areas were 5.1, 9.3 and 5.2 respectively. Hot climate areas were found free from *M. incognita*.

These results are also agreed with Abu Gharbieh (1982) and Atieh (1986) who mentioned that 75% of root knot nematode *M. javanica* in Jordan was located in the hot climate of the south middle of Ghour. They have also affirmed the presence of *M. incognita* in the higher areas of North Ghour, Deir alla, Zarka and Jarash.

Concerning the rainfall level, the current result conflict with the assertion mentioned by Toyler and Sasser (1982). Indeed, they have recognized that *M. javanica* are located in areas with rainfall level less than 550 mm (the North areas of West Bank). On the other hand, *M. incognita* is distributed in areas with rainfall levels higher than 550 mm. However, in current study (greenhouses), the rainfall level has no significant effects on the population building up of root knot nematodes, since current data has been taken from plants grown in greenhouses. It is well known that all the West Bank greenhouses are under closed systems with steady treatment (water quantity). However, the rainfall may play an important role in the spread of root knot nematodes in uncovered and unirrigated vegetables.

Previous results indicated that the populatiom building up of *M. incognita* and *M. javanica* were corelated to the temperature of the districts which agrees to Abu Gharbieh (2004).

Table 3.3.1 Distribution of *M. javanica* and *M. incognita* in relation to the mean temperature avarage in the growing season (from 1/ June to 1/ October)

	Area	**Mean Temperature °C(from 1 June- 30 September) ****	**Percent of root knot nematodes infestation**	**Percent of *M. javanica* %**		**Percent of *M. incognita* %**	
Cool Areas	**Bethlehem**	22.5	30%		16.67		83.33
	Hebron	21.5	24.4%	30.4	18.18	69.6	81.82
	Nablus	24.1	17.14%		66.67		33.33
Moderate Areas	**Jenin**	26.8	20%		66.67		33.33
	Tulkarm	29.4	22.86%	80	87.5	20	12.5
	Qalqilia	28.4	20%		83.33		16.67
Hot Areas	**Tubas**	30	16.66%	100	100	0	0
	Jericho	31	17.14%		100		0

***Cool Areas**: Mean temperature avarage from 1/ June- 1 October range between 21-25 **°C**, **Moderate Areas**: Mean temperature avarage from 1/ June- 1 October range between 25.1- 29.5 **°C** and **Hot Areas**: Mean temperature avarage from 1/ June- 1 October range higher than 29.6 **°C**.

Plate 3.3.1**(High infestation with *M. incognita*- Cucumber/ Hebron)**

Plate 3.3.2 **(EM: Eggmass of *M. incognita* on Grapevine root, Hebron)**

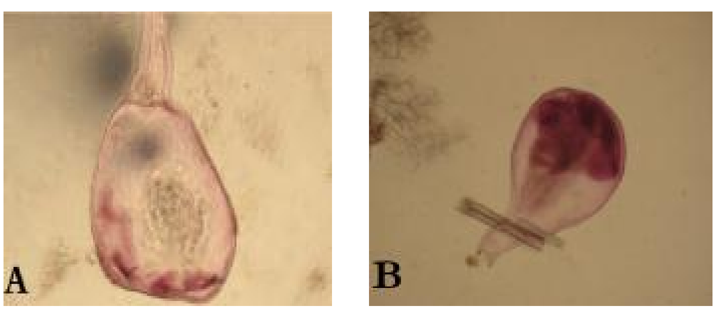


Plate 3.3.4: **A: First day maturity of *M. incognita* female, B: *M .incognita* mature female began the production of eggs.**

Table 3.3.2: Mean number of root knot nematode stages in 5 gram of infected roots of cucumber grown in greenhouses

District	Sample #	PA	RKN spp.	MF	3ST	2ST
Nablus	N1	2	*M. incognita*	1.3	2.7	3
	N2	4	*M. javanica*	20.3	6.7	6.7
	n6	3	*M. javanica*	11.7	14.7	8.3
Jenin	J 8	3.5	*M. javanica*	16.7	18.7	13
	J 7	3	*M. incognita*	6.7	3.3	4
	J6	2	*M. javanica*	23	21.3	14
	J 9	2	*M. javanica*	7.3	12.3	15.7
Qalkelia	Q10	3	*M. javanica*	27.7	22.3	25.3
	Q7	2	*M. javanica*	25.3	22	19.7
Tulkarm	T 16	2.5	*M. javanica*	30	24.7	22.3
	T3	2	*M. incognita*	1	2.3	3
	T 18	4	*M. incognita*	5.7	3.7	5.7
	T 5	3	*M. javanica*	36.7	30	34.3
	T8	2	*M. javanica*	30	23.3	24.7
Tubas	Tu7	2	*M. javanica*	33	29.3	30.7
	Tu1	3	*M. javanica*	43	37.7	36
Bethlehem	B 3	3	*M. incognita*	37	32.3	35
	B 4	2	*M. incognita*	31.3	29	31.3
Hebron	H1	4	*M. javanica*	18.7	11	11.3
	H2	4	*M. incognita*	46	30	31.3
	H.3	2	*M. incognita*	26.7	19.7	20.3
	H4	4	*M. incognita*	39.3	30	31
	H5	3.5	*M. javanica*	35.3	28.7	30.7
Jericho	Je1	3	*M. javanica*	39.7	33.7	33.7
	Je2	3	*M. javanica*	36.7	26.7	32.7

*PA: Plant age (month), MF: The Number of mature fem/5 g root, 2ST: Second Stage Larva/ 5 g Root, 3ST: 3rd Stage Larva/ 5 g Root.

*Each value represents the mean number of 3 replicate to one infected greenhouse.

Table3.3.3: Mean Number of Root Knot Nematode stages in 5 gram of Infected Roots of Tomatoes Grown in Greenhouses

Districts	Sample#	PA	RKN spp.	MF	3ST	2ST
Nablus	N 7	4	*M. incognita*	9	5.3	4.3
	n12	4	*M. javanica*	18.7	4	6.3
	n13	2	*M. javanica*	6	11.3	12.3
	N 11	3	*M. incognita*	7.3	7.3	5.3
Jenin	J1	4	*M. incognita*	6.7	4.3	2.7
	J5	3	*M. javanica*	19.7	19.3	15
Qalkelia	Q23	3.5	*M. javanica*	31	24.7	26.7
	Q17	2.5	*M. incognita*	1	2	3
	Q5	3	*M. javanica*	32.7	24	25.7
	Q1	2	*M. javanica*	25	19.3	23
	Q2	4	*M. incognita*	3	3.7	7.7
Tulkarm	T 17	3.5	*M. javanica*	36.3	31	30.7
	T10	3.5	*M. javanica*	39	31.7	36.7
Tubas	Tu5	2	*M. javanica*	35	31.3	34.3
	Tu3	3	*M. javanica*	43	35.7	37
	Tu4	2.5	*M. javanica*	35.7	27	33.7
Bethlehem	B 1	2	*M. javanica*	13.3	11.7	13.7
	B 2	2.5	*M. incognita*	35.3	30.7	29.3
	B 11	3	*M. incognita*	37.3	30.7	36
Hebron	H7	3	*M. javanica*	18.7	19.3	20.7
	H8	2.5	*M. incognita*	26.7	18.7	22.7
	H9	3.5	*M. incognita*	30	21.7	20.3
	H10	4	*M. incognita*	38.7	24.7	24.7
	H12	2	*M. incognita*	23.7	17	18.3
	H13	3	*M. incognita*	30.7	26	28.3
Jericho	Je13	2	*M. javanica*	29.3	23.3	25
	Je8	2.5	*M. javanica*	37	30.3	26.3
	Je6	2	*M. javanica*	31.7	28	24.3

*PA: Plant age (month), MF: The Number of mature fem/5 g Root, 2ST: Second Stage Larva/ 5 g Root, 3ST: 3^{rd} Stage Larva/ 5 g Root.

*Each value represents the mean number of 3 replicate to one infected greenhouse

Table3.3.4: Mean Number of Root Knot Nematode eggmasses per 5 gram of Infected Roots of Cucumber Grown in Greenhouses and the Mean Number of eggs per Eggmass

District	Sample #	PA	RKN spp.	Mean Number of Eggmass/5 gram Roots	Mean Number of eggs per Eggmass
Nablus	N1	2	*M. incognita*	1	44.3
	N2	4	*M. javanica*	24.3	304.3
	n6	3	*M. javanica*	13.3	345.3
Jenin	J 8	3.5	*M. javanica*	16.3	422.7
	J 7	3	*M. incognita*	7.3	60.3
	J6	2	*M. javanica*	15.7	453
	J9	2	*M. javanica*	8	456.7
Qalkelia	Q10	3	*M. javanica*	18	455
	Q7	2	*M. javanica*	15.7	598.3
Tulkarm	T3	2	*M. incognita*	1.7	38.7
	T 16	2.5	*M. javanica*	25	531.7
	T 18	4	*M. incognita*	5	45.7
	T 5	3	*M. javanica*	31	508.3
	T8	2	*M. javanica*	23.7	520
Tubas	Tu7	2	*M. javanica*	30.7	616.7
	Tu1	3	*M. javanica*	36	501.7
Bethlehem	B 3	3	*M. incognita*	28.3	523.3
	B 4	2	*M. incognita*	25.3	553.3
Hebron	H1	4	*M. javanica*	12.3	150.7
	H2	4	*M. incognita*	32.3	478.3
	H3	2	*M. incognita*	22	583.3
	H4	4	*M. incognita*	30	405
	H5	3.5	*M. javanica*	32.7	411.7
Jericho	Je1	3	*M. javanica*	34.3	500
	Je2	3	*M. javanica*	30.3	490

*PA: Plant age (month), RKNspp: Root knot nematode species**.**

*Each value represents the mean number of 3 replicate to one infected greenhouse

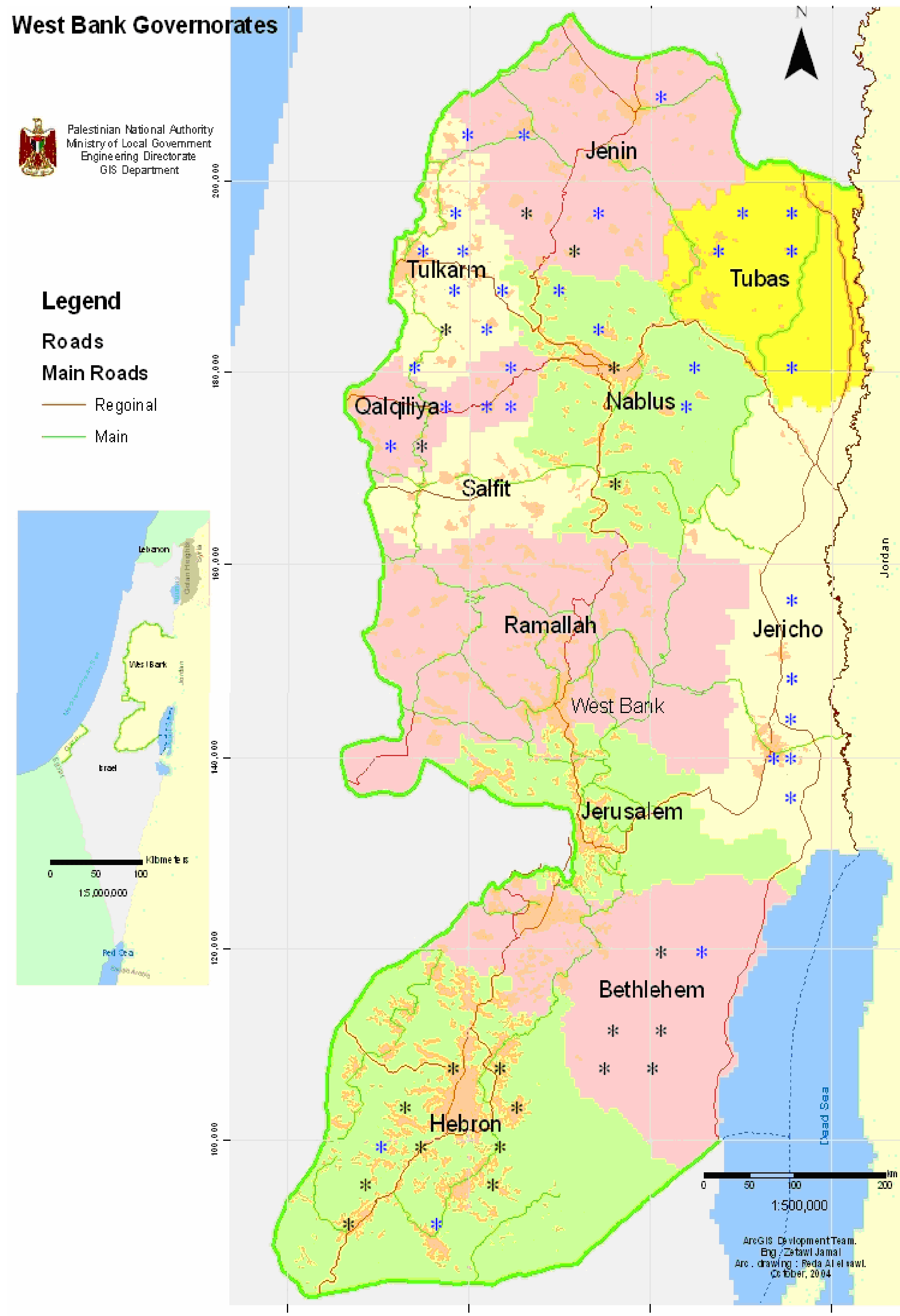
Table3.3.5: Mean Number of Root Knot Nematode eggmasses per 5 gram of Infected Roots of Tomatoes Grown in Greenhouses and the Mean Number of eggs per Eggmass

District	Sample#	PA	RKNspp.	Mean Number of Eggmass/5 gram Roots	Mean Number of eggs per Eggmass
Nablus	N 7	4	*M. incognita*	12	58.3
	n12	4	*M. javanica*	23.7	347
	n13	2	*M. javanica*	5.7	361
	N 11	3	*M. incognita*	5.7	71.7
Jenin	J1	4	*M. incognita*	7.3	55.7
	J5	3	*M. javanica*	16.3	410.7
Qalkelia	Q23	3.5	*M. javanica*	21.3	401.7
	Q17	2.5	*M. incognita*	1.7	40.7
	Q5	3	*M. javanica*	18.3	458.3
	Q1	2	*M. javanica*	19.7	568.3
	Q2	4	*M. incognita*	3.3	64
Tulkarm	t17zeta	3.5	*M. javanica*	31	491.7
	T10	3.5	*M. javanica*	34.3	495
Tubas	T5	2	*M. javanica*	29.3	608.3
	T3	3	*M. javanica*	33.7	543.3
	T4	2.5	*M. javanica*	29.7	533.3
Bethlehem	B N1	2	*M. javanica*	10.7	113.3
	B.Tq 2	2.5	*M. incognita*	29.3	523.3
	B 1	3	*M. incognita*	32	495
Hebron	H7	3	*M. javanica*	22.7	167.3
	H8	2.5	*M. incognita*	23	556.7
	H9	3.5	*M. incognita*	20.7	473.3
	H10	4	*M. incognita*	24.3	426.7
	H12	2	*M. incognita*	19.3	545
	H13	3	*M. incognita*	30	461.7
Jericho	Je13	2	*M. javanica*	20.3	615
	Je8	2.5	*M. javanica*	30.7	588.3
	Je6	2	*M. javanica*	25.3	621.7

*PA: Plant age (month), RKNspp: Root knot nematode species.

*Each value represents the mean number of 3 replicate to one infected greenhouse

Map3.3.1 **Distribution of Root Knot Nematode species (*M. javanica* and *M. incognita*) in Tomato and Cucumber Greenhouses in West Bank.**



*: *M. javanica*. *: *M. incognita*.

Fig 3.3.1**: *M. javanica* Mature, Immature Females and Eggmasses Number/ 5 Gram Roots (3-4 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

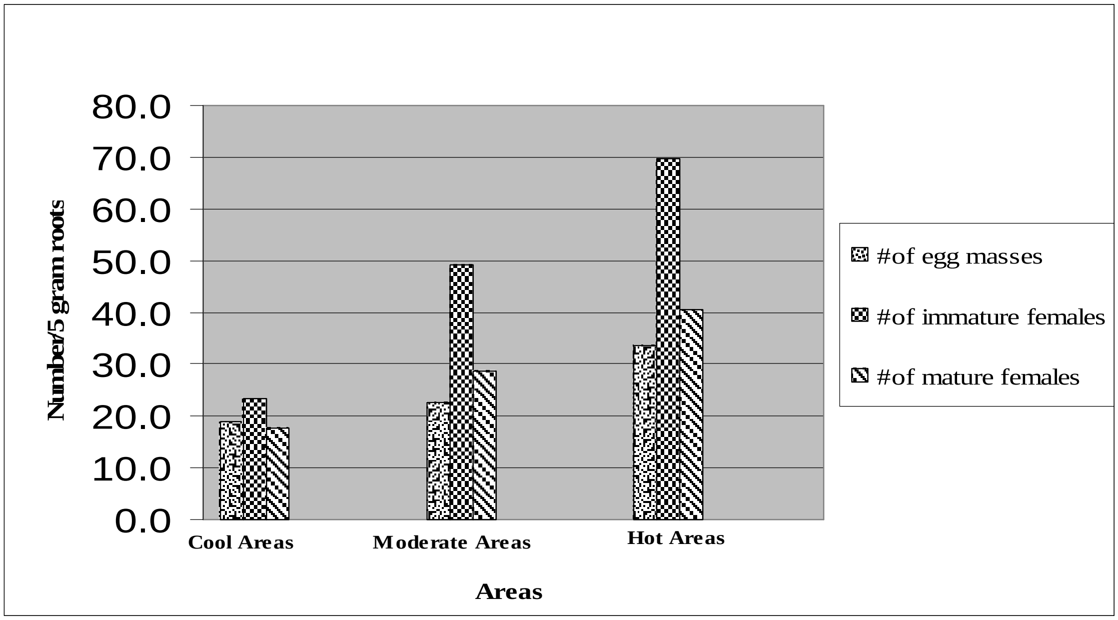


Fig 3.3.2: **Mean Number of Eggs / One Eggmass of *M. javanica* Distributed in Greenhouses Areas in the West Bank (3-4 Month Age Cucumber and Tomatoes) in Relation to The Mean Temperature in the Growing Season.**

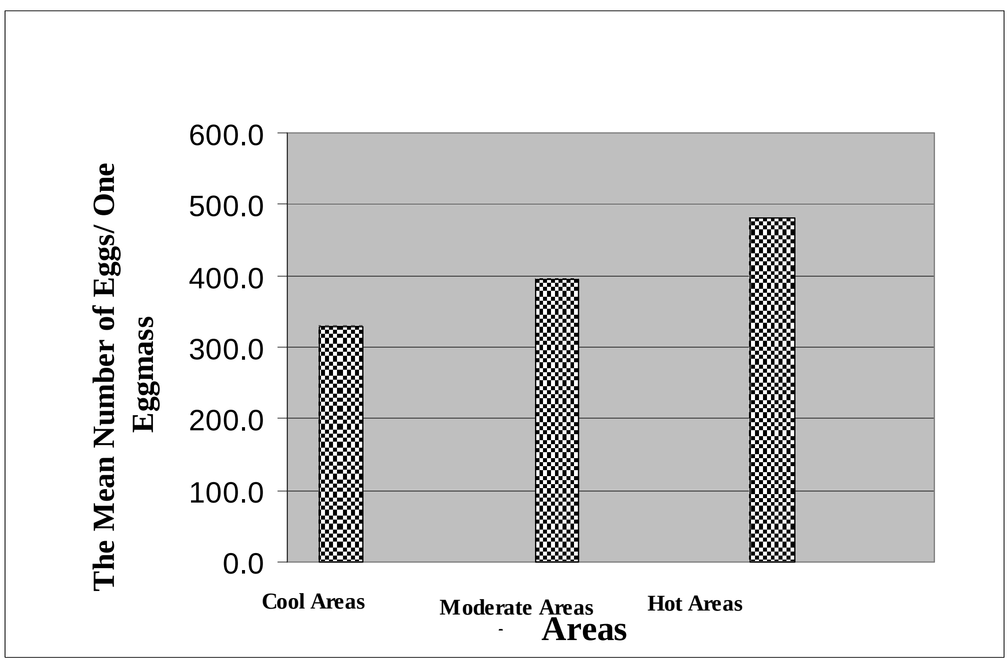


Fig 3.3.3: **Mean Number of *M. javanica* Mature, Immature Females Eggmasses/ 5 Gram Roots (Less Than 3 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

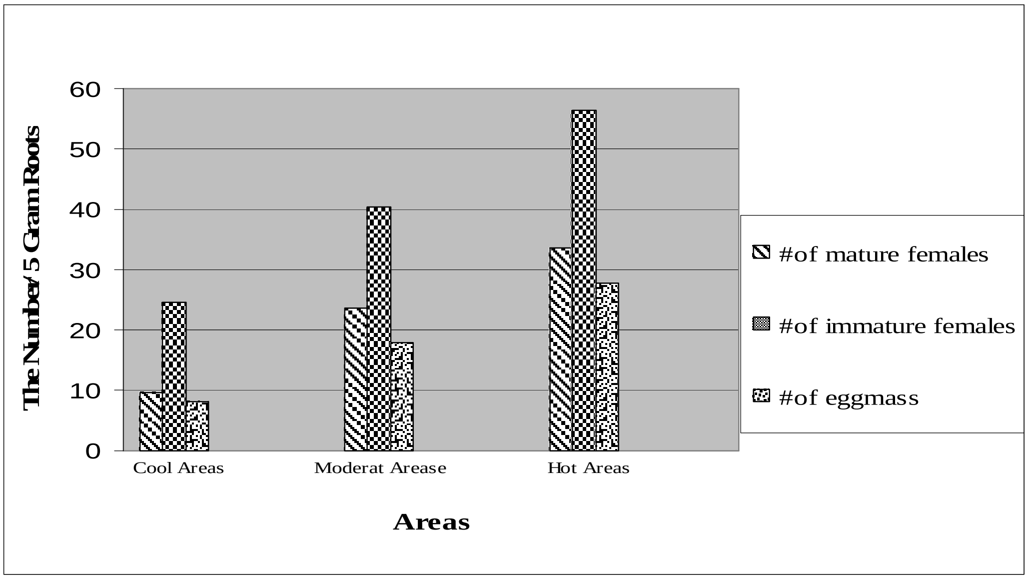


Fig 3.3.4: **Mean Numbers of Eggs/ One Eggmass of *M. javanica* Distributed in Greenhouses Areas in the West Bank(Less Than 3 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

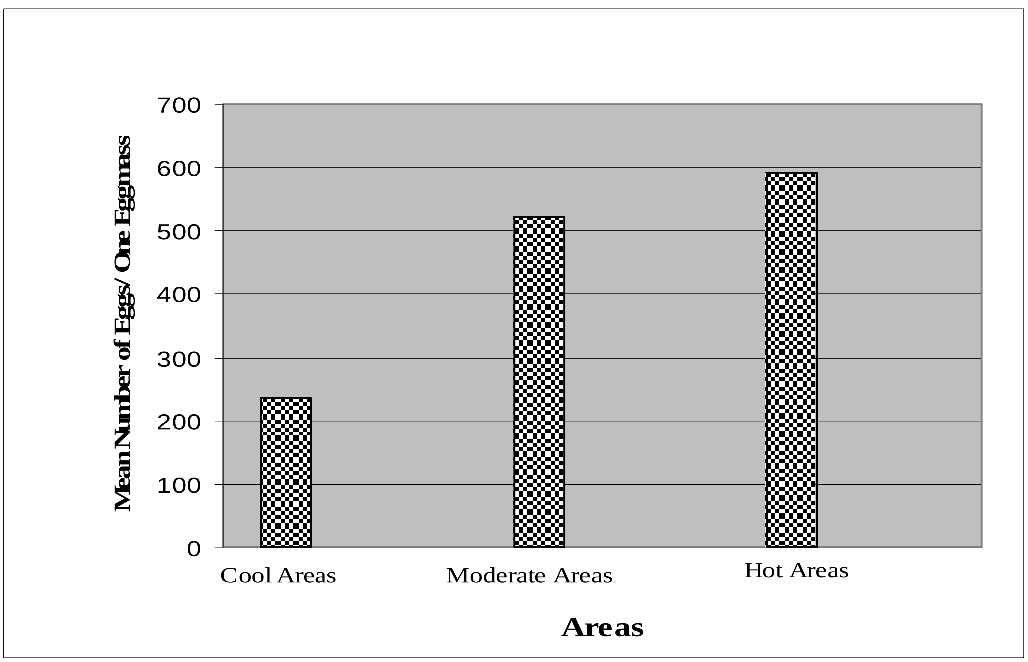


Fig 3.3.5: **Mean Number of *M. incognita* Mature, Immature Females and Eggmasses/ 5 Gram Roots (3-4 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

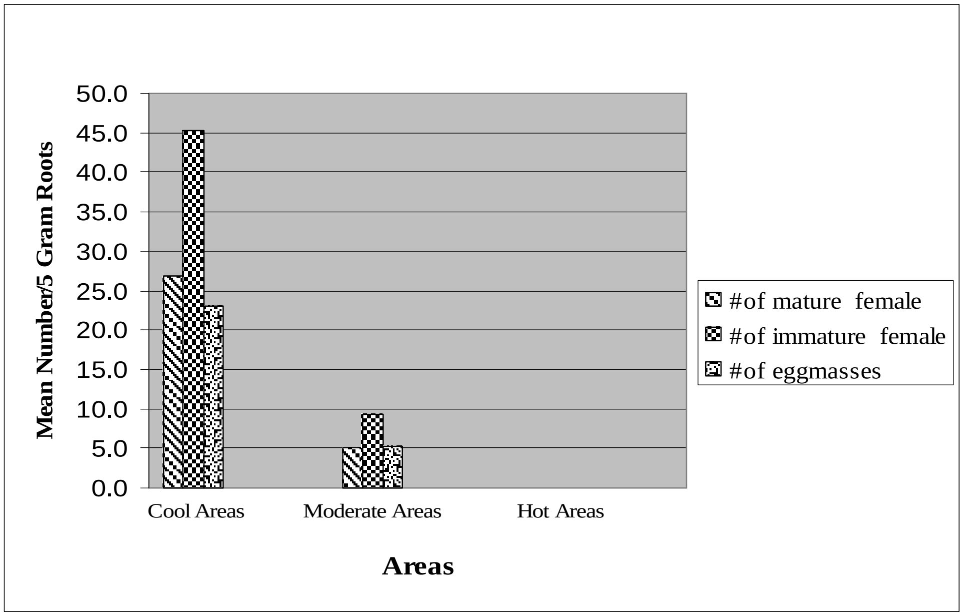


Fig 3.3.6: **The Mean number of Eggs/ Eggmass of *M. incognita* Distributed in Greenhouses Areas in the West Bank (3-4 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

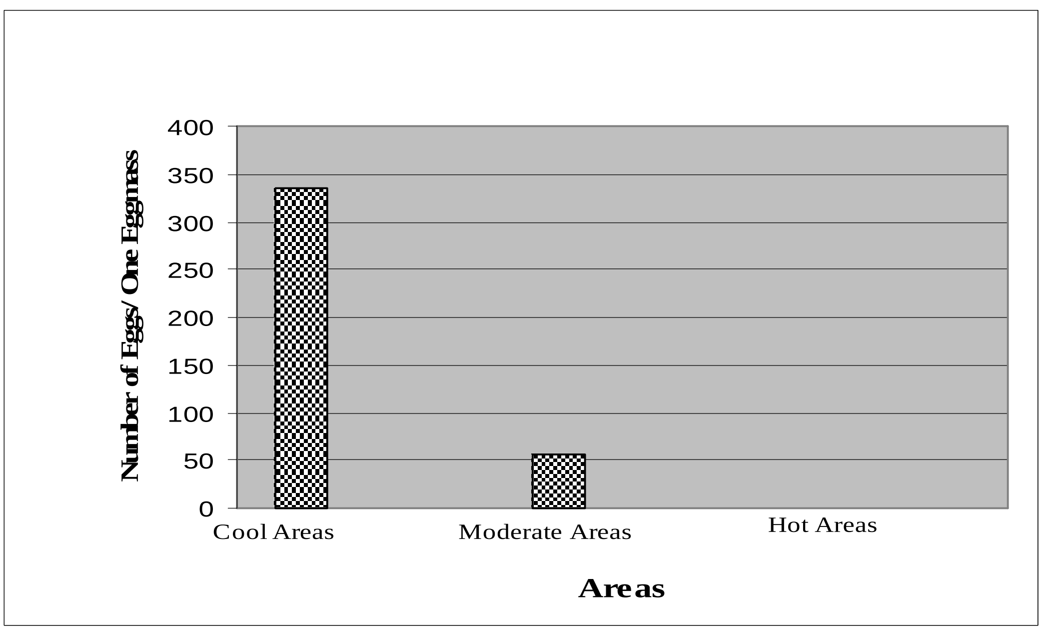


Fig 3.3.7: **The Mean Number of *M. incognita* Mature, Immature Females and Eggmasse / 5 Gram Roots (Less Than 3 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature in the Growing Season.**

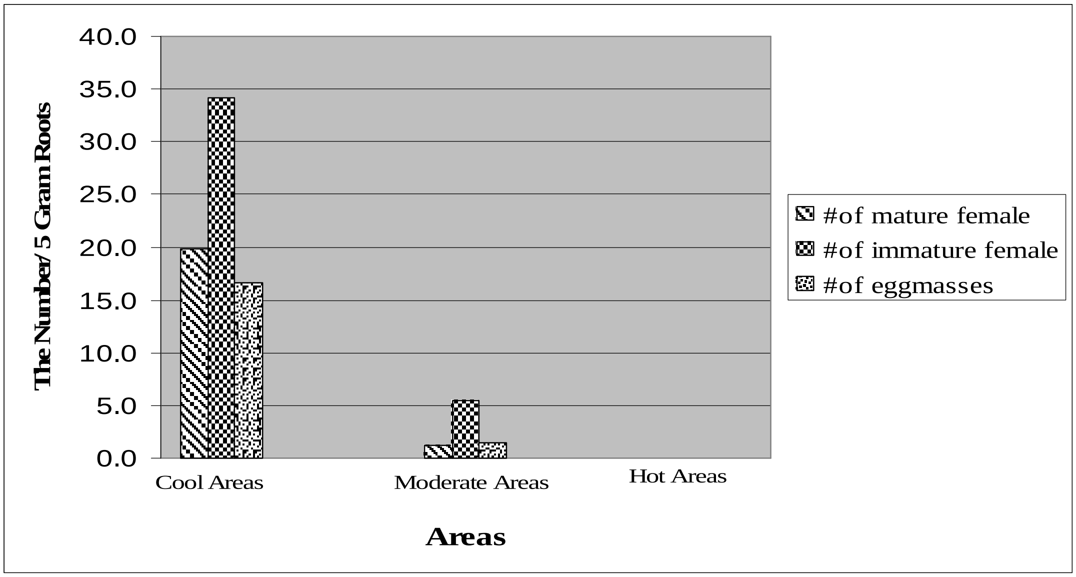
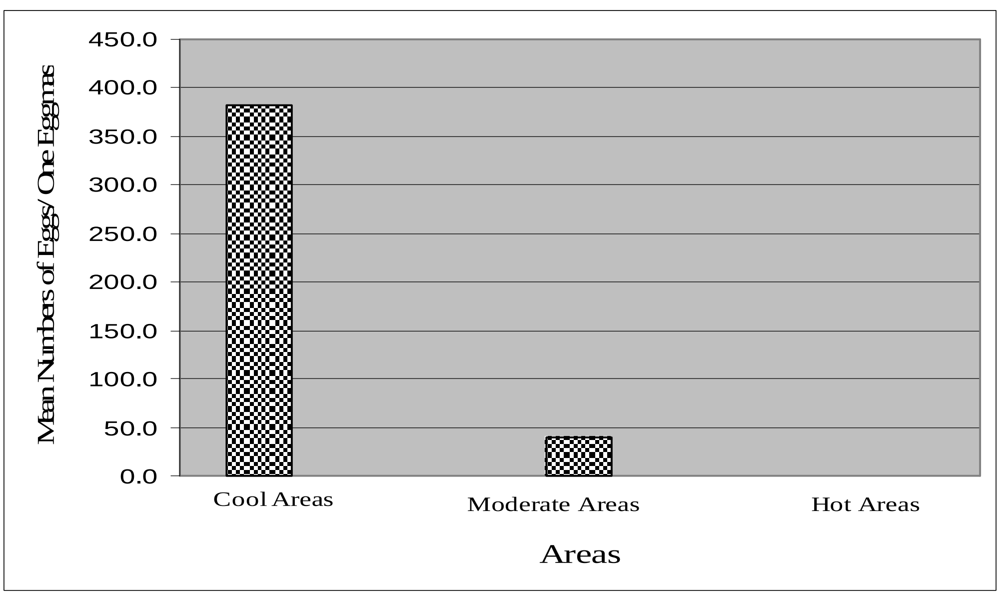


Fig 3.3.8: **Mean Number of *M. incognita* which Found Distributed in Greenhouses Areas in The West Bank (Less than 3 Month Age Cucumber and Tomatoes) in Relation to the Mean Temperature In The Growing Season.**



Conclusion

Plant parasitic nematodes represent one of the most important problems and national cruxes that threat the agricultural production cycle, qualitatively and quantitatively in the West Bank.

Generally speaking, very limited investigstion and information were recorded about plant parasitic nematodes in Palestine and in the West Bank in particular.

However, this study showed that plant parasitic nematodes are widely spread in the rhizosphere and roots of cultivated plants in different fields of cereal crops, vegetables, orchards and in a number of nurseries in the West Bank areas. Although its expansion and populations' distribution placements vary according to host plants' differences, natural characteristics, locations, climate, and environmental conditions (temperature and rainfall).

Most nurseries' samples were infested with at least one species of plant parasitic nematodes with different populations. This significant, unexpected result means that, nurseries represent one of the main important sources leading to plant parasitic nematodes' spread all over agriculture.

The study also showed that root knot nematodes *Meloidogyne* spp. were the most serious nematodes prevailed in tomatoes and cucumber greenhouses. Two species of *Meloidogyne* were identified in the West Bank; *M javanica* was found in all the West Bank areas samples and identified with high populations, especially in the North, Jericho and Jordan Valley in addition to the hot areas of the Hebron district. However, *M. incognita* was located vastly in most West Bank areas except Jericho, Jordan Valley and Tubas. Subsequently, the high populations of *M. incognita* were more concentrated in the high land areas of Bethlehem and

Hebron districts. Furthermore, it should be noticed that these parasitic nematodes naturally exist in different habitats of West Bank mainly under intensive agriculture. Worth mentioning, that nematodes distributed all over West Bank in the areas characterized by high moisture content and intensive irrigation of vegetables and nurseries.

Future research and studies:

- Broaden research on each potential species of plant parasitic nematode in the West Bank in terms of economic threshold, host range, population dynamics and other important epidemiological information.
- Study the effect of soil physical and chemical properties of the West Bank on nematode ecology, epidemiology and distribution.
- Study the influence of growers cultural practices on plant parasitic nematodes population build up and distribution.
- Studies on environment friendly control programs such as IPM.

References

Abu-Gharbieh, W. I. 1963. Experiments on Plant Diseases. Department of Scientific Research, Ministry of Agriculture, Jordan. The Annual Report of Al-Fara'a Station for Scientific Researches. Pp. 13-21.

Abu-Gharbieh, W. I., and Hammo, A. 1970. Survey of Plant Parasitic Nematodes in Jordan. Department of Agriculture Research and Extension. Ministry of Agriculture. Rep. no: 19/96.

Abu-Gharbieh, W. I. 1982a. Distribution of *Meloidogyne javanica* and *Meloidogyne incognita* in Jordan. Journal of Nematology, 28:34-37.

Abu-Gharbieh, W. I. 1982b. Identification of *Meloidogyne* spp. in the Major Irrigated Areas of the East Bank of Jordan. Dirasat, 9(1):7-12.

Abu-Gharbieh, W. I. 1987. Plant Parasitic Nematodes Associated with Cereal and Forage Crops in Jordan. Pp. 160-168. In : Nematodes Parasitic to Cereals and Legumes in Temperate Semi-arid Regions. M.C. Saxena, R.A. Sikora and J.P. Srisatava (Editors). ICARDA-135, Proceeding of Workshop Held at Larnaka, Cyprus, 1-5 March.

Abu-Gharbieh, W. I. 1994. Root Knot Nematodes, *Meloidogyne* spp. in Jordan: Biology and Control. University of Jordan Publications. 2/94.

Abu-Gharbieh, W. I., and Azzeh, T. 2004. Plant Parasitic Nematodes in Arab Countries. Journal of Arab Plant Protection, Vol. 22, No.22- 1-22/ 2004.

Abu-Gharbieh, W. I., and Perry, V.G. 1970. Host Differences among Populations of *Belonolaimus longicaudatus* Rau. Journal of Nematology, 2:209-216.

Acosta, N., and Malek, R. B. 1979. Influence of Temperature on Population Development of Eight Species of *Pratylenchus* on Soybean. Journal of Nematology, 11:229-232.

Akhtar, M. M., and Alam, M. 1993. Utilization of Waste Materials in Nematode Cont. Rev. Bioresource Technology, 45: 1-7.

Alam, M. M., Saxena, S.K., and Khan, A. M. 1979. Suitability of Crops to the Reniform, Stunt and Root-Knot Nematodes. In: Bir, S.S. (Ed.) Recent Researches in Plant Sciences. Kalyani Publishers, New Delhi, India, Pp. 631 – 634.

Al Hazmi, A.S., Al Yahya, F.A., and Abdul-Razig, A. T. 1995. Occurrence, Distribution and Plant Association of Plant Nematodes in Saudi Arabia. Research Bulletin No. 52, Agriculture Research Center, King Saud University. Pages 5-45.

Ammati, M. 1987. Nematodes Status on Food Legumes and Cereals in Morocco, 169-172. In: Nematodes Parasitic to Cereals and Legumes in Temperate Semi-arid Regions. Saxena, M.C., Sikora, R.A., and Srisatava, J.P. (Editors). Proceeding of Workshop Held at Larnaka, Cyprus, 1-5 March, 217.

Anderson, R.V., and Coleman, D. C. 1982. Journal of Nematol. 14:69-76.

Atieh, S. A. 1987. Pathogenicity and Histopathology of *Meloidogyne javanica* and *Meloidogyne incognita* on Olive and Tomato. M.Sc. Thesis. Faculty of Agriculture, University of Jordan, 144-145.

Ayoub, S. M. 1980. Plant Nematology: An Agricultural Training Aid. Sacramento, Calif.: Nema Aid Publications, 195.

Barker, K. R., and Clayton, C. N. 1973. Nematodes Attacking Cultivars of Peach in North Carolina. Jour. Nematology 5:265-271.

Barker, K, R., Shoemaker, P.B., and Nelson, L. A. 1976. Relationships of Initial Population Densities of *Meloidogyne incognita* and *M. hapla* to Yield of Tomato. Journal of Nematology. 8:232-239.

Barker, K. R., and Olthof, T. H. A. 1976. Relationships between Nematode Population Densities and Crop Responses. Annual Review of Phytopathology 14: 327-353.

Bridge, J., Fogain, R., and Paul, S. P. 1997. The Root Lesion Nematodes of Banana: *Pratylenchus coffeae* and *Pratylenchus goodeyi.* Pest Fact Sheet No.2.

Brown, J. J., Reidel, R. M., and Rose, R. C. 1980. Species of *Pratylenchus* Associated with *Solanum tuberosum* cv. 'Superior' in Ohio. Journal of Nematology. 12:189-192.

Christie, R. 1959. Plant Nematodes: Their Bionomics and Control. Gainesville, Fla.: University of Florida Agricultural Experiment Station, 256.

Cobb, J. A., and Orion, D. 1970. The Pathological Effect of the Representative *Xiphinema* and *Longidorous* spp. on Selected Host Plants. Journal of Nematology. 16:423-428.

Cohn, E., and Minz, G. 1961. Citrus Nematode on American Persimmon in Israel. Plant Disease Reporter. 45: 505.

Diab, K. A., and El-Eraki, S. 1968. Plant Parasitic Nematodes Associated with Olive Decline in the United Arab Republic. Journal of Plant Disease. 52:150-154.

Di Vito, M. and Zacheo, G. 1987. Responses of Cultivars of Wheat to *Meloidogyne artiellia*. Journal of Nematologia Mediterranea. 15: 405-408.

Di Vito, M., Greco, N., and Zacheo, G. 1985. The Host Range of *Meloidogyne artiellia*. Journal of Nematologia Mediterranea. 13: 207-212.

El-Maleh, A., and Edongali, Z. 1995. Plant Parasitic Nematodes Associated with Grape Vine in Libya and Pakistan. Journal of Nematology. 13: 77-81.

Ferris, J. M. 1970. Soil Temperature Effects on Onion Seedling Injury by *Pratylenchus penetrans*. Journal of Nematology. 2:248-251.

Ferris, V. R., and Bernard, R. L. 1971. Crop Rotation Effects on Population Densities of Ectoparasitic Nematodes. Journal of Nematology. 3, 119-122.

Floret. C., and Serpantie, G. 1993. La Jachère en Afrique de l'Ouest. ORSTOM, Colloques et séminaires, Paris Poblaciones de malezas nematodos hospedados por algunas de.

Fortuner, R. 1977. *Pratylenchus thornei*. C. I. H. Descripitions of Plant-parasitic Nematodes. Set 7, No. 93. Commonwealth Institute of Helminthology, England.

Franklin, M. T. 1965. Meloidogyne-Root-Knot Eelworm. Journal of Plant Nematology. 7: 58-88.

Franklin, M. T. 1972. *Heterodera schachtii*. C. I. H. Descriptions of Plant-parasitic Nematodes. Set 1, No. 1. Commonwealth Institute of Helminthology, 103 St. Peter's Street, St. Albans, Herts., England.

Franklin, M.T., Clarck, S.A., and Course, J. A. 1971. Population Changes and Development of *Meloidogyne naasi* in the Field. Journal of Nematology. 17:575-590.

Goodey, B. T. 1951. Soil and Freshwater Nematodes. Methuen, London.

Goody, J. B. 1963. Laboratory Methods for Work with Plant and Soil Nematodes. Edited by J. F. Southy 1970. Tech Bull. No. 2. Ministry of Agric. Fish. and Food. London.

Gottlieb, Y., Cohn, E., and Spiegel-Roy, P. 1986. Biotypes of the Citrus Nematode *Tylenchulus semipenetrans* in Israel. Phytoparasitica 14: 193-198.

Gray, F.A., Francl, G. D., and Kerr, F. D. Sugar Beet Nematodes. University of Wyoming. College of Agriculture. Department of Plant , Soil, and Insect Sciences. Cooperative Extention Survice. B-975/1992.

Greco, N., Di Vito, M., Saxena, M.C., and Reddy, M.V. 1984. Investigation on the Root Lesion Nematode *Pratylenchus thornei* in Syria. Journal of Nematologia Medetrania. 16: 101-105.

Griffin, G.D. 1984. Nematode Parasites of Alfalfa, Cereals, and Grasses. In: W.R. Nickle, ed. Plant and Insect Nematodes, 243-321. Marcel Dekker. NY, USA.

Hagan, A. 1994. Nematode Pests of Peanut. ANR-393, Extension Center of Plant Pathology. Entomology and Plant Pathology, Auburn University.

Hallmann, J., Rodriguez-Kabana, R., and Kloepper, J.W. 1999. Chitin-mediated Changes in Bacterial Communities of Soil Rhizosphere and Roots of Cotton in Relation to Nematode Control. Journal of Soil Biology. Biochem. 31:551–60.

Hashim, Z. 1979. A preliminary Report on the Plant Parasitic Nematodes in Jordan. Journal of Nematologia Mediterranea, 7: 177- 186.

Hashim, Z. 1983. Plant Parasitic Nematodes Associated With Pomegranate *Punica granatum* L in Jordan and An Attempt to Chemical Control. Journal of Nematologia Mediterranea 11: 199-200.

Hattar, B. I., Al-Banna, L., and Abu-Gharbieh, W. I. 1988. Effect of Elemental Sulfur and Sulfuric Acid Soil Amendments on Root Knot Nematode and Tomato Grown in Calcareous Soils. Journal of Damascus Univ. Vol 4 -no 15 -1988.

Huebner, R.A., Rodriguez-Kabana, R., and Patterson, R. M. 1983. Hemicellulosic Waste and Urea for Control of Plant Parasitic Nematodes: Effect on Soil Enzyme Activities. Journal of Nematropica 13:37-54.

Ibrahim, A.M., Al-Hazmi, A.S., Al-Yahya, F.A. and Alderfasi, A.A. 1999. Damage Potential and Reproduction of *Heterodera avenae* on Wheat and Barley under Saudi Field Conditions. Journal of Nematology, 1(6): 625-630.

Ibrahim, I. A. 2002. Nematodes of Agricultural Crops. Monshaat Al-Maaref. Alexandria, 344.

Ibrahim, I. A., Handoo, Z. A., and El- Serbiny, A. A. 2000. A Survey of Phytoparasitic nematodes on Cultivated and non Cultivated Plants in Northern- West Egypt. Journal of Nematology. Vol 2: 478-485.

Ingerson, J. 2003. Diagnosing Alfalfa Problems in New Jersey. Fact sheet FS879, by Rutgers Cooperative Extension. New Jersey Agricultural Experiment Station.

Ismail, A. E. 1997. Population Dynamics of Root Knot and Spiral Nematodes on Sweet pop *Annona Squamosa* in Relation to Soil Temperature. Pakistan. Journal of Nematology. Vol. 15: 267-278.

Jacobsen, B. J. 1997. Plant Disease the Ectoparasitic Nematodes of Illinois RPD no.1106, Department of Crop Science, University of Illinois at Urbana-Champaign.

Kiryanova, E. S., and Krall, E. L. 1980. Plant Parasitic Nematodes and Their Control. Springfield, Va. Translated and published by USDA, Agricultural Research Service, 748.

Kort, J. 1972. Nematode Diseases of Cereals of Temperate Climates. In: J.M. Webster, ed. Economic nematology, 97-126. New York, NY, USA, Academic.

Lahdenpera, M., L. E. Simon, and J. Uoti. 1991. Mycostop - A Novel Biofungicide Based on Streptomyces Bacteria. In: Biotic Interactions and Soil Borne Diseases (Beemster, A. B. R. Bollen, G., J., Gerlach, M., Ruissen, M., A., Schippers, B., and Tempel, A., Eds.) .Elsevier, Amsterdam: 258-265.

Lamberti, F. 1981. Plant Nematode Problems in the Mediterranean Region. Helminth. Abstr. Ser. B, 50: 145-166.

Lamberti, F., and Vovlas, N. 1993. Plant Parasitic Nematodes Associated with Olive. EPPO Bull. 23:481-488.

LaMondia, J. A., and Cowles, R. S. 2002. Effect of Entomopathogenic Nematodes and *Trichoderma harzianum* on the Strawberry Black Root Rot Pathogens *Pratylenchus penetrans* and *Rhizoctonia fragariae*. Journal of Nematology.

Loof, P. A. 1974. *Tylenchorhynchus claytoni.* CIH Descriptions of Plant Parasitic Nematodes. Set 3, No. 39. CAB Institute of Parasitology. St. Albans. UK.

Mallozzi, T., Kratochvil, R., Sardanelli, S., Meyer, S., and Everts, K. 2001. Evaluating Alternatives to Methyl Bromide for Management of

Root-Knot Nematode. University of Maryland, 2001 IPM Progress Report, 34.

Mamluk, O.F., Augustin, B., and Bellar, M. 1983. New Record of Cyst and Root-Knot Nematodes on Legume Crops in the Dry Areas of Syria. Jour Phytopathol. Med. 22: 80.

Mamluk, O.F., Abu-Gharbieh, W.I., Shaw C.G., Al- Musa, A., and Al-Banna, L.S. 1984. A Chicklist of plant Diseases in Jordan. Publication of the University. Jordan, 107.

Maqbool, M.A. 1988. Present Status of Research on Plant Parasitic Nematodes in Cereals and Food and Forage Legumes in Pakistan. In: M.C. Saxena, R.A. Sikora & J.P. Srivastava, eds. Nematodes parasitic to cereals and legumes in temperate semi-arid regions, 173-180. Aleppo. Syria. ICARDA.

McElroy, F. D. 1972. Studies on the Host Range of *Xiphinema bakeri* and its Pathogenicity to Raspberry. Journal of Nematology. 4:16-22.

Melakeberhan, H., Dey, J., Baligar, V. C., Carter., and Thomas, E. 2004. Effect of Soil pH on the Pathogenesis of *Heterodera glycines* and *Meloidogyne incognita* on *Glycine max* Genotype. Journal of Nematology. Vol. 6: 585-592.

Meteorology directorate- Ramallah. 2007. Mean Avarage for Climate Elements for West Bank Districts. Palestinian National Authority.

Meyer, S. L. F., Roberts, D. P., Nitao, J. K., and Chitwood, D. J. 2002. Examination of rhizosphere-associated microbes for production of compounds active against plant-parasitic nematodes. Nematology 4: 288.

Michael, A., and McClure, B. 1999. Plant Parasitic Nematode in Arizona Vineyards. Department of Plant Pathology. Wine Grape Research Report, index at: http: //ag.arizona.edu/pubs/crops/az1148.

Milestone, M. 2002. Biologically Based IPM Systems for Management of Plant –Parasitic Nematodes, SAES-422.

Miller, P. M. 1980. Reproduction and Survival of *Xiphinema americanum* on Selected Woody Plants, Crops, and Weeds. Journal of Plant Disease. 174-175.

Minz, G., Ziv, D., and Strich- Harari, D. 1960. Decline of Banana Plantations in Jordan Valley and it's Control by DBCP. Ktavim. 10: 147- 157.

Mokabli, A., Valette, S., Gauthier, J. P., and Rivoal, R. 2001. Influence of Temperature on the Hatch of *Heterodera avenae* Woll. Populations from Algeria. Journal of Nematology. 3(2): 171-178.

Noe, J.P., Sasser, J.N. & Imbriani, J.L. 1991. Maximizing the potential of cropping systems for nematode management. Journal of Nematolgy 23: 353-361

Mor, M. and Cohn, C. 1989. New Nematode Pathogens in Israel: *Meloidogyne* on Wheat and *Hoplolaimus* on Cotton. Phytoparasitica. 17: 221.

Norton, D. C., Donald, P., Kimpinski, J., Myers, R., Noel, G., Noffsinger, E. M., Robbins, R. T., Schmitt, D. P., Sosa-Moss, C., and Vrain, T. C. 1984. Distribution of Plant Parasitic Nematode Species in North America. Society of Nematologists, Lakeland, FL.

Noling, J. W. 2003. Citrus Nematode. Citrus Research and Education Center (CREC). ENY608 Florida Cooperative Extension Service.

Nicol, A. I., Rapoport, H. F., Jimenez-Diaz, R. M., and Castillo, P. 2002. Incidence and Population Density of Plant-Parasitric Nematodes Associated With Olive Planting Stocks at Nurseries in Southern Spain. Plant Disease. Vol. 86:1075-1079.

Orion, D., Krikun, J., and Amir, J. 1982. Population Dynamics of *Pratylenchus thornei* and its Effect on Wheat in a Semi Arid Region. Abstr. 16th Int. Symp. European Society of Nematologists, 48. St. Andrews, Scotland, UK.

Osseni, B., Sarah, J., and Hugon, R. 2006. Effect of Soil pH on the Population Development of *Pratylenchus brachyurus* (Godfrey) in Pineapple Roots and on the Growth and Yield of the plant. International Society for Horticultural Science. ISHS. Acta Horticulturae 425: 2.

Oteifa, B. A., and Shaarawi, A. T. 1962. Observation on the Citrus Nematode *Tylenchulus semipenetrance* Cobb in united Arab Republica. Journal of Nematologia. Vol. 8:267-271.

Philis, J. 1991. Assessment of Potato Yield Loss Caused by the Potato-cyst Nematode, *Globodera rostochiensis* Woll. Journal of Nematologia Mediterranea. 19: 191-194.

Peterson, G. W. 1962. Root lesion Nematode Infestation and Control in a Plains Forest Tree Nursery. Res. Note 75. Fort Collins, CO: U. S. Department of Agriculture. Forest Service. Rocky Mountain Forest and Range Experiment Station, 2.

Potter, J. W., and Olthof, H. A. 1993. Nematode Pests of Vegetable Crops, 171-207 In*:* Evans, K., D. L. Trudgill and J. M. Webster. 1993. Plant Parasitic Nematodes in Temperate Agriculture. CAB International, Wallingford, England.

Rashid, A., Khan, F.A., and Khan, A.M 1973. Plant Parasitic Nematodes Associated with Vegetables, Fruits, Cereals and other Crops in North India. I: Uttar Pradesh. Indian. Journal of Nematol. Vol. 3, 8–23.

Ritter, M. 1972. Role Economique et Importance des *Meloidogyne* en Europe et dans le bassin Mediterraneen. OEPP/EPPO Bull., 2: 17-22.

Rodriguez-Kabana. R. 1986. Organic and Inorganic Amendments to Soil as Nematode Suppressants. Journal of Nematology. 18:129-135.

Ruehle, J. L. 1975. Nematodes. In: Peterson, Glenn W.; Smith, Richard S., Jr., tech. Cords. Forest Nursery Diseases in the United States. Agric. Hand book. 470; Washington, DC: U.S. Department of Agriculture: 31-34.

Sardanelli, S., Siskind, L., Mc Elrone, A., and Robinson, J. 2002. Root Knot Nematode. NDRF. Fact Sheet. No. 5/ 2002.

Saxena, M. C., Sikora, R. A., and Srivastava, J. P. 1988. Nematodes Parasitic to Cereals and Legumes in Temperate Semi-arid Regions, 69-84. Aleppo, Syria, ICARDA.

Sharma, S. B., and Swarup, G. 1984. Cyst Forming Nematodes of India. New Delhi. Ind. Cosmo Publ., 1: 150.

Shafiee, M. F., and Jenkins, W. R. 1963. Host-Parasite Relationships of *Capsicum frutescens*, *Pratylenchus penetrans, Meloidogyne incognita*, and *M. hapla*. Journal of Phytopathology. Vol. 53:325-328.

Shiabova, T. N. 1981. *Meloidogyne artiellia* a Parasite of Cereals in Western Siberia. Nauchno Tekhnicheskii Byulleten Sibirskogo. N. I.I. Zemledeliya i Khimizatsii Sel'skogo Kosyaistva (Vrednye gryzuny fitonematody Zapadnoi Sibiri i bor'ba snimi 37: 29-32. (In Russian). Helminth. Abstr. Ser. B, 54: 986.

Siddiqi, M. R. 1974. *Tylenchulus semipenetrans*. C.I.H. Descriptions of Plant-parasitic Nematodes. Set 3, No. 34. Commonwealth Institute of Parasitology. C.A.B. International, 4.

Siddiqui, I. A., Sher, S. A., and French, A. M. 1973. Distribution of Plant Parasitic Nematodes in California. State of California Department of Food and Agriculture. Division of Plant Industry. Sacramento, California, 324.

Siddiqui, M. A. 2003a. Further Studies for the Integrated Management of the Stunt, Lance and Spiral Nematodes with Cropping Sequences Ploughing. 22EBSCO Publishing. 2003. Vol. 36, 9.

Siddiqui, M. A. 2003b. Suitability of Crops, Fruit Trees/ Plant to Plant Parasitic Nematodes, Plant University, Aligarh- India. Journal of Phytopathology and Plant Protection, Vol. 37, 83-87.

Siddiqui, M. A. 2004. Suitability of Crops, Fruit Trees/Plants to Plant Parasitic Nematodes. Plant Pathology/Nematology Section. Department of Botany. Aligarh Muslim University, Aligarh-202 002. India. Journal of Phytopathology and Plant Protection. 2004. Vol.37., 83 .87.

Sikora, R. A. 1988. Plant Parasitic Nematodes of Wheat and Barley in Temperature and Temperate Semi-arid Regions - A Comparative Analysis. In: M. C. Saxena, R. A. Sikora and J. P. Srivastava, eds. Nematodes Parasitic to Cereals and Legumes in Temperate Semi-arid Regions, 46-48. Aleppo, Syria, ICARDA.

Sikora, R. A., and Oostendorp, M. 1986. Report: Occurrence of plant parasitic nematodes in ICARDA experimental fields. Aleppo, Syria, ICARDA, 4.

Smith, K. L., Sally, R. M., Randall, A. M., and Rowe, C. 1996. Root Knot Nematode. HYG-3115-96. Ohio State University. OSU Extension. TDD No. 800-589-8292 or 614-292-1868.

Stirling, G.R., Nicol, J.M., and Reay, F. 1998. Advisory Services for Nematodes Pests - Operational Guide. Rural Industries Research and Development Corporation Publication No. 99/41. Canberra, 120.

Swarup, G., and Sosa-Moss, C. 1990. Nematode Parasites of Cereals. In: M. Luc, R.A. Sikora & J. Bridge, eds. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 109-136. Wallingford, UK, CAB International.

Story, C. G. 1939. The lasting effects of Molasses used as fertilizer. Queensland. Journal of Agricultural. Vol. 52:310-311.

Sultan, S. A. 1981. Influence of Interspecific Competition on the Population Densities of Phytoparasitic nematodes. PhD. Theses. Faculty of Agriculture, Ain Shams University. Pp. 147.

Tan, K.H.1995. Soil Sampling Preparation and Analysis. The University of Georgia. Marcel Dekker, Inc. New York. 95-31146.

Thorne, G. 1961. Principles of Nematology. McGraw- Hill Book Company, INC. New Yourk Toronto London.

Troccoli, A., Lamberti, F., and Greco, N. 1992. *Pratylenchus* Species Occurring in Algeria (Nematoda Pratylenchidae). Journal of Nematologia Mediterranea. 20: 97-103.

Tucker, M. R. 1998.; Soil pH: Crucial for Nursery Crop Production. Nursery Notes 32:3-21.

Taylor, A. L., and Sasser, J. N. 1978a. Biology, Identification and Control of Root-Knot Nematodes. Raleigh, NC, USA, North Carolina State University Graphics, 111.

Taylor, A. L., and Sasser, J. N. 1978b. International *Meloidogyne* Project, contract No. AID/ta-c-1234. Biology, Identification and Control of Root Knot Nematode (*Meloidogyne* spp).

Taylor, A. L., and Sasser, J. N. 1982. Relationship of Climate and Soil Characteristics to Geographical Distribution of *Meloidogyne* spp in Agricultural Soils. A Cooperative Publication of Dept. of Plant Pathology. North Carolina State University and US/AID, 65.

Vawdrey, L. L., and Stirling, G. R. 1997. Control of Root-Knot Nematode *Meloidogyne javanica* on Tomato with Molasses and other Organic Amendments. Australasian Plant Pathology. 26:179-187.

Wallace, H. R. 1959. *Heterodera*- Soil Texture Relations. Journal of Nematology. 4:245-252.

Warfield, C. 2002. Foliar Nematodes: Are These a Problem Worming? Their Way into Your Nursery? NC Nursery Short Course Department of Plant Pathology. North Carolina State University. McKimmon Center Raleigh, North Carolina.

Whitehead, A.G. 1998. Plant Nematode Control. Wallingford, CAB. UK,

Widmer, T. L., Mitkowski, N. A., and Abawi, G. S. 2002. Impact of Organic Matter Management on Plant-Parasitic Nematodes, their Damage to Host Crops and Soil Health. Journal of Nematology. 34 (4) 1289- 295.

Wick. R. L. 1999. Minor Diseases of Pepper. New England Vegetable & Berry Growers MA.01003, 101-103.

Williams, T. D., and Siddiqi, R, R. 1972. *Heterodera avenae*. C. I. H. Descriptions of Plant-parasitic Nematodes. Set 1, No. 2. Commonwealth Institute of Helminthology, St. Albans, Herts., England.

Yassin, A. M. 1987. The Status of Research on Plant Nematology in Cereals and Food and Fodder Legumes in the Sudan. Pages. 181-191. In: M.C. Saxena., R.A. SiKora., and J.P. Srivastava.1988. Nematodes Parasitic to Cereals and Legumes in Temperate Simi-arid Regions.. Proceedings of Workshop Held at Larnaka, Cyprus, 1-5 March, 217.

Yousef, D. M., and Jacob, J. J. S. 1994. A nematode Survey of Vegetable Crops and Some Orchards in the Ghour of Jordan. Journal of Nematologia Mediterranea. Vol. 22: 11- 15.

Yu, M. Q. 1997. First report of *Pratylenchus thornei* from Spring Wheat in Southern Ontario. Can. Journal of Plant Pathology. 19(3): 289-292.

Appendix 1

Plant Parasitic Nematode Sample Submission Form

Sample number		Sampling Date				
Plant Type/ Scientific Name						
Planting Type						
Last Crops						
Plant Parasitic Nematodes spp.	**#/ 100 cc soil**					
1 -						
2-						
3-						
4-						
5-						
6-						
For Nurseries Samples	Sand %	Silt %	Clay %	Organic Matter %	pH	

Notes: **(plowing times, Solarization, Organic Matter Amendment, Usage of Pesticides in the soil….)**

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Appendix (2)

Root Knot Nematodes Sample (Roots) Submission Form

Sample number									
Sampling Date									**Choice**
Location/ Distract	**Hebron**	**Bethlehem**	**Jericho**	**Ramallah**	**Nablus**	**Jinen**	**Tulkarm**	**Qalkelia**	

Last Crop/s	**Crop**	**Date(From-To)**	**Plant history/ soil Pesticides treatments**	
	1-	**1-**		
	2-	**2-**		
Current Plant (Cucumber/ Tomato)		**Age/month**		

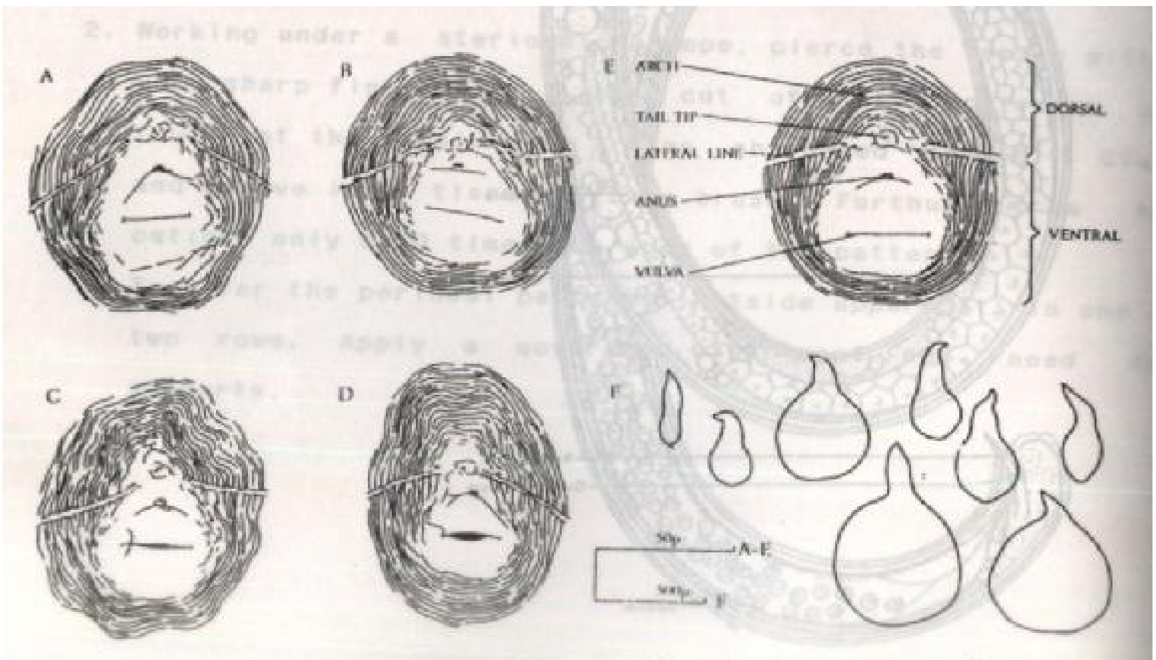
Root Knot Nematodes species	**M. Javanica/ M. incognita**

	The number/ five Gram of infected roots					
RKN Stages	1st stage larva	2nd stage larva	3rd stage larva	Mature Females	Eggmass	Egg/eggmass

Notes: (plowing times, Solarization, Organic Matter Amendment, Usage of Pesticides in the soil….---

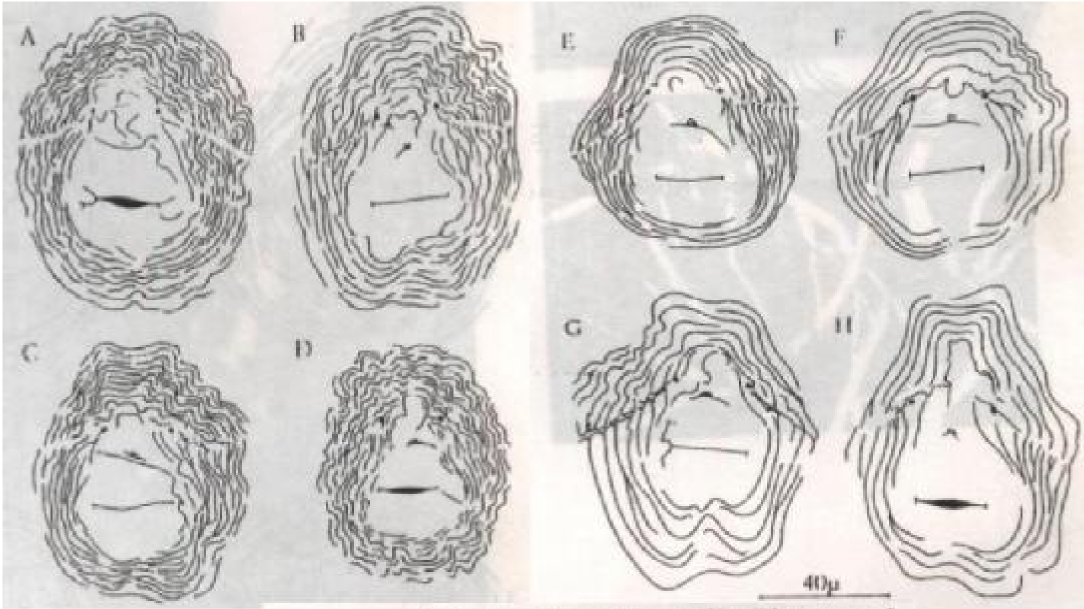
Appendix (3)

Root Knot Nematodes Perennial Pattern



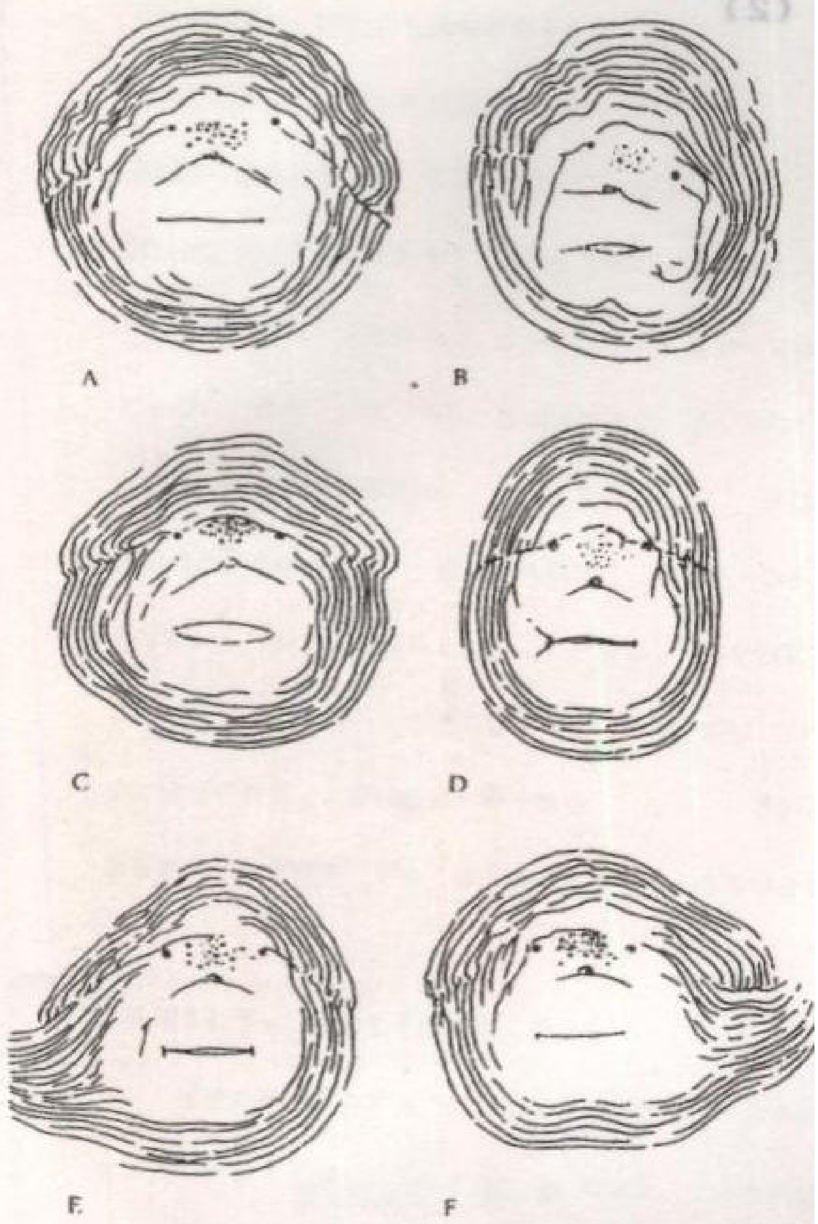
Meloidogyne javanica. A–D. Posterior cuticular patterns of females. E. Diagram of pattern showing parts. F. Shapes of immature and adult females.

(Taylor and Sasser 1978)



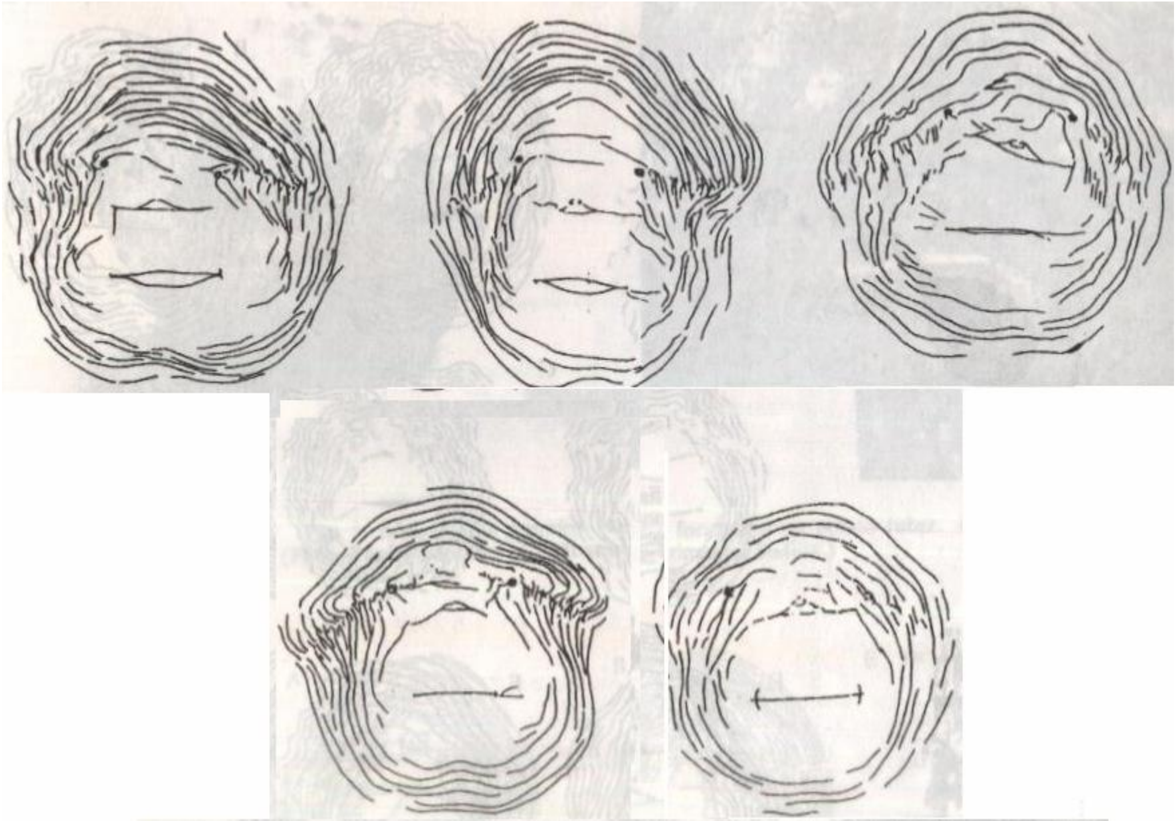
Meloidogyne incognita. A–H. Diagrams of posterior cuticular patterns of females. A. Typical "incognita type". H. Extreme "acrita type." (Fine striae omitted in F–H.)

(Taylor and Sasser 1978a)



Above. *Meloidogyne hapla*. A–F. Posterior cuticular patterns of adult females; ventral striae expanded on left side in E and right side in F to form "wings".

(Taylor and Sasser 1978a)



Meloidogyne arenaria. Posterior cuticular patterns (photograph: Rothamsted Experimental Station).

(Taylor and Sasser 1978a)

Appendix (4)

Yearly rainfall (ml) and mean temperature (^{0}C) average in the West Bank districts

District	Hebron	Bethlehem	Jericho& J.valley	Ramallah	Nablus	Jenin	Tulkarm
Yearly rainfall average(ml)	595.9	518.4	166	615.2	660	468.2	602
Yearly mean temperature (^{0}C)	15.5	16	22.4	17.1	17.8	20.3	19

Meteorology directorate- Ramallah (2007).