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DISTRIBUTION, PATHOGENICITY AND CONTROL OF NEMATODES ASSOCIATED WITH OLIVE

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The common olive tree, *Olea europaea* L., is an evergreen native of western Asia and extensively grown in the Mediterranean Basin. In recent times it has been introduced in sub-tropical regions of Australia, southern Africa and North and South America.

Wherever olive is grown it is likely to be associated with plant-parasitic nematodes. The first record of such an association appears to be that of Buhrer, Cooper and Steiner (1933), who found *Meloidogyne* spp. parasitizing olive in the USA. Since that time, a fair amount of literature has accumulated on nematodes associated with olive, with brief reviews of this subject by Lamberti (1969*a*, 1981). Nevertheless, present-day knowledge of the geographical distribution, pathogenicity and control of nematodes on olive remains meagre. In most olive-growing regions, studies have been restricted to routine surveys which revealed the presence of plant-parasitic nematodes associated with olive displaying no disease symptoms. However, from recent work in certain areas (notably within the Mediterranean Basin), more detailed information concerning the nematode diseases of olive has become available, though the control of such diseases remains largely unknown.

Nematodes associated with olive

Numerous plant-parasitic nematodes have been found associated with olive and these are listed in Table 1. This list was compiled from a thorough study of the available literature, but errors or omissions are still possible. In most instances, the nature of the association has not been evaluated, but some species have been shown to be both parasitic on, and pathogenic to, olive. Thus, certain species belonging to the genera *Helicotylenchus* Steiner, *Meloidogyne* Goeldi, *Pratylenchus* Filipjev and *Xiphinema* Cobb are undoubtedly of the utmost economic significance to oliviculture, at least in some regions.

Helicotylenchus spp. (spiral nematodes)

Several species of *Helicotylenchus* have been recovered from the rhizosphere of olive, but the pathogenicity of most of these to olive is not known. However, Diab and El-Eraki (1968) showed that *H. dihystera* (Cobb) Sher, at inoculum levels of 1 000 nematodes per plant, can cause severe stunting and 78% reduction in top weight of olive seedlings in Egypt after six months, as well as reducing root growth.

Graniti (1955) reported that *H. erythrinae* (Zimmermann) Golden caused necrosis of olive roots in Italy. It was then suggested that the nematode may have been partly responsible for the gradual chlorosis and necrosis of leaf tips, the desiccation of branches and leaves and the progressive decline of the plants.

H. digonicus Perry *in* Perry, Darling & Thorne was often found in the olive groves of Jordan (Bridge, 1978 ; Hashim, 1979), where it was observed partially embedded in the feeder roots. *H. digonicus* was also found associated with olive in Cyprus (Philis & Siddiqi, 1976) and Greece (Hirschmann, Paschalaki-Kourtzi & Triantaphyllou, 1966).

Inserra, Vovlas and Golden (1979) observed *H. oleae* Inserra, Vovlas & Golden in semi-endoparasitic feeding positions on olive feeder roots in Italy; brown lesions were formed in the roots in the vicinity of the nematodes.

Meloidogyne spp. (root-knot nematodes)

Species of *Meloidogyne* occur in several of the olive-growing regions of the world, the most frequently encountered being *M. incognita* (Kofoid & White) Chitwood and *M. javanica* (Treub) Chitwood. However, their distribution on olive tends to be localized. Thus, *Meloidogyne* species were detected only in 2% of the olive groves sampled in southern Italy (Inserra *et al.*, 1976) and in less than 1% of those sampled in other parts of Italy (Inserra & Vovlas, 1981). Similarly, parasitization of olive in Jordan by either *M. incognita* or *M. javanica* was evident only in a few groves and nurseries, where plants were grown under irrigation (Hashim, 1979); *Meloidogyne* species were apparently absent from the elevated, non-irrigated areas where the majority of the established olive groves occurred.

Despite their relatively rare occurrence in olive groves, *Meloidogyne* species should, nevertheless, be considered potentially important pathogens of olive. Thus, *M. javanica* reduced top growth of olive in Egypt by 28%, six months after inoculation with 5 000 second-stage larvae per plant (Diab & El-Eraki, 1968).

Olive varieties differ in their response to *Meloidogyne* species. Thus, although both the 'Manzanillo' and 'Ascolano' varieties were readily parasitized by *M. javanica* in glasshouse tests, the former variety seemed more tolerant than the latter (Lamberti & Lownsbery, 1968).

Additional glasshouse tests by Lamberti and Baines (1969*b*) demonstrated that infection levels of 10 000 second-stage larvae of *M. javanica* per plant resulted in a considerable reduction of top weight of both 'Ascolano' and 'Sevillano' olive trees (52% and 45% respectively), but only a slight reduction of top weight (6%) of 'Manzanillo' trees, after an eleven month period. They also showed that the 'Manzanillo' variety was more susceptible to *M. incognita* than the 'Ascolano' variety : eight months after inoculation with 1 000 and 10 000 larvae per plant, the 'Manzanillo' trees were stunted with a 39% and 44% reduction in top weight respectively, whereas a significant decrease in top growth (44%) of the 'Ascolano' trees was evident only with the high inoculum levels (10 000 larvae/plant). Moreover, they found that the 'Ascolano' and 'Manzanillo' varieties were highly resistant to both *M. arenaria* (Neal) Chitwood and *M. hapla* Chitwood.

Pratylenchus spp. (root-lesion nematodes)

Six species of *Pratylenchus* have been found in association with olive. Condit and Horne (1938) reported that *P. musicola* (Cobb) Filipjev caused cortical lesions on olive roots in California (USA); however, the nematode involved was *P. vulnus* Allen & Jensen (see Sher & Allen, 1953).

P. vulnus was also found in several olive groves in Italy (Lamberti, 1969*c*; Inserra *et al.*, 1976; Inserra & Vovlas, 1981), where it was implicated as a possible cause of olive decline (Lamberti, 1969*c*). Thus, 'Coratina' olive trees naturally infested by this nematode had relatively few (often yellow) leaves, short internodes and young twigs completely defoliated : primary roots had longitudinal lesions and secondary roots were distorted and necrotic.

Lownsbery and Serr (1963) considered the olive variety 'Verdalion' a relatively poor host for *P. vulnus*. On the other hand, Lamberti and Baines (1969*a*) showed that both the 'Manzanillo' and 'Ascolano' varieties were favourable hosts for this nematode. The latter workers also showed that 'Manzanillo' trees, inoculated with 4 000 *P. vulnus*, were stunted, partially defoliated and weighed 42% less than non-infected trees, after one year : the roots were also reduced in size. 'Ascolano' trees, treated similarly, were not adversely affected and, therefore, were considered tolerant to *P. vulnus*.

The pathogenicity of other *Pratylenchus* species to olive has not been studied.

Xiphinema spp. (dagger nematodes)

Xiphinema species are common in some olive-growing regions, where they may be causing yield decline. In Egypt, olive seedlings grown with 500 *X. elongatum* Schuurmans Stekhoven & Teunissen per plant for six months exhibited poor growth, with 65% reduction in top weight, and had reduced, necrotic root systems (Diab & El-Eraki, 1968). On the other hand, Lamberti (1969*b*) found that, after ten months, the growth of 'Manzanillo' olive seedlings was unaffected by inoculation with 100 *X. californicum* Lamberti & Bleve-Zacheo (formerly *X. americanum* Cobb *s.l.*) per plant, although there was a concomitant increase in nematode population densities.

In general, *Xiphinema* species are difficult to culture under glasshouse conditions, possibly due to their extreme sensitivity to moisture and temperature fluctuations (Cohn & Mordechai, 1970). It is possible, therefore, that these nematodes are more pathogenic to olive in the field than is indicated by glasshouse tests, since their population densities in such situations are likely to exceed those that can be attained in glasshouses.

Gallo Donoso and Jiménez Roco (1976) considered *Xiphinema* species to be serious pathogens of olive in Chile. *X. pachtaicum* (Tulaganov) Kirjanova, a common nematode in the Mediterranean region, may be pathogenic to olive in Jordan (Hashim, 1979) and in some other countries.

Tylenchulus semipenetrans Cobb (citrus nematode)

Citrus spp. and some other members of Rutaceae are common hosts for *T. semipenetrans*. However, on the basis of infectivity and reproductive capacity on certain hosts, Lamberti and Baines (1970) and Baines, Cameron and Soost (1974) identified several strains or biotypes of the nematode, some of which infected *Olea* L. and other genera not belonging to Rutaceae. More recently, Inserra, Vovlas and O'Bannon (1980) suggested that currently-known populations of *T. semiepenetrans* occur in four biotypes, only one of which, the so-called "Citrus biotype", infects olive. The histological changes induced by this nematode in both olive and citrus roots are similar (Inserra & Vovlas, 1978 ; Inserra, Vovlas & O'Bannon, 1980), though infestations of olive are invariably much lighter than those of citrus (Baines & Thorne, 1950, 1952 ; Baines, 1951 ; Baines, Cameron & Soost, 1974 ; Inserra & Vovlas, 1978).

In California (USA), Lamberti and Baines (1970) found that a population of *T. semipenetrans* occurring on olive was more infective and apparently reproduced more rapidly on either 'Ascolano' or 'Manzanillo' olive trees than the populations obtained from citrus (*C. sinensis* (L.) Osb.) ; also, two populations of the nematode, one from olive and the other from citrus, caused a significant retardation of the growth of 'Ascolano', but not of 'Manzanillo', olive trees, even though the population from citrus did not reproduce readily on the 'Ascolano' variety.

Lamberti, Vovlas and Tirrò (1976) reported that each of three Italian populations of *T. semipenetrans* from citrus, at inoculum levels of 4 500 larvae per plant, significantly reduced root growth of 'Frangivento' olive (48.6, 36.7 & 52.1%) after one year without reproducing on it. Such a detrimental effect presumably was a consequence of initially high infection levels of the nematodes.

Gracilacus spp.

G. peratica Raski occurs in association with olive in Italy (Scognamiglio, Talamè & Giandomenico, 1968 ; Inserra *et al.*, 1976 ; Raski, 1976 ; Inserra & Vovlas, 1977, 1981). According to Inserra and Vovlas (1977), mature females of this species feed ectoparasitically on olive roots, each inserting its stylet into a cortical cell where it apparently becomes enveloped by a "feeding tube" formed either by hardened saliva or by coagulated cytoplasm ; the cortical cell had a thickened wall (probably due to lignification) near the point of stylet penetration. Nothing is known about the pathogenicity of *G. peratica* to olive.

Paratylenchus spp. (pin nematodes)

P. vandenbrandei De Grisse is an ectoparasite of olive in Italy, having been recovered in densities ranging from thirteen to 1 093 nematodes/g root in 13.7% of the samples collected (Inserra *et al.*, 1976). The pathogenicity of *Paratylenchus* species to olive has not been established.

Rotylenchulus spp. (reniform nematodes)

Rotylenchulus species have been found in certain olive groves in Algeria (Lamberti, Greco & Zaouchi, 1975), Greece (Hirschmann, Paschalaki-Kourtzi & Triantaphyllou, 1966 ; Koliopanos & Vovlas, 1977), Israel (Dasgupta, Raski & Sher, 1968) and Italy (Vovlas & Lamberti, 1974 ; Inserra *et al.*, 1976 ; Vovlas & Inserra, 1976 ; Inserra & Vovlas, 1981). In Italy, *R. macrodoratus* Dasgupta, Raski & Sher was the most common nematode species on olive : in the southern region, it occurred in 20% of the groves sampled and in densities of up to 883 nematodes/g root (Inserra *et al.*, 1976) ; in other regions, it occurred in 22% of the groves sampled (Inserra & Vovlas, 1981).

Histopathological studies of olive roots infested with females of *R. macrodoratus* showed that the parasite induces the formation of an enlarged "nurse cell" with dense cytoplasm, within either the vascular cylinder or both the cortex and vascular cylinder, from which it subsequently feeds (Vovlas & Inserra, 1976). It was noted that the vascular tissues, notably the xylem were compressed as a result of the enlargement of this feeding cell, and that epidermal and cortical cells adjacent to the nematode's body also appeared crushed, as well as necrotic.

Inserra and Vovlas (1979, 1980) elucidated some aspects of the life cycle of *R. macrodoratus* on olive roots. Badra and Khattab (1980) found that population levels of *R. reniformis* Linford & Oliveira on olive were significantly increased by foliar application and slightly decreased by soil application of urea or ammonium sulphate : foliar application of ammonium nitrate increased nematode densities but soil application had no effect.

Hirschmann, Paschalaki-Kourtzi and Triantaphyllou (1966) reported that poor growth of olive trees in Greece was frequently associated with heavy infections of *R. reniformis*. However, the pathogenesis of olive by *Rotylenchulus* species remains unknown.

Ogma spp.

O. rhombosquamatum (Mehta & Raski) Andrássy was found in several olive groves in Italy (Inserra & Vovlas, 1981 ; Vovlas & Inserra, 1981). Vovlas and Inserra (1981) observed colonies of females of the nematode in ectoparasitic feeding positions on olive feeder roots and in densities of 280-360 nematodes/g fresh root : each parasite was attached to the root by its stylet which penetrated the epidermis and outer

Table 1
Plant-parasitic nematodes found in the rhizosphere of olive (*Olea europaea* L.)

Nematodes	*Regions*	*References*
APHELENCHIDA		
Aphelenchoides sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
Aphelenchus avenae Bastian	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
Aphelenchus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & d'Errico (1971) Fiume (1978).
	Jordan	Hashim (1979).
TYLENCHIDA		
Amplimerlinius amplus Siddiqi	Portugal	Siddiqi (1976).
A. macrurus (Goodey) Siddiqi	Jordan	Hashim (1979).
Coslenchus costatus (De Man) Siddiqi	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
Criconemoides informis (Micol.) Taylor	Jordan	Hashim (1979).
Criconemoides sp.	Chile	Gallo & Jiménez (1976).
	Egypt	Diab & El-Eraki (1968).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
	Jordan	Anon. (1970) ; Bridge (1978).
Crossonema multisquamatum (= *C. civellae*) (Kirjanova) Mehta & Raski	Zimbabwe	Mehta & Raski (1971).
Ditylenchus virtudesae Tobar Jiménez	Spain	Tobar Jiménez (1964).
Ditylenchus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio Talamé & D'Errico (1971).
	Jordan	Anon. (1970).
Dolichodorus heterocephalus Cobb	Italy	D'Errico, Lamberti & Fiume (1977).
Dolichodorus sp.	Italy	Fiume (1978).
Filenchus filiformis (Bütschli) Meyl	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
Gracilacus peratica Raski	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Inserra *et al.* (1976) ; Raski (1976) ; Inserra & Vovlas (1977, 1981).
Gracilacus sp.	Italy	Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
Helicotylenchus digonicus Perry *in* Perry, Darling & Thorne	Cyprus	Philis & Siddiqi (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Jordan	Bridge (1978) ; Hashim (1979).
H. dihystera (Cobb) Sher	Cyprus	Philis & Siddiqi (1976).
	Egypt	Tarjan (1964) ; Diab & El-Eraki (1968).
	Spain	Romero & Arias (1969).
	Zimbabwe	Sher (1966).

Table 1 *(continued)*

Nematodes	*Regions*	*References*
H. erythrinae (Zimmermann) Golden	Italy	Graniti (1955).
H. neopaxilli Inserra, Vovlas & Golden	Italy	Inserra, Vovlas & Golden (1979) ; Inserra & Vovlas (1981).
H. oleae Inserra, Vovlas & Golden	Italy	Inserra, Vovlas & Golden (1979) ; Inserra & Vovlas (1981).
H. pseudorobustus (= *H. microlobus*) (Steiner) Golden	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Jordan	Hashim (1979).
H. tunisiensis Siddiqi	Israel	Sher (1966).
	Jordan	Hashim (1979).
Helicotylenchus sp.	Algeria	Lamberti, Greco & Zaouchi (1975).
	Chile	Gallo Donoso & Jiménez Roco (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Fiume (1978).
	Jordan	Anon. (1970).
Hemicycliophora sp.	Chile	Gallo & Jiménez (1976).
Heterodera sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
Hoplolaimus spp.	Egypt	Diab & El-Eraki (1968).
Meloidogyne hapla Chitw.	Israel	Minz (1961).
M. incognita (Kofoid & White) Chitw.	Israel	Minz (1961).
	Italy	Lamberti & Vito (1972) ; Vovlas, Inserra & Lamberti (1975) ; Inserra *et al.* (1976) ; Inserra & Vovlas (1981).
	Jordan	Abu-Gharbieh, Makkouk & Saghir (1978) ; Hashim (1979).
	Lebanon	Saad & Nienhaus (1969) ; Saad & Tanveer (1972).
M. javanica (Treub) Chitw.	Egypt	Diab & El-Eraki (1968).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Israel	Tarjan (1953).
	Italy	Lamberti & Vito (1972) ; Inserra & Vovlas (1981).
	Jordan	Hashim (1979).
	USA (Calif.)	Lamberti & Lownsbery (1968).
Meloidogyne sp.	Chile	Gallo & Jiménez (1976) ; Jimenez (1979).
	Cyprus	Philis & Siddiqi (1976).
	Italy	Graniti (1955) ; Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
	Jordan	Anon. (1970) ; Qasem (1970).
	Portugal	Almeida Santos & Abrantes (1979).
Meloidogyne spp.	USA	Buhrer, Cooper & Steiner (1933).
Merlinius brevidens (Allen) Siddiqi [1]	Cyprus	Philis & Siddiqi (1976).

(1) Formerly identified in Jordan as *M.* cf. *nanus* (Allen) Siddiqi (Hashim, 1979).

Table 1 *(continued)*

Nematodes	*Regions*	*References*
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Jordan	Hashim (1979).
Ogma rhombosquamatum (Mehta & Raski) Andrássy	Italy	Vovlas & Inserra (1981) ; Inserra & Vovlas (1981).
Ogma sp.	Italy	Fiume (1978).
Paratylenchus vandenbrandei De Grisse	Italy	Inserra *et al.* (1976).
Paratylenchus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
	Jordan	Anon. (1970).
Pratylenchoides sp.	Jordan	Anon. (1970).
Pratylenchus coffeae (Zimmermann) Filipjev & Sch. Stek.	Australia	Colbran (1964).
P. crenatus Loof	Italy	Inserra *et al.* (1976).
P. neglectus (= *P. minyus)* (Rensch) Filipjev & Sch. Stek.	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Inserra *et al.* (1976).
P. penetrans (Cobb) Filipjev & Sch. Stek.	Italy	Inserra *et al.* (1976) ; Inserra & Vovlas (1981).
P. thornei Sher & Allen	Jordan	Hashim (1979).
P. vulnus Allen & Jensen (2)	Italy	Lamberti (1969 *c*) ; Inserra *et al.* (1976) ; Inserra & Vovlas (1981).
	USA (Calif.)	Condit & Horne (1938) ; Serr & Day (1949) ; Day & Serr (1951) ; Lamberti & Baines (1969*a*).
Pratylenchus sp.	Algeria	Lamberti, Greco & Zaouchi (1975).
	Chile	Gallo & Jiménez (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
	Jordan	Anon. (1970).
Psilenchus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Fiume (1978).
Radopholus sp.	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966). Greece Koliopanos & Vovlas (1977)
Rotylenchulus macrodoratus Dasgupta, Raski & Sher		Greece koliopanos & Voulas (1977)
	Italy	Vovlas & Lamberti (1974) ; Inserra *et al.* (1976) ; Vovlas & Inserra (1976) ; Inserra & Vovlas (1981).
R. macrosomus Dasgupta, Raski & Sher	Israel	Dasgupta, Raski & Sher (1968).
R. reniformis Linford & Oliveira	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).

(2) Erroneously identified by Condit & Horne (1938) as *P. musicola* (Cobb) Filipjev (see Sher & Allen, 1953) and by Serr & Day (1949) as *P. pratensis* (De Man) Filipjev (see Allen & Jensen, 1951 and Sher & Allen, 1953).

Table 1 *(continued)*

Nematodes	Regions	References
Rotylenchulus sp.	Algeria	Lamberti, Greco & Zaouchi (1975).
Rotylenchus sp.	Cyprus	Philis & Siddiqi (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968); Scognamiglio, Talamé & D'Errico (1971); Fiume (1978).
Telotylenchus sp.	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
Trophurus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968).
Tylenchorhynchus clarus Allen	Jordan	Hashim (1979).
T. dubius (Butschli) Filipjev	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
T. goffarti Sturhan (3)	Jordan	Hashim (1979).
T. striatus Allen	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
Tylenchorhynchus sp.	Algeria	Lamberti, Greco & Zaouchi (1975).
	Chile	Gallo & Jiménez (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968); Scognamiglio, Talamé & D'Errico (1971); Fiume (1978).
	Jordan	Anon. (1970).
Tylenchorhynchus spp.	Egypt	Diab & El-Eraki (1968).
Tylenchulus semipenetrans Cobb	Australia	Colbran (1955, 1964).
	Egypt	Diab & El-Eraki (1968).
	Italy	Inserra & Vovlas (1978, 1981); Inserra, Vovlas & O'Bannon (1980).
	USA (Calif.)	Allen (1949); Baines (1951); Baines & Thorne (1950, 1952); Lamberti & Baines (1970); Baines, Cameron & Soost (1974).
Tylenchulus sp.	Chile	Gallo & Jiménez (1976).
	Italy	Fiume (1978).
Tylenchus sp.	Chile	Gallo & Jiménez (1976).
	Greece	Hirschmann, Paschalaki-Kourtzi & Triantaphyllou (1966).
	Italy	Scognamiglio, Talamé & Giandomenico (1968); Scognamiglio, Talamé & D'Errico (1971); Fiume (1978).
Tylenchus spp.	Jordan	Hashim (1979).
DORYLAIMIDA		
Longidorus africanus Merny (4)	Egypt	Tarjan (1964).
L. siddiqii Aboul-Eid	Jordan	Hashim (1979).
Longidorus sp.	Italy	Scognamiglio, Talamé & Giandomenico (1968); Scognamiglio, Talamé & D'Errico (1971); Fiume (1978).
Longidorus spp.	Egypt	Diab & El-Eraki (1968).

