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20

NEMATODE PESTS OF SPICES AND CONDIMENTS

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I. BLACK PEPPER (*Piper nigrum* L.)

BLACK pepper has its origin in the hills of South Western India. The other major pepper producing countries are Indonesia, Malaysia and Brazil. In India, the total area under pepper cultivation during 1987-88 was 1,58,500 ha with an annual production of 49,200 tonnes. The export earnings from pepper during the above period was Rs. 2,400 million (Source: Statistics Unit, CPCRI, Kasaragod, 7/89). Of the 36 species of nematodes reported on pepper, the two most important ones are *Radopholus similis* and *Meloidogyne* spp. (Sharma & Loof, 1974; Ichinohe, 1975; Reddy, 1977; Bridge, 1978; Sundararaju *et al.*, 1979a; Dasgupta & Rama, 1987; Rama, 1987; Ramana & Mohandas, 1987a).

A. *Radopholus similis*

Association of the burrowing nematode with the yellows disease of pepper was first reported by Van der Vecht (1950). It caused 'yellows disease' in black pepper which wiped out 22 million pepper vines from the Bangka Island in Indonesia within 20 years (Christie, 1957, 1959). In Kerala and Karnataka states of India it causes the 'slow-wilt' disease in black pepper which is almost identical with the pepper yellows of Bangka Island (Van der Vecht, 1950; Mohandas & Ramana, 1987b; Ramana *et al.*, 1987a.) In Kerala, surveys showed that high population of *R. similis* occurred in roots of slow-wilt disease-affected vines (Ramana *et al.*, 1987a).

Table 1. Area, production, export and import details of important tree and seed spices

Crop	Year	Total Area (hectares)	Production (metric tonnes)	Export value (Rs.)	Import qty. (metric tonnes)	Import value (Rs.)
Coriander	1987-88	3,29,899	1,34,433	1,39,47,000	—	—
Cumin	1987-88	1,51,469	78,500	2,48,22,000	—	—
Fennel	1987-88	17,433	20,042	1,53,82,000	—	—
Fenugreek	1987-88	30,079	30,696	1,99,84,000	—	—
Clove	1985-86	1,600	1,300	—	1,133 (1987-88)	5,01,00,000 (1987-88)
Nutmeg	1985-86	—	—	—	331	5,05,700
Nutmeg Mace	1985-86	—	—	—	128	2,09,600
Cinnamon	1984-85	—	—	2,43,000	254 (1985-86)	8,58,300 (1985-86)
Cassia	1984-85	—	—	83,94,000	733 (1987-88)	2,28,94,000 (1987-88)

1. Hosts: Coconut and arecanut on which black pepper vines are trailed are good hosts of the nematode. Intercrops like banana, ginger and turmeric are also susceptible to *R. similis*.

The life cycle, biotype and influence of environmental factors is the same as given in the chapter19.

2. Nature of Damage: Primary symptom of slow-wilt disease is the appearance of a few, pale, yellow, drooping leaves whose number gradually increases and within a year or two the entire foliage may become yellow. This is followed by shedding of leaves, cessation of growth and die-back symptoms. In the very early stage, the symptoms may disappear with the onset of south-west monsoon. However, within three to five years of initiation of yellowing all the leaves are shed and death of the vine occurs. In bearing vines spike shedding takes place. In large plantations, affected patches are conspicuous with many barren standards. Young and old plants are affected (Fig.20.1).

The tender, thin, white, feeder roots show typical orange to purple coloured lesions. The root system exhibits extensive rotting with the main roots devoid of feeder roots. Extensive necrosis of large roots develops subsequently.

R. similis is found to penerate roots within 24 hours of inoculation and the cells around the site of penetration become brown. It does not enter the stelar portion (Venkitesan, 1976). Nematodes are found in inter and intracellular positions within the cortex. The xylem vessels are seen plugged with a "gum-like substance" (Freire & Bridge, 1985a).

3. Losses: A population level of 250 nematodes per g of root was constantly recorded with slow-wilt affected pepper vines in Kerala, India (Ramana, 1986).

In Sumatra, Indonesia, a nematode population of 2 per 100 g of soil and 25 per 10 g of roots was recorded from vines with yellows disease (Mustika, 1978).

4. Control: Symptoms of slow-wilt/pepper yellows are known to ameleorate with mulching.

A total of 106 cultivated germplasm, 36 wild related *Piper* spp., 20 inteculticar hybrids, 90 selections of cv. Karimunda and 12,200 open pollinated seedlings of popular pepper cultivars were screened against *R. similis* and no resistance/tolerance was found in any of them (Ramana *et al.*, 1987b).

Aldicarb sulphone at 8 kg a.i. per ha gave best control of *R. similis* followed by fensulfothion and DBCP (Venkitesan, 1976). Under Indian conditions, aldicarb/carbofuran/phorate @ 3 g a.i. per vine applied in May/ June and again in September/October resulted in the remission of foliar yellowing and reduction in nematode population. Among these phorate was found to be superior to others (Ramana, 1986; Mohandas & Ramana, 1987a). But studies on the cost-benefit ratio and residue analysis of these chemicals have not been carried out.

For heavily infested areas, an integrated method of management is suggested.

- ★ Planting nematode-free rooted cuttings
- ★ Uprooting affected vines and replanting after 9-12 months
- ★ Use of non-living standards and exclusion of *R. similis* susceptible trees as standards for trailing black pepper vines and avoiding susceptible intercrops such as banana, ginger, turmeric etc.

B. *Meloidogyne* spp.

Meloidogyne sp. was the first nematode to be recorded on black pepper (Delacroix, 1902) in Cochin-China. In 1906, Butler reported root-knot nematodes from black pepper in Wynad, Kerala, India.

1. Distribution: Meloidogyne javanica and *M. incognita* have been reported from India, Brazil, Sarawak, Borneo, Cochin-China, Malaysia, Brunei, Kampuchea, Indonesia, Thailand and Vietnam (Lordello & Silva, 1974; Ichinohe, 1975; Reddy, 1977; Freire & Monteiro, 1978) and *M. arenaria* from Sri Lanka (Lamberti *et al.*, 1983).

2. Hosts: Among the commercially used standards, *Oroxylon indicum* Vent, *Erythrina lithosperma* Blume, *Ceiba pentandra* (Linn.) Gaerth and *Bombax malabaricum* DC. are highly susceptible to root-knot nematode

Fig. 20.1. Slow-wilt disease of black pepper vines in an arecanut plantation; 1 – vine showing sparse yellowing of leaves and reduced growth, 2 – vine showing 70% defoliation and yellowing of remaining leaves, 3 – vine showing severe defoliation, 4 – barren arecanut standard that has lost the vine, 5 – healthy vine.

(Koshy *et al.*, 1977). Large numbers of weeds found in pepper gardens are also highly susceptible to this nematode (Ramana, 1986).

3. *Biology:* The eggs are laid in a gelatinous matrix. Its contents undergo a series of determinate cleavage giving rise to the first juvenile stage which moults within the egg and gives rise to the second stage juvenile which hatches out. The J2 juveniles penetrate host plants above the meristematic zone and orient parallel to the stele. It starts feeding on the pericycle cells for several weeks, gradually swelling. A series of three moults occur in quick succession. Reproduction may be parthenogenetic or bisexual with a female laying 400-500 eggs. Egg laying is completed within a week. The life cycle under optimum condition takes 3-4 weeks.

4. *Nature of Damage:* The black pepper vines on infestation by root-knot nematodes prominently show unthrifty growth and yellowing of leaves. The interveinal areas of leaves of such vines show dense yellowish discolouration making the leaf veins appear quite distinct with deep green colour. The roots show prominent galls.

The pepper variety Cingapura recorded high concentrations of total phenols on inoculation with 6,000 *M. incognita* juveniles per pot, 95 days after planting although no resistance was shown (Ferraz *et al.*, 1984). Changes in levels of amino acids, organic acids and sugars in *M. incognita* infected plants, compared to uninfected plants were reported by Freirie & Bridge (1985b).

5. *Interaction with other Micro-organisms: Meloidogyne incognita* and *Fusarium solani* were found associated with black pepper vines in Brazil. Both the organisms together were found to do more harm than either of them alone (Lopes & Lordello, 1979). Increased susceptibility of *M. incognita* and *M. javanica* infested pepper cultivar, Kuching, to *Phytophthora* infection was reported in Malaysia (Winto, 1972).

6. *Losses:* An initial inoculum level of ten second stage juveniles per rooted cutting was found to reduce growth by 16%, while at a level of 1,00,000 juveniles, 50% reduction in growth was observed over one year period (Koshy *et al.*, 1979a). Root-knot nematode infestation is a major problem in black pepper in several departmental nurseries in Kerala.

7. *Control:* Growing of non-host cover plant siratro (*Macroptilium atropurpureus*) in the interspaces and mulching with Guatemala grass are recommended to reduce population of *M. incognita* on black pepper in the Amazonian region(Ichinohe, 1980).

Among the seven popular cultivars screened, the cultivar Panniyur-1 was the most susceptible and Valiakaniakadan the least (Koshy & Sundararaju, 1979). The intensity of damage on infestation with *M. incognita* was less in cultivar Karimunda compared to the variety Panniyur-1 (Mohandas & Ramana, 1983). The cultivars Kalluvalli, Balankotta, Narayakodi and Padapan had fewer galls when compared with Panniyur-1 (Jacob & Kurien, 1979). Of the 101 cultivars, 74 accessions of wild *Piper* sp. and 140 intercultivar hybrids screened, one cultivar CLT-P-812 was found resistant to *M. incognita* (Ramana & Mohandas, 1986, 1987b; Koshy, 1987).

The only attempt made in controlling the root-knot nematode using bio-control agents is by Freirie & Bridge (1985c). The rates of infection of *Paecilomyces lilacinus* and *Verticillium chlamydosporum* on *M. incognita* egg masses on black pepper seedlings were 15 and 12%, respectively when the fungi are introduced to sterile soil before inoculation of nematodes to potted plants.

Most of the nematicides have been found effective in reducing root-knot nematode population on black pepper. Under Indian conditions when a live standard is used, the dosage differs depending on the susceptible/resistant reaction of the standard to the nematode. Application of aldicarb @ 1 g a.i. per vine twice a year (May/June and October/November) integrated with fertilizers (N = 100g, P = 40g, K = 140g per vine) in two equal split doses, earthing up to 50 cm radius at the base of the vines and mulching the base of the vines with leaves reduces foliar yellowing by 83% and *M. incognita* larval population by 33-88% (Venkitesan & Jacob, 1985).

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

Cardamom has its origin in the evergreen rain forests of the Western hills of South India. Other cardamom growing countries include Guatemala, Brazil, Tanzania, Sri Lanka, El Salvador, Vietnam, Laos, Kampuchea and Papua New Guinea. The area under cultivation in India during 1987-88 was 1,05,000 ha, with an annual production of 3,200 metric tonnes. The export earning during 1987-88 was Rs. 34 million (Anon., 1988).

The most important nematode problem is the root-knot nematode, *Meloidogyne* spp. (D'Souza *et al.*, 1970; Kumar *et al.*, 1971; Kasi Viswanathan *et al.*, 1974; Sundararaju *et al.*, 1979a).

A. *Meloidogyne* spp.

1. Distribution: The two *Meloidogyne* spp. widely occurring in cardamom nurseries and plantations in Kerala, Karnataka and Tamil Nadu are *Meloidogyne incognita* and *M. javanica* (Kumar *et al.*, 1971; Koshy *et al.*, 1976; Ali, 1982, 1986).

2. Hosts: Many annual weeds and common shade trees like *Erythrina indica* and *E. lithosperma* present in cardamom plantations are susceptible to root-knot nematodes.

3. Nature of Damage: On infestation, mature plants in a plantation show stunting, yellowing, reduced tillering, delay in flowering, immature fruit-drop and reduction in yield. Roots do not show galling. Instead, they show excessive branching.

In primary nurseries germination is reduced by more than 50%. Infested seedlings fail to establish in secondary nurseries. The roots show heavy galling. In secondary nurseries, infested plants exhibit stunting, yellowing, poor tillering and heavy galling of roots (Ali & Koshy, 1982).

4. Interaction with other Micro-organisms: In nurseries, presence of *M. incognita* increases incidence of rhizome rot and damping off diseases caused by *Rhizoctoni solani* (Ali, 1986; Eapen 1987).

5. Losses: Thirty two to forty seven per cent yield loss occurs due to root-knot nematode infestation (Ali, 1984, 1986). An initial population level of 100 nematodes per plant causes considerable damage to cardamom (Eapen, 1987).

6. Control: The popular cardamom cultivars, Malabar, Mysore and Vazhuka are susceptible to root-knot nematodes.

Disinfesting nursery beds with methyl bromide @ 500 g per 10 m^2 is effective in controlling root-knot nematodes in cardamom nurseries. Sed beds can also be drenched with two per cent formalin to a depth of 20-30 cm and covered with polythene sheets for three to seven days. Seeds can be sown two weeks after formalin application when the soil is free from formalin fumes. Application of aldicarb @ 5 kg a.i. per ha three times after every three months results in increase in growth and vigour of seedlings both in primary and secondary nurseries (Koshy *et al.*, 1979b; Ali, 1986). Aldicarb at 15 kg per ha reduced nematode population by 90% (Ali, 1987). An increase of 88% in yield of cardamom plants infested with *M. incognita* was obtained on application of aldicarb/carbofuran/phorate @ 5g and 10g a.i. per plant and *neem* oil cake @ 500g and 1000g per plant twice a year (Ali, 1984).

Integration of the following practices can help in the successful nematode management.

★ Changing nursery sites frequently
★ Disinfesting nursery beds
★ Introduction of biocontrol organisms at nursery level
★ Control of susceptible weeds
★ Exclusion of susceptible shade trees
★ Destruction of infested crop residues
★ Application of nematicide and *neem* oil cake
★ Mulching with dead leaves

III. GINGER (*Zingiber officinale* Rosc.)

The country of origin of ginger is not known with certainty. It is presumed to be in the region of India or China. Apart from India and China other ginger producing countries are Jamaica, Sierra Leone, Nigeria, Japan, Taiwan and Australia. India is the largest producer (1,27,000 metric tonnes) and exporter of dry ginger in the world (export earning Rs. 191 millon). The total area under cultivation during 1986-87 was 5,24,600 ha (Anon., 1988).

A large number of nematode species have been recorded from ginger of which the most important are the root-knot and burrowing nematodes (Colbran, 1958; Reddy, 1977; Sundararaju *et al.*, 1979a; Rama & Dasgupta, 1985; Routaray *et al.*, 1987b; Kaur, 1987).

A. *Meloidogyne* spp.

The first report of *Meloidogyne* sp. on ginger was by Nagakura (1930). Later, it was recorded from other areas also. Several weeds found in ginger growing areas are known hosts of root-knot nematodes. In fleshy and fibrous roots the nematode develops to maturity in 24 days, while in rhizomes it takes 43 days at a soil temperature of 30°C (Huang, 1966). Infested rhizomes help in long distance dissemination of nematodes.

1. Nature of Damage: Heavily infested plants show stunting and chlorosis and marginal necrosis of leaves. Roots and underground rhizomes exhibit galling and rotting. The rhizome is attacked by second stage juveniles through axils of leaf sheaths in the shoot apex. Fleshy roots are invaded along the entire length, while in fibrous roots it is in the area of differentiation. Infested rhizomes have brown, water-soaked areas in the outer tissues especially in angles between shoots.

Abnormal xylem and hyperplastic parenchyma are observed in all infested tissues except in rhizome meristems. Giant cells are found in all the infected tissues. An infection sites in differentiated rhizomes and fleshy roots, wound cork and lignified wall thickening of endodermis and pericycle are formed (Huang, 1966; Shah & Raju, 1977).

2. Interaction with other Micro-organisms: Interaction between *Pythium myriotylum* and *M. incognita* on ginger results in fungal antagonism against the nematode, but has no influence on the soft-rot disease syndrome (Lanjewar & Shukla, 1985).

3. Losses: Under potted conditions an initial inoculum level of 10,000 nematodes per plant over a period of six months resulted in 74% reduction in rhizome weight. A population level of one infective juvenile per 30g of soil can cause significant reduction in yield (Sukumaran & Sundararaju, 1986).

Under potted conditions with an initial level of 50 larvae per 100 ml soil with *M. incognita* and *M. hapla* cause significant reduction in growth characters. At higher initial inoculum levels both the species cause withering of aerial shoots. *M. arenaria* on the other hand caused typical symptoms of drying and twisting of leaves (Kaur, 1987).

At an inoculum level of two nematodes per g of soil the fibrous roots are very much reduced (Parihar, 1985; Routaray *et al.*, 1987a).

4. Control: Application of well decomposed cattle manure or compost @ 25-30 tonnes per ha, *neem* cake @ two tonnes per ha, and mulching with green leaves @ 10-12 tonnes per ha at planting and mulching again during the growth period help in reducing nematode population (Kaur, 1987).

In Himachal Pradesh, application of phenamiphos @ 3 kg a.i. per ha resulted in 70-144% increase in yield of ginger in fields infested with *M. incognita* (Kaur, 1987).

B. *Radopholus similis*

Radopholus similis infestation in ginger was first reported by Hart (1956) in Florida. In India, it was reported from Kerala by Charles & Kuriyan (1979). The coconut isolate of *R. similis* in Kerala reproduced well on ginger (Koshy & Sosamma, 1975, 1977). The perpetuation and dissemination of the nematode take place through infested rhizomes used for planting. Affected plants exhibit stunting, reduced vigour and tillering and mature and dry out faster than healthy plants. The topmost leaves become chlorotic with scorched tips. The infected rhizomes exhibit small, shallow, sunken, water-soaked lesions (Vilsoni *et al.*, 1976; Sundararaju *et al.*, 1979b).

The nematodes penetrate through cell walls and are found coiled within a single cell. Due to infection large channels or galleries are found within the rhizomes. An initial inoculum level of 10,000 nematodes per plant causes 74% reduction in rhizome weight (Sundararaju *et al.*,1979c).

No study appears to have been carried out on control aspects of burrowing nematode on ginger. But the measures adopted for control of root-knot nematode could be adopted to reduce loss till definite measures become available.

IV. TURMERIC (*Curcuma domestica* Val. (*C. longa* L.))

Turmeric is best known as an important spice crop. In India its area of cultivation is 1,07,700 ha and total production is 2,94,900 tonnes during 1987-88. India's export earning from turmeric was Rs. 92 million annually (Source-Statistics Unit Kasaragod 7/89). Of the many plant parasitic nematodes reported in association with turmeric (Sundararaju *et al.*,1979a) the *Meloidogyne* sp., *Radopholus similis* and *Pratylenchus coffeae* are important.

A. *Meloidogyne* spp.

Affected plants show stunted growth, yellowing, marginal and tip drying of leaves and reduced tillering. Galling and rotting are exhibited on the root system. Infested rhizomes tend to lose their bright yellow colour.

Among 60 germplasm collections screened against *M. incognita* the varieties 5379-1-2, 5363-6-3, Kodur, Chayapasupu, 5335-1-7 and 5335-2-7 were found to be resistant (Gunasekharan *et al.*, 1987).

Aldicarb and carbofuran applied @ 1kg a.i.per ha increased yield by 71 and 68 per cent, respectively. The cost benefit ratio in aldicarb treatment was 1 : 6 and in carbofuran, 1 : 2.

B. *Radopholus similis*

Turmeric was reported as a host a *Radopholus similis* by Koshy & Sosamma (1975). Nematodes get disseminated through infested planting material.

Infested rhizomes lose the golden yellow colour seen in healthy rhizomes. They exhibit shallow water soaked brownish areas. Scale leaves also harboured *R. similis*. Roots show rotting and most of the decayed roots are devoid of cortex and stelar portion. The infested plants dry faster than healthy plants. Avoid turmeric as an intercrop in *R. similis* infested coconut and arecanut based farming systems. There appears to have been no studies on control of *R. similis* on turmeric.

C. *Pratylenchus coffeae*

Pratylenchus coffeae was reported to cause discolouration and rotting of mature rhizomes of turmeric. As infection advances, the rhizomes become deep red to dark brown in colour, less turgid, wrinkled and exhibit dry-rot symptoms. The fingers are more severely affected. Infected rhizomes show dark brown necrotic lesions (Sharma *et al.*,1974).

V. OTHER SPICES

A number of spice crops including tree spices and seed spices are cultivated over large areas in India (Table 1), but there is very little information available on the damage and yield loss caused by plant parasitic nematodes on some of these crops. This is not because nematode problems do not exist on these crops, but it is only due to lack of nematological investigations. The plant parasitic nematodes reported in association with these crops are given in Table 2. Clove (Ghesquiere, 1921; Goodey *et al.*, 1965; Sharma & Loof, 1974; Sundararaju *et al.*, 1979a); Nutmeg (Goffart, 1953; Goodey *et al.*,1965; Kumar *et al.*, 1971; Sundararaju *et al.*, 1979a; Chawla & Samathanam, 1980); Cinnamon (Goffart, 1953; Goodey *et al.*, 1965; Sundararaju *et al.*, 1979a; Chawla & Samathanam, 1980); Cumin (Frank, 1855; Swarup *et al.*, 1967; Verma & Prasad, 1969; Shah & Raju, 1977; Shah & Patel, 1979; Patel *et al.*, 1986); Fenugreek (Krishnamurthy & Elias, 1967; Chandwani & Reddy, 1967; Mathur *et al.*, 1969; Khan & Khan, 1969; Rashid *et al.*, 1973; Khan & Khan, 1973; Khan, 1975; Sharma *et al.*, 1988); Coriander (Krishnamurthy & Elias, 1967; Chandwani & Reddy, 1967; Sen & Dasgupta, 1977; Das & Sultana, 1979; Midha & Trivedi, 1988).

Table 2. Economically important plant-parasitic nematodes reported on important tree and seed spices

Nematode	Nutmeg	Clove	Cinnamon	Coriander	Cumin	Fenugreek
Caloosia sp.	—	+	—	—	—	—
Criconemoides sp.	—	—	+	—	—	—
Dolichodorus sp.	—	+	—	—	—	—
Helicotylenchus dihystera	—	+	—	—	—	—
Helicotylenchus sp.	+	+	+	—	—	—
Hoplolaimus indicus	—	—	—	—	—	—
Hoplolaimus sp.	+	+	—	—	—	—
Meloidogyne incognita	+	+	—	+	+	+
M. incognita acrita	—	—	—	+	+	—
M. javanica	—	—	—	+	+	+
Meloidogyne n. sp.	—	—	—	—	—	+
Meloidogyne sp.	+	+	+	+	+	+
Paratrichodorus mirzai	—	—	—	—	—	+
Paratylenchus sp.	+	—	—	—	—	—
Pratylenchus exilis	—	—	—	+	—	—
Pratylