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PLANT PARASITIC NEMATODES ASSOCIATED WITH SPICES

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ABSTRACT

A literature review of the nematodes associated with the important spice plants is given. As many as 35 nematodes have been recorded on black pepper, 14 on ginger, 12 on cardamom, 6 on turmeric, 10 on cloves, 9 on nutmeg, and 6 on cinnamon. Nematodes are particularly important on black pepper, cardamom, and ginger.

India has been known since time immemorial, as the "home of spices". No detailed nematological investigations have been done on any of them in India except for a few reports of root-knot nematode infestations. In this review, an attempt has been made to consolidate the scattered information on nematodes of various spices.

1. Black pepper (*Piper nigrum* L.)

Meloidogyne sp. was the first nematode to be recorded on black pepper (Delacriox, 1902 in Cochin-China). In 1906, Butler reported root-knot nematode from black pepper in Wynad, Kerala, India. The burrowing nematode, *Radopholus similis*, is notorious for having wiped out 22 million trees (a pepper 'tree' is a teakwood or concrete post set in the field with two pepper vines entwined about it) during 20 years' time in the Bangka Island of Indonesia (Christie, 1959). Association of *R. similis* with yellows disease of pepper was first reported by Van der Vecht (1950), who made extensive field studies and also demonstrated the pathogenicity of this nematode under laboratory conditions. Later, Hubert (1957) reported the endemic occurrence of burrowing nematode in various areas of Bangka Island and suggested a fungus-nematode complex as the cause of yellows disease. The first indication of yellows disease is the appearance of occasional yellowed leaves, which increase in numbers until, within a large portion, or even all of the foliage, may become affected. Growth ceases soon after yellowing becomes apparent, and production of pepper rapidly declines. Severe die-back and eventual death of the plants follow. The rootlets of affected vines show small lesions. These enlarge and disintegrate the rootlets. Thus, the main roots become devoid of small feeder roots and the larger laterals gradually develop necrosis also. Christie (1957) reported that pepper planted in isolated areas escaped the burrowing nematode infestation for at least five years. According to him, application of different organic and commercial fertilisers failed to retard development of yellows disease. No resistance was located in any of the pepper cultivars available then in Bangka. Recently Ichinohe (1976b) has reported an increase in area under black pepper in Bangka island during the past 20 years in newly cleared areas. According to him, the "yellows disease" attributed to *R. similis* was rare, but *Meloidogyne* sp. was widely distributed.

He differentiated the symptom picture in pepper due to *Meloidogyne* sp. and *R. similis*. Plants infested with *Meloidogyne* sp. exhibited dense yellowish discolouration of leaves, whereas those infested with *R. similis* exhibited pale yellow or whitish discoloration and the hanging yellow leaves curl inwards. Holliday and Mowat (1963) observed that infestation by *Meloidogyne* sp. did not significantly enhance the susceptibility of pepper vine to foot-rot in Sarawak. Winto (1972) studied the effect of *M. incognita* and *M. javanica* on the pepper cultivar Kuching in Malaysia and reported increased susceptibility of root-knot affected plants to infection by *Phytophthora* and other pathogens. Ting (1975) reported *Meloidogyne* spp. as the most important group of nematodes in Malaysia, causing gradual decline of black pepper characterized by unthrifty growth and yellowing of leaves. Black pepper decline in Brunei has also been reported to be associated with *Meloidogyne* and certain root rotting fungi (Anonymous, 1974b). In Brazil, Ichinohe (1975) observed that as much as 91% of pepper plants in fields near Belem, Para, were infested with *M. incognita*. Vines upto five years age were less affected than older ones. *R. similis* was not found, although symptoms of yellowing leaves similar to those attributed to *R. similis* in Indonesia were seen here also.

Though as early as in 1906, Butler, and later Ayyar (1926), had reported root-knot nematode from pepper in Wynad, Kerala, India, no follow up investigations were carried out until recently to assess the role of *M. incognita* or *R. similis* in the incidence of slow and quick wilt diseases of pepper in India. Seshadri (1972, personal communication) recorded the association of *Meloidogyne* sp. and *R. similis* with slow wilt of pepper. Venkitesan (1972) recorded high populations of *R. similis* in the rhizosphere of pepper (also Koshy, Sundararaju, and Sosamma, 1978). Samples collected from the root system of the hybrid cultivar Panniyur-I trained on arecanut palms in Bandadka, Kasaragod, Kerala yielded very high populations (94 nematodes/g of root) of *R. similis* (Koshy et al., 1978). On young feeder roots, brown lesions could be clearly seen, followed by blackening and disintegration of the root system. The optimum temperature for extraction of nematodes from infested pepper roots was determined to be 10-20°C.

Venkitesan and Setty (1978) screened 18 cultivars of black pepper, four *Piper* species and five wild *Piper* collections against *R. similis*. The wild collection VTP 430, *Piper hymenophyllum*, and *P. attenuatum* recorded least (less than 30%) root reduction and minimum (1.5 times) nematode reproduction ninety days after inoculation. The hybrid pepper cultivar Panniyur-1 recorded 91.4% root reduction and 7.6 times nematode reproduction. Koshy and Sundararaju (1979) screened seven popular cultivars of black pepper against *M. incognita* and found the hybrid cultivar Panniyur-1 as the most susceptible one and Valiakanakadan the least susceptible.

In the Panniyur-1 seedling distribution programme, methyl bromide fumigation of nursery potting mixture under polythene cover for 24-48 hr has been recommended as a guard against the incidence of root-knot nematode in Kerala (Anonymous, 1973).

Venkitesan and Setty (1977) studied pathogenicity of *R. similis* to black pepper using 10, 100, 1000, and 10,000 nematodes as initial inoculum leavels. There was decline in growth of plants with increase in inoculum levels. From the above studies, they reported that *R. similis* could be a primary incitant of slow wilt disease. Koshy et al. (1979) also studied the pathogenicity of *M. incognita* on black pepper, Even 10 larvae/cutting reduced the plant growth by 16% over a period of one year, and a maximum of 50%

Rotylenchulus reniformis	Kerala, Delhi, India	Sundararaju et al. (1979b); Swarup et al (1967)
Tylenchorhynchus sp.	Kerala, India	Sundararaju et al. (1979b)
Tylenchus	Malaysia	Reddy (1977)
Xiphinema basiri	Rajasthan, India;	Yadav & Varma (1967)

IV. TURMERIC (*Curcuma longa* L.)

Helicotylenchus sp.	Kerala, India	Sundararaju, et al. (1979b)
Hoplolaimus sp.	–do–	–do–
Meloidogyne javanica	Bihar, India	Nirula & Kumar (1963)
M. incognita	Bihar, Kerala, India	Nirula & Kumar (1963), Nadakal & Thomas (1964), Sundaraju et al. (1979b)
Pratylenchus sp.	Kerala, India	Sarma et al. (1974) Sundararaju et al. (1979b)
Radopholus similis	Kerala, India	Koshy & Sosamma (1975), Sosamma et al. (1979), Sundararaju et al. (1979b)

V. CLOVE (*Eugenia caryophyllus* Thunb.)

Caloosia sp.	Kerala, India	Sundararaju et al. (1979b)
Dolichodorus sp.	Bahia, Brazil	Sharma & Loof (1974)
Helicotylenchus dihystera	–do–	–do–
Helicotylenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Hoplolaimus sp.	–do–	–do–
Meloidogyne incognita	Bahia, Brazil	Sharma & Loof (1974)
Meloidogyne sp.	Kerala, India	Ghesquiere (1921)*; Goodey et al. (1965); Sundararaju et al. (1979b)
Pratylenchus sp.	Kerala, India	Sundararaju (1979b)
Rotylenchus reniformis	Bahia, Brazil; Kerala, India	Sharma & Loof (1974); Sundararaju et al. (1979b)
Trichodorus sp.	Bahia, Braizl	Sharma & Loof (1974)
Tylenchorhynchus sp.	Kerala, India	Sundararaju et al. (1979b)
Xiphinema sp.	–do–	–do–

VI. NUTMEG (*Myristica fragrans* Houtt).

Helicotylenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Hoplolaimus sp.	–do–	–do–
Meloidogyne incognita	Karnataka, India	Kumar et al. (1971)
Meloidogyne sp.		*Goffart (1953), Goodey et al. (1965),
	Kerala India	Sundararaju et al. (1979b),
Paratylenchus sp.	–do–	Sundararaju et al. (1979b)
Radopholus similis	–do–	Koshy & Sosamma (1975), Sundararaju et al. (1979b)
Rotylenchulus reinformis	–do–	Sundararaju et al. (1979b)
Rotylenchus sp.	–do–	–do–
Xiphinema sp.	–do–	–do–

VII. CINNAMON (*Cinnamomum zeylanicum* Nees.)

Criconemoides sp.	Kerala, India	Sundararaju et al. (1979b)
Helicotylenchus sp.	–do–	–do–
Meloidogyne sp.		*Goffart (1953) Goodery et al. (1965)
Rotylenchulus reinformis	Kerala, India	Sundararaju et al. (1979b)
Rotylenchus sp.	–do–	–do–
Xiphinema sp.	–do–	–do–

* Original not seen

X. vulgare	Bahia, Brazil	Sharma & Loof (1974)
Xiphinema sp.	Kerala, India; Malaysia	Sundararaju et al. (1979b); Reddy (1977)

II. CARDAMOM (*Elettaria cardamomum* (L.) Maton.)

Aphelenchoides sp.	Kerala, India	Sundararaju et al. (1979b)
Helicotylenchus sp.	–do–	–do–
Hemicycliophora argiensis	Karnataka, India	Khan & Nanjappa (1972)
Hoplolaimus sp.	Kerala, India	Sundararaju, et al. (1979b)
Meloidogyne incognita	Kranataka, Kerala, India.	D'souza et al. (1970), Koshy et al. (1976, 1979b), Sundararaju, et al. 1979b)
Meloidogyne spp.	Karnataka, India	D'souza et al. (1970)
Nothocriconema cardamomi	–do–	Khan & Nanjappa (1972)
N. coorgi	–do–	–do–
Pratylenchus coffeae	Karnataka, India	D'souza et al. (1970); Kumar et al. (1971)
Pratylenchus sp.	Karnataka, Kerala; India	D'souza et al. (1970); Sundararaju et al. (1979b)
Radopholus similis	Karnataka, India	D'souza et al. (1970)
Rotylenchulus reniformis	Karnataka, India	Kumar et al. (1971)
Trichodorus minor	Karnataka, India	Anonymous, (1974a)
Trichodorus sp.	–do–	D'souza et al. (1970)
Xiphinema sp.	–do–	Sundararaju et al. (1979b)

III. GINGER (*Zingiber officinale* Rosc.)

Aphelenchus avenae	Malaysia	Reddy (1977)
Helicotylenchus dihystera	Thailand	–do–
H. erythrinae	–do–	–do–
Helicotylenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Hemicycliophora sp.	–do–	–do–
Heterodera radicicola	Japan	*Nagakura (1930)
Hoplolaimus sp.	Kerala, India	Sundararaju et al. (1979b)
Meliodogyne acrita	Fiji	Reddy (1977)
M. javanica	USA (Plant Quarantine Interception); Queensland, Australia	*Goodey et al. (1965), *Mumford (1960); Colbran & Davis (1969); Colbran (1972), Pegg et al. (1974)
M. incognita acrita	USA (Plant Quarantine Interception)	*Mumford (1963)
M. incognita	Queensland, Austrialia; Hawaii; Fiji; Kerala, Madhya Pradesh, India	Colbran (1958, 1961, 1962, 1968); Pegg et al. (1974); Huang (1966), Haynes et al. (1973), Nadakal (1963), Memmen (1973), Sundararaju et al. (1979b); Agrawal et al. (1974);
Meloidogyne sp.	Madhya Pradesh, Gujarat, India; Austrialia; Malaysia,	Kulkarni & Jain (1965); Haware & Joshi (1972); Shah and Raju, (1977); Reddy (1977)
Pratylenchus pratensis	Sri Lanka	*Gadd (1939)
Radopholus similis	Florida, USA; Fiji; Kerala, India	Hart (1956), Butler & Vilsoni (1975), Vilsoni et al. (1976); Reddy (1977); Koshy & Sosamma (1975), Sundararaju et al. (1979a, 1979b)

of ginger by *R. Similis* in Fiji and the spread of the nematode has been found to take place through infested planting materials. The nematodes enter the rhizomes and penetrate the tissues intercellularly (Vilsoni, McClure, and Butler, 1976). Heavy infestation results in destruction of tissues and formation of channels or galleries within the rhizome. Infested ginger plants exhibit stunting, chlorosis, and sparse tillering.

For controlling root knot nematodes in Fiji, hot water treatment of ginger seed material at 50°C for 10 minutes has been recommended (Anonymous, 1971). Colbran (1972) in Australia assessed the efficacy of granular nematicides such as Mocap, Nemacur, Temik, and Vydate against *M. javanica*, and Nemacur was found to be the most effective. It increased the rhizome yield upto 15%. Late (November) and split applications were more promising than higher rates applied early in the season. Further studies (Colbran, 1974) showed that a high level of control of root-knot nematodes was obtained with saw dust mulching upto a depth of 50-75 mm combined with an application of Nemacur. Such a postplanting treatment with Nemacur or oxamyl also reduced *Fusarium* yellows of ginger cuased by *Fusarium oxysporum* f. sp. *zingiberi*. In Fiji, Haynes, Partridge, and Sivan (1973) recommended a control schedule for *M. javanica* involving the use of clean seed and a ginger-dalo-fallow rotation. Both *M. javanica* and *M. incognita* have been reported from ginger in Queensland (Australia) by Pegg, Moffet, and Colbran (1974) and they suggested controlling them by hot water treatment of seed materials followed by growing the crop in fumigated soil. Sukul, Das, and De (1974), while studying the action of plant extracts against *M. incognita*, found that ethanol extract of fresh ginger rhizome possessed nematicidal properties, but, since ginger extract was phytotoxic, its use was recommended only as a preplant treatment. Agrawal, Joshi, and Haware (1974) reported increased linear growth and thickness of hypae of *Fusarium oxysporum* f. sp. *zingiberi* when treated with extract of ginger roots infested with *M. incognita* as compared to exposure to healthy root extract.

Sundararaju, Sosamma, and Koshy (1979a) studied the pathogenic effect of *R. similis* on ginger using different levels of population, viz., 0, 10, 100, 1000, and 10,000. In general, increase in nematode population caused directly proportional reduction in growth of plants and increase in number of root lesions and rotting. The weight of root and rhizomes was also significantly reduced. For instance, rhizome weight was reduced by 74% with an initial inoculum level of 10,000 nematodes over a period of six months, and shoot weight, root weight, and rhizome weight were reduced by 43, 56, and 40% respectively, with an initial inoculum level of 10 nematodes/plant.

Sundararaju et al. (1979b) examined soil and root samples collected from the root zone of ginger in Kerala, India, and recorded the following nematode species: *Helicotylenchus* sp. *Hemicycliophora* sp., *Hoplolaimus* sp., *M. incognita*, *R. similis*, *Rotylenchulus reniformis*, and *Tylenchorhynchus* sp.

4. Turmeric (*Curcuma longa* L.)

Root-knot nematode was the first nematode to be reported on turmeric (Ayyar, 1926). Later turmeric was reported as a host for *Meloidogyne javanica* and *M. incognita* (Nirula and Kumar, 1963) and *Radopholus similis* (Koshy and Sosamma, 1975). A *Pratylenchus* sp. also was found in association with brown rot affected tissues of mature turmeric rhizomes (Sarma, Nambiar, and Nair, 1974).

Sosamma, Sundararaju, and Koshy (1979) studied the pathogenic effect of *R. similis* on turmeric using five levels of inoculum, viz., 10, 100, 1000, 10,000 and 1,00,000. *R. similis* infested rhizome exhibited small,

reduction was noted at 1,00,000 inoculum level.

Koshy, Sosamma, and Sundararaju (1977) screened 19 species of plants commonly used as pepper standards against *M. incognita* and recommended *Garuga pinnata* for large scale use. Wherever *G. pinnata* is not available, they suggested the use of *Macaranga indica* and *Erythrina indica.*

Sundararaju, Koshy, and Sosamma (1979b) surveyed the pepper gardens of Kerala and Karnataka and reported the presence of plant parasitic nematode species belonging to 17 genera from the root zone of pepper, viz., *Aphelenchoides, Aphelenchus, Criconemoides, Diphtherophora, Ditylenchus, Helicotylenchus, Hemicycliophora, Hoplolaimus, Longidorus, Meloidogyne incognita, Paratylenchus, Pratylenchus, Radopholus similis, Rotylenchulus reniformis, Rotylenchus, Tylenchorhynchus,* and *Xiphinema.*

Pepper is grown in Kerala usually with coconut, arecanut, banana, ginger, turmeric, etc. All these are common hosts for root-knot and burrowing nematodes. Intensive studies are therefore suggested to develop suitable cropping patterns in such gardens. Though both these nematodes have been reported on pepper, they are not always found together. The effect of either of them on the multiplication of the other as well as their combined or individual role in the incidence of diseases such as pepper decline, slow wilt, and quick wilt also needed immediate attention.

2. Cardamom (*Elettaria cardamomum* (L.) Maton)

The nematodes *M. javanica, M. incognita,* and *R. similis,* were recorded from cardamom in coffee growing tracts of South India by Kumar, Viswanathan, and D'Souza (1971). They also reported cardamom to be a suitable host for the multiplication of *Pratylenchus coffeae, M. incognita,* and *Rotylenchulus reniformis.* Other nematodes recorded on cardamom were *Nothocriconema cardamomi, N. coorgi,* and *Hemicycliophora argiensis* (Khan and Nanjappa, 1972).

Koshy et al. (1976) has recorded widespread occurrence of *M. incognita* in the cardamom nurseries in the High Ranges of Kerala, India. They tested three dosages each of fensulfothion, aldicarb, and carbofuran against *M. incognita* in cardamom nurseries (Koshy et al., 1979a) and reported that two applications of fensulfothion @ 15 kg ai/ha or aldicarb @ 5 kg ai/ha, or carbofuran @ 4 kg ai/ha first at the time of transplanting and again after three months, improved plant growth and reduced nematode population considerably, but none of these treatments controlled *M. incognita* completely in cardamom nurseries.

Sundararaju et al. (1979b) have recorded *Aphelenchoides* sp., *Helicotylenchus* sp., *Hoplolaimus* sp., *M. incognita, Pratylenchus* sp., and *Xiphinema* sp. from the rhizosphere of cardamom in the High Ranges of Kerala, India.

3. Ginger (*Zingiber officinale* Rosc.)

Nagakura (1930) was the first worker to report a nematode, *Meloidogyne* sp. on ginger. Hart (1956) observed parasitisation by burrowing nematode. Nadakal (1964b) obtained *M. incognita* from ginger and reported that eggs and larvae failed to survive in the upper 10 cm soil during summer months of Kerala. Root knot nematode has also been reported from the rhizome and fibrous and fleshy roots from Hawaii (Huang, 1966) and Gujarat, India, (Shah and Raju, 1977). The histopathology studies revealed that the target of infection was near the xylem pole (Shah and Raju, 1977), and that the nematode induced the formation of giant cells and active division of cells surrounding the infected area. Hyperplasia of parenchyma cells was common in the infected rhizomes and roots and gall formation was conspicuous in adventitious roots. Butler and Vilsoni (1975) reported heavy unfestation

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4. Turmeric (*Curcuma longa* L.)

Root-knot nematode was the first nematode to be reported on turmeric (Ayyar, 1926). Later turmeric was reported as a host for *Meloidogyne javanica* and *M. incognita* (Nirula and Kumar, 1963) and *Radopholus similis* (Koshy and Sosamma, 1975). A *Pratylenchus* sp. also was found in association with brown rot affected tissues of mature turmeric rhizomes (Sarma, Nambiar, and Nair, 1974).

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Helicotylenchus dihystera	Bahia, Brazil	Sharma & Loof 1974)
H. erythrinae	Africa; Malaysia	*Luc & Quiran (1960), Reddy (1977)
H. trivandranus	Kerala, India	Mohandas (1975)
Helicotylenchus sp.	Kerala, India; Bahia, Brazil; Brunei, Borneo; Malaysia	Venkitesan (1972); Sundararaju et al. (1979b), Sharma& Loof (1974), Anonymous (1975a), Reddy (1977).
Hemicriconemoides mangiferae	Thailand	Reddy (1977)
Hemicycliophora sp.	Kerala, India.	Venkitesan (1972), Sundararaju et al. (1979b)
Heterodera marioni	Indonesia	Reddy (1977)
H. radicicola	Kerala, India; Kampuchea; Laos, Vietnam	Ayyar (1926); Reddy (1977)
Heterodera (larvae)	Kerala, India	Venkitesan (1972)
Hoplolaimus columbus	Malaysia	Reddy (1977)
H. seinhorsti	Thailand	Reddy (1977)
Hoplolaimus sp.	Kerala, India; Brunei, Borneo	Venkitesan (1972); Sundararaju et al. (1979b); Anonymous, (1975a)
Longidorus sp.	Kerala, India	Sundararaju et al. (1979b)
Macroposthonia onoensis	Brunei, Borneo	Anonymous (1975a)
Meloidogyne javanica	Sarawak, Malaysia	Winto (1972), Anonymous (1974b)
M. incognita	Kerala, India; Para, Brazil; Sarawak; Borneo	Venkitesan (1972), Koshy et al. (1977, 1979b), Koshy and Sundararaju (1979), Sundararaju et al. (1979b), Lordello & Martins (1974), Ichinohe (1975), Anonymous (1974b)
Meloidogyne sp.	Cochin-china; Kerala, India; Karnataka, India; Malaysia; Brunei, Borneo; Kampuchea; Thailand; Vietnam	*Delaeriox (1902); Butler (1906); D' Souza et al. (1970), Ting (1975), Anonymous (1975a), Reddy (1977)
Paratylenchus leptos	Nova Teutonia, Brazil	Raski (1975)
Paratylenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Pratylenchus coffeae	Karnataka, India	D'Souza et al. (1970), Kumar et al. (1971)
Pratylenchus sp.	Karnataka, India; Malaysia	D'souza et al. (1970); Reddy (1977)
Radopholus similis	Bangka island, Indonesia; Karnataka, Kerala, India; Malaysia;	*Van der Vecht (1950), Hubert (1957), Christie (1957, 1959), Ichinohe (1976), D'Souza et al. (1970), Kumar et al. (1971), Venkitesan (1972), Koshy & Sosamma (1975), Koshy et al. 1(978), Sundararaju et al. (1979b), Reddy (1977)
Rotylenchulus reniformis	Karnataka, Kerala, India;a, Bahi Brazil; Thiland	Kumar et al. (1971), Venkitesan (1972), Sundararaju et al. (1979b), Sharma & Loof (1974), Reddy (1977)
Rotylenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Scutellonema siamense	Brunei, Borneo	Anonymous (1975a)
Scutellonema sp.	Malaysia	Reddy (1977)
Trichodorus sp.	Bahia, Brazil; Thailand,	Sharma & Loof (1974), Reddy (1977),
Tylenchorhynchus sp.	Malaysia	Reddy (1977)
Xiphinema elongatum	Malayaisa	Reddy (1977)
X. radicicola	Brunei, Borneo; Thailand	Anonymous (1975a); Reddy (1977)

shallow water soaked brownish areas. Roots which showed advanced rotting and rotten roots were found to have only the epidermis. The nematode significantly decreased shoot, root, and rhizome weights, length of lamina, and number of rhizome fingers. An initial inoculum level of 10 nematodes caused 35% reduction of rhizome weight after four months and 45% reduction at the end of the season. With 10,000 nematodes, the extent of reduction in rhizome weight was 65% and 76% respectively, after four and eight months. The nematode disseminated through infested material.

Sundararaju et al. (1979b) in a preliminary survey of Kerala, India recorded *Helicotylenchus* sp., *Hoplolaimus* sp., *Meloidogyne incognita*, *Pratylenchus* sp., and *R. similis* from the soil around the root zone of turmeric.

5. Tree Spices

Meloidogyne sp. has been reported from nutmeg (Goffart, 1953; Kumar, et al., 1972 Koshy and Sosamma, 1975) and clove (Ghesquiere, 1921). Recently, Sharma and Loof (1974) examined soil and root samples collected from clove in Bahia, Brazil and recorded the following five species: *Helicotylenchus dihystera*, *M. incognita*, *Dolichodorus* sp., *R. reniformis*, and *Trichodorus* sp., Sundararaju et al. (1979b) have recorded the following nematode species, *Helicotylenchus* sp., *Hoplolaimus* sp., *Meloidogyne* sp., *Paratylenchus* sp., *R. similis*, *R. reniformis*, *Rotylenchus* sp., *Tylenchorhynchus* sp., and *Xiphinema* sp., on nutmeg; *Caloosia* sp., *Hoplolaimus* sp. *Meloidogyne* sp., *Pratylenchus* sp., *R. reniformis*, *Helicotylenchus* sp., *Tylenchorhynchus* sp., and *Xiphinema* sp. on clove and *Criconemoides* sp., *R. reniformis*, *Helicotylenchus* sp., *Rotylenchus* sp., and *Xiphinema* sp., on einnamon.

From the foregoing review, it is clear that nematological investigations on spice crops are still at a very elementary level only. This is so, in spite of the fact that spices are economically very important crops in certain countries of the world and nematodes cause serious losses to several of them like pepper, ginger, and cardamom. Systematic investigations are called for particularly to determine the role of nematodes in the aetiology of pepper wilts.

Table I. *Nematodes associated with spices*

Nematode	Locality	Reference
I. BLACK PEPPER (*Piper nigrum* L.)		
Aglenchus sp.	Malayasia	Reddy (1977)
Alaimus sp.	Brunei, Borneo	Anonymous (1975a)
Aphelenchoides sp.	Bahia, Brazil; Malaysia, Thailand, Karnataka, India	Sharma & Loof (1974); Reddy (1977); Sundararaju et al. (1979b)
Aphelenchus avenae	Brunei, Borneo	Anonymous (1975a)
Aphelenchus sp.	Kerala, India	Sundararaju et al. (1979b)
Aporcelamellus sp.	Brunei, Borneo	Anonymous (1975a)
Aporcelaimus sp.	-do-	-do-
Criconemoides sp.	Malaysia; Thailand; Kerala, India.	Reddy (1977); Sundararaju et al. (1979b)
Diphtherophora sp.	Thailand; Kerala, India	Reddy (1977); Sundararaju et al. (1979b)
Discocriconemella limitanea	Bahia, Brazil	Sharma & Loof (1974)
Ditylenchus sp.	Sarawak, Malaysia; Kerala, India	Reddy (1977); Sundararaju et al. (1979b)
Dolichodorus sp.	Bahia, Brazil	Sharma & (Loof 1974)
Dorylaimellus sp.	Brunei, Borneo	Anonymous (1975a)

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**Original not seen*