(3) Erroneously identified by Hashim (1979) as *T. dubius* (Bütschli) Filipjev.
(4) Erroneously identified by Tarjan (1964) as *L. elongatus* (De Man) Thorne & Swanger (see Lamberti, 1969*a*).

Table 1 *(continued)*

Nematodes	*Regions*	*References*
Paralongidorus sp.	Italy	Fiume (1978).
Trichodorus sp.	Chile	Gallo & Jiménez (1976).
	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Fiume (1978).
Xiphinema californicum Lamberti & Bleve-Zacheo ([5])	USA (Calif.)	Lamberti (1969*b*) ; Lamberti & Bleve-Zacheo (1979).
X. elongatum Sch. Stek. & Teun.	Egypt	Diab & El-Eraki (1968).
X. ingens Luc & Dalmasso	Italy	Lamberti, Bleve-Zacheo & Martelli (1975).
	Jordan	Hashim (1979).
X. italiae Meyl	Italy	Martelli, Cohn & Dalmasso (1966).
X. pachtaicum (Tulaganov) Kirjanova	Jordan	Hashim (1979).
X. sahelense Dalmasso	Spain	Arias (1975).
X. vuittenezi Luc, Lima, Weischer & Flegg	Spain	Arias (1975).
Xiphinema sp.	Chile	Gallo & Jiménez (1976).
	Israel	Minz, Strich-Harari & Cohn (1963).
	Italy	Scognamiglio, Talamé & Giandomenico (1968) ; Scognamiglio, Talamé & D'Errico (1971) ; Fiume (1978).
	Jordan	Anon. (1970).
	Spain	Tobar Jiménez (1964).

cortex ; nematode feeding induced a thickening of cortical cell walls and hypertrophy of the nuclei and nucleoli, in addition to necrosis in epidermal and cortical tissue. The pathogenicity of *Ogma* species to olive is not known.

Control of nematodes on olive

Chemical methods

Soil treatment

The application of fumigant nematicides to the soil is generally a successful, though often an expensive, method of control of plant-parasitic nematodes. Since most fumigants are phytotoxic, their time of application necessarily precedes that of planting (pre-plant treatment). Fumigants such as dichloropropane-dichloropropene (D-D) and ethylene dibromide (EDB), as well as precursors of methyl isothiocyanate (e.g. dazomet), may be effective in eliminating nematodes from land where olive seedlings are to be introduced. However, their use in clayey soils is not recommended because their prolonged persistence in such soils may adversely affect the plants (Basile & Lamberti, 1978) ; more volatile fumigants, such as methyl bromide, could be used in such instances but these are generally economically unacceptable.

The chemical 1,2 - dibromo-3-chloropropane (DBCP) is the only fumigant nematicide that is normally used on soil under crop (post-plant treatment) as it is not highly phytotoxic. It is particularly suitable for perennial crops, as are olives. In Italy, olive groves infested with *Pratylenchus vulnus* and showing decline symptoms were treated with DBCP, applied in irrigation water at rates of up to 14 ml a.i./tree and 70 l a.i./ha, but, after about two years, there was no significant effect on olive yield (Inserra *et al.*, 1976). This may have been a consequence of insufficient penetration and diffusion of the chemical within the deeper soil layers, resulting in insignificant reduction of nematode population densities. Alternatively, since the effect of

([5]) In Lamberti (1969*b*), the nematode is referred to as *X. americanum* Cobb *sensu lato*.

DBCP on the nematode populations was not recorded, the possibility exists that the decline symptoms observed in the experimental groves were not primarily caused by nematodes, so that the yield data obtained were independent of nematode population levels.

In contrast, Lamberti and Vito (1972) reported that, in Italy, DBCP treatment of an olive nursery infested with a mixed population of *Meloidogyne incognita* and *M. javanica* resulted in improved plant growth, but did not significantly affect the nematode densities within the roots; the application of a variety of systemic organophosphate and carbamate nematicides to the nursery beds gave similar results. Glasshouse trials by Vovlas, Inserra and Lamberti (1975) also indicated that soil and/or foliar application of systemic organophosphate or carbamate nematicides were unsuccessful in eliminating *M. incognita* from the roots of olive seedlings.

D-D is a pre-plant fumigant nematicide which is considered toxic to most plants. However, in Italy, Graniti (1955) reported that the application of this chemical in irrigation water, at the rate of 15 ml/m², around the base of unthrifty olive trees infected with *Helicotylenchus erythrinae* and *Meloidogyne* sp., resulted in improvement of the vegetative state of the plants within a short period (approx. four months); the application of parathion (a derivative of phosphorothionic acid), at the rate of 75 g a.i./m², to similarly affected trees had no discernible effect on their condition. It should be noted that, following such nematicidal treatments, established trees normally require long periods of time (one to two years) in order to recover from nematode damage and exhibit improved growth. The rapid improvement of olive trees treated with D-D observed by Graniti (1955) may not have been a consequence of a lowering of nematode densities, but due to some unknown side-effect of the chemical.

The fruit quality of olive trees may be affected following nematicidal treatments, and this is a factor which must be taken into consideration when instituting control measures. Thus, Lamberti and Basile (1978) found that repeated applications of DBCP to olive plants resulted in relatively high concentrations of bromide in the fruit.

Plant treatment

Pathogenic nematodes in nurseries may be disseminated widely with infested plant material and, therefore, their elimination from nursery stocks is important in reducing their spread. Several methods are currently available for the control of nematodes in nurseries, the most effective of which involves the disinfestation of stocks by dipping the bare roots in aqueous solutions or suspensions of nematicidal chemicals. This technique was applied in Italy by Lamberti and Vito (1972) when assessing the efficacy of a variety of chemicals in the sanitation of olive stocks infested with *Meloidogyne incognita* and *M. javanica*. They found that several of the chemicals, at certain concentrations and exposure times, eradicated the nematodes; Nemacur P, at the rate of 40 ml/10 l, resulted in complete control at all exposure times. Some of the chemicals, namely Nemacur P, Thionazin and DBCP, were phytotoxic when exposure times were prolonged. Apparently, then, there is an optimum concentration and exposure time for each chemical at which most effective disinfestation of olive stocks is achieved, and these should be determined prior to their use in large-scale sanitation programmes.

Varietal resistance

Some varieties of olive appear to be resistant or tolerant to certain species of *Meloidogyne*, *Pratylenchus* and *Tylenchulus (loc. cit.)*. The use of such cultivars is potentially very effective in reducing economic losses caused by pathogenic nematodes, but varietal differences in fruit yield and quality may be limiting factors.

References

Abu-Gharbieh, W. I., Makkouk, K. M. & Saghir, A. R. (1978). Response of different tomato cultivars to the root-knot nematode, tomato yellow leaf curl virus, and *Orobanche* in Jordan. *Pl. Dis. Reptr*, 62 : 263-266.

Allen, M. W. (1949). Root lesion nematodes — resistant rootstocks most promising method of control. *Calif. Agric.*, 3 : 8-14.

ALLEN, M. W. & JENSEN, H. J. (1951). *Pratylenchus vulnus*, new species (Nematoda : Pratylenchinae), a parasite of trees and vines in California. *Proc. helminth. Soc. Wash.*, 18 : 47-50.

ALMEIDA SANTOS, M. S. Newton de & O. ABRANTES, I. M. de (1979). Root-knot nematodes in Portugal. In : *Proc. Second Res. Planning Conf. on Root-knot Nematodes,* Meloidogyne *spp. November 26-30, 1979, Athens, Greece :* 17-23.

ANON. (1979). [Nematology section]. (In Arabic). *Annual Report, Dept. Agric. Res. & Extn., Ministry of Agriculture, Jordan :* 92-96.

ARIAS, M. (1975). Nuevas aportaciones al conocimiento del genero *Xiphinema* (Nematoda) y su distribucion en los suelos Españoles. *An. Edafol. y Agrobiol.*, 34 : 183-198.

BADRA, T. & KHATTAB, M. M. (1980). The effect of nitrogen fertilizers on the growth of olive and in relation to infestations of *Rotylenchulus reniformis. Nematol. medit.*, 8 : 67-72.

BAINES, R. C. (1951). Citrus-root nematodes on olive pest pathologically and morphologically similar to that on orange roots infests and reproduces on olive roots. *Calif. Agric.*, 5 : 11.

BAINES, R. C., CAMERON, J. W. & SOOST, R. K. (1974). Four biotypes of *Tylenchulus semipenetrans* in California identified, and their importance in the development of resistant citrus rootstocks. *J. Nematol.*, 6 : 63-66.

BAINES, R. C. & THORNE, G. (1950). Olive, a new host for the citrus-root nematode. *Phytopathology,* 40 : 963.

BAINES, R. C. & THORNE, G. (1952). The olive tree as a host of the citrus-root nematode. *Phytopathology,* 42 : 77-78.

BASILE, M. & LAMBERTI, F. (1978). Distribuzione verticale persistenza dell' 1,3 dichloropropene in tre tipi di terreno dell' Italia meridionale. *Nematol. medit.*, 6 : 135-145.

BRIDGE, J. (1978). Plant nematology in Jordan. *ODM, Report of Scientific Liaison officer,* 20 p.

BUHRER, E. M., COOPER, C. & STEINER, G. (1933). A list of plants attacked by the root-knot nematode *(Heterodera marioni). Pl. Dis. Reptr,* 17 : 64-96.

COHN, E. & MORDECHAI, M. (1970). The influence of some environmental and cultural conditions on rearing populations of *Xiphinema* and *Longidorus. Nematologica,* 15 : 295-302.

COLBRAN, R. C. (1955). A preliminary survey of plant nematodes in Queensland. *J. Aust. Inst. agric. Sci.*, 21 : 167-169.

COLBRAN, R. C. (1964). Studies of plant and soil nematodes. 7. Queensland records of the order Tylenchida and the genera *Trichodorus* and *Xiphinema. Queensland J. agric. Sci.*, 21 : 77-123.

CONDIT, I. J. & HORNE, W. T. (1938). Nematode infestation of olive roots. *Phytopathology,* 28 : 756-757.

DASGUPTA, D. R., RASKI, D. J. & SHER, S. A. (1968). A revision of the genus *Rotylenchulus* Linford & Oliveira, 1940 (Nematoda : Tylenchidae). *Proc. helminth. Soc. Wash.*, 35 : 169-192.

DAY, L. H. & SERR, E. F. (1951). Comparative resistance of rootstocks of fruit and nut trees to attack by a root lesion or meadow nematode. *Proc. Am. Soc. hort. Sci.*, 57 : 150-154.

D'ERRICO, F. P., LAMBERTI, F. & FIUME, F. (1977). Ritrovamento di *Dolichodorus heterocephalus* Cobb nell'Italia meridionale. *Nematol. medit.*, 5 : 99-101.

DIAB, K. A. & EL-ERAKI, S. (1968). Plant parasitic nematodes associated with olive decline in the United Arab Republic. *Pl. Dis. Reptr,* 52 : 150-154.

FIUME, F. (1978). I generi dei nematodi viventi nella rizosfera dell'olivo in Calabria. *Inftore fitopatol.*, 28 : 11-14.

GALLO, D. P. & JIMÉNEZ, R., M. (1976). Nematofauna fitoparásita asociada al olivo (*Olea europaea* L.) en el Valle de Azapa. *Idesia, Chile,* No. 4 : 105-109.

GRANITI, A. (1955). Un deperimento dell'olivo in Sicilia associato a due specie di nematodi. *Olearia,* 9 : 114-120.

HASHIM, Z. (1979). A preliminary report on the plant-parasitic nematodes in Jordan. *Nematol. medit.*, 7 : 177-186.

HIRSCHMANN, H., PASCHALAKI-KOURTZI, N. & TRIANTAPHYLLOU, A. C. (1966). A survey of plant-parasitic nematodes in Greece. *Annls. Inst. phytopath. Benaki,* 7 : 144-156.

INSERRA, R. N. & VOVLAS, N. (1977). Parasitic habits of *Gracilacus peratica* on olive feeder roots. *Nematol. medit.*, 5 : 345-348.

INSERRA, R. N. & VOVLAS, N. (1978). *Tylenchulus semipenetrans* on olive trees in northern Italy. [Abstr.] In : *Third Int. Congr. Pl. Path., München, GFR, 16-23 Aug., 1978. Abstracts of Papers,* 151.

INSERRA, R. N. & VOVLAS, N. (1979). Life-cycle and biology of *Rotylenchulus macrodoratus. (18th Ann. Meet., Salt Lake City, Utah, 23-26 July, 1979. Abstr.). J. Nematol.*, 11 : 302.

INSERRA, R. N. & VOVLAS, N. (1980). The biology of *Rotylenchulus macrodoratus. J. Nematol.*, 12 : 97-102.

INSERRA, R. N. & VOVLAS, N. (1981). Indagine sulla distribuzione geografica dei nematodi parassiti dell' olivo in Italia. *Inftore fitopatol.*, 31 : 117-119.

INSERRA, R. N., VOVLAS, N. & GOLDEN, A. M. (1979). *Helicotylenchus oleae* n. sp. and *H. neopaxilli* n. sp. (Hoplolaimidae), two new spiral nematodes parasitic on olive trees in Italy. *J. Nematol.*, 11 : 56-62.

INSERRA, R., VOVLAS, N., LAMBERTI, F. & BLEVE ZACHEO, T. (1976). Plant parasitic nematodes associated with declining olive trees in southern Italy. *(Acta IV Congr. Un. Phytopath. Mediterr., Zadar, Yugoslavia, 5-11 Oct., 1975.) Poljoprivredna Znanstvena Smotra, Agriculturae Conspectus Scientificus,* No. 39 : 419-424.

INSERRA, R. N., VOVLAS, N. & O'BANNON, J. H. (1980). A classification of *Tylenchulus semipenetrans* biotypes. *J. Nematol.*, 12 : 283-287.

JIMENEZ, R. M. (1979). Antecedentes sobre el Nemátodo cecidógeno en la la Región, Chile. *Idesia, Chile,* No. 5 : 41-47.

KOLIOPANOS, C.N. & VOVLAS, N. (1977). Records of some plant parasitic nematodes in Greece with morphometrical descriptions. *Nematol. medit.*, 5 : 207-215.

LAMBERTI, F. (1969*a*). Nematodi parassiti dell'olivo. *Inftore fitopatol.*, 19 : 405-408.

LAMBERTI, F. (1969*b*). The Olive as a host for *Xiphinema americanum* Cobb. *Phytopath. medit.*, 8 : 230.

LAMBERTI, F. (1969*c*). Presenza in Italia di un deperimento dell'Olivo causato dal nematode *Pratylenchus vulnus* All. & Jens. *Phytopath. medit.*, 8 : 232-234.

LAMBERTI, F. (1981). I nematodi dell'olivo e la relativa lotta. *Inftore fitopatol.*, 31 : 93-96.

LAMBERTI, F. & BAINES, R. C. (1969*a*). Effect of *Pratylenchus vulnus* on the growth of 'Ascolano' and 'Manzanillo' olive trees in a glasshouse. *Pl. Dis. Reptr*, 53 : 557-558.

LAMBERTI, F. & BAINES, R. C. (1969*b*). Pathogenicity of four species of *Meloidogyne* on three varieties of olive trees. *J. Nematol.*, 1 : 111-115.

LAMBERTI, F. & BAINES, R. C. (1970). Infectivity of three biotypes of the citrus nematode *(Tylenchulus semipenetrans)* on two varieties of olive. *Pl. Dis. Reptr*, 54 : 717-718.

LAMBERTI, F. & BASILE, M. (1978). Residui di bromo in drupe d'olivo prodotte da piante trattate con DBCP. *Atti Giornate Fitopatologiche 1978, Acireale, Catania :* 45-49.

LAMBERTI, F. & BLEVE-ZACHEO, T. (1979). Studies on *Xiphinema americanum sensu lato* with descriptions of fifteen new species (Nematoda, Longidoridae). *Nematol. medit.*, 7 : 51-106.

LAMBERTI, F. & LOWNSBERY, B. F. (1968). Olive varieties differ in reaction to the root-knot nematode *Meloidogyne javanica* (Treub) Chitw. *Phytopath. medit.*, 7 : 48-50.

LAMBERTI, F., BLEVE-ZACHEO, T. & MARTELLI, G. P. (1975). Un caso di intersesso in *Xiphinema ingens* Luc *et* Dalmasso (Nematoda, Longidoridae). *Nematol. medit.*, 3 : 181-183.

LAMBERTI, F., GRECO, N. & ZAOUCHI, H. (1975). A nematological survey of date palms and other major crops in Algeria. *F.A.O., Pl. Prot. Bull.*, 23 : 156-160.

LAMBERTI, F. & DI VITO, M. (1972). Sanitation of root-knot nematode infected olive-stocks. In : *Actas do III Congresso da União Fitopat. Medit., Oeiras, 22-28 Outubro, 1972,* 401-411.

LAMBERTI, F., VOVLAS, N. & TIRRÒ, A. (1976). Infettività e patogenicità di tre popolazioni italiane di *Tylenchulus semipenetrans* su Agrumi ed altri ospiti. *Nematol. medit.*, 4 : 85-91.

LOWNSBERY, B. F. & SERR, E. F. (1963). Fruit and nut tree rootstocks as hosts for a root-lesion nematodes *Pratylenchus vulnus. Proc. Am. Soc. hort. Sci.*, 82 : 250-254.

MARTELLI, G. P., COHN, E. & DALMASSO, A. (1966). A redescription of *Xiphinema italiae* Meyl, 1953 and its relationship to *Xiphinema arenarium* Luc & Dalmasso, 1963 and *Xiphinema conurum* Siddiqi, 1964. *Nematologica*, 12 : 183-194.

MEHTA, U. K. & RASKI, D. J. (1971). Revision of the genus *Criconema* Hofmänner and Menzel, 1914 and other related genera (Criconematidae : Nematoda). *Indian J. Nematol.*, 1 : 145-198.

MINZ, G. (1961). Additional hosts of the root-knot nematode, *Meloidogyne* spp., recorded in Israel during 1958 - 1959. *Israel J. agric. Res.*, 11 : 69-10.

MINZ, G., STRICH-HARARI, D. & COHN, E. (1963). [Plant parasitic nematodes in Israel and their control.] (In Hebrew). *Tel Aviv, "Sifriat Hassadeh" Publishing House,* vii+84 p.

PHILIS, J. & SIDDIQI, M. R. (1976). A list of plant parasitic nematodes in Cyprus. *Nematol. medit.*, 4 : 171-174.

QASEM, S. (1970). Occurrence and distribution of plant diseases in Jordan. *Res. Bull., Jordanian Scient. Res. Counc.*, No. 1, 28 p.

RASKI, D. J. (1976). Revision of the genus *Paratylenchus* Micoletzky, 1922 and descriptions of new species. Part III of three parts - *Gracilacus. J. Nematol.*, 8 : 97-115.

ROMERO, M. D. & ARIAS, M. (1969). Nematodes de solanáceas cultivadas en la zona mediterranea del sur de España. 1. Tylenchida. *Boln R. Soc. esp. Hist. nat. (Biol.)*, 67 : 121-142.

SAAD, A. T. & NIENHAUS, F. (1969). Plant diseases in Lebanon. *Z. PflKrankh. (PflPath.) PflSchutz.*, 76 : 537-551.

SAAD, A. T. & TANVEER, M. (1972). Prevalence and host range of *Meloidogyne* species in Lebanon. *F.A.O. Pl. Prot. Bull.* 20 : 31-35.

SCOGNAMIGLIO, A., TALAMÉ, M. & D'ERRICO, F. P. (1971). Indagine sui Nematodi viventi nella rizosfera dell'olivo (2° contributo). *Boll. Lab. Ent. agr. "Filippo Silvestri", Portici*, 29 : 43-59.

SCOGNAMIGLIO, A., TALAMÉ, M. & GIANDOMENICO, N. (1968). Indagine sui Nematodi viventi nella rizosfera dell'olivo (1° contributo). *Boll. Lab. Ent. agr. "Filippo Silvestri", Portici*, 26 : 205-226.

SERR, E. F. & DAY, L. H. (1949). Lesion nematode injury to California fruit and nut trees, and comparative tolerance of various species of Juglandaceae. *Proc. Am. Soc. hort. Sci.*, 53 : 134-140.

SHER, S. A. (1966). Revision of the Hoplolaiminae (Nematoda) VI. *Helicotylenchus* Steiner, 1945. *Nematologica*, 12 : 1-56.

SHER, S. A. & ALLEN, M. W. (1953). Revision of the genus *Pratylenchus* (Nematoda : Tylenchidae). *Univ. Calif. Publs Zool.*, 57 : 441-470.

SIDDIQI, M. R. (1976). New plant nematode genera *Plesiodorus* (Dolichodorinae), *Meiodorus* (Meiodorinae subfam. n.), *Amplimerlinius* (Merliniinae) and *Gracilancea* (Tylodoridae grad. n.). *Nematologica*, 22 : 390-416.

TARJAN, A. C. (1953). Geographic distribution of some *Meloidogyne* spp. in Israel. *Pl. Dis. Reptr*, 37 : 315-316.

TARJAN, A. C. (1964). Plant-parasitic nematodes in the United Arab Republic. *F.A.O. Pl. Prot. Bull.* 12 : 49-56.

TOBAR JIMÉNEZ, A. (1964). *Ditylenchus virtudesae* n. sp. (Nematoda : Tylenchidae), habitante de los suelos granadinos. *Revta ibér. Parasit.*, 24 : 51-56.

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VOVLAS, N. & INSERRA, R. N. (1976). Istopatologia di radici di olivo infestate da *Rotylenchulus macrodoratus* Dasgupta, Raski *et* Sher. *Nematol. medit.*, 4 : 223-230.

VOVLAS, N. & INSERRA, R. N. (1981). Parasitic habits of *Ogma rhombosquamatum* and description of the male. *J. Nematol.*, 13 : 87-90.

VOVLAS, N., INSERRA, R. & LAMBERTI, F. (1975). Risanamento di piantoni di arancio amaro, olivo e vite infestate da nematodi. *Atti Giornate Fitopatologiche 1975, Torino :* 271-277.

VOVLAS, N. & LAMBERTI, F. (1974). Nuovi ospiti naturali di *Rotylenchulus macrodoratus* Dasgupta, Raski e Sher, 1968 nella regione Mediterranea. *Nematol. medit.*, 2 : 177-179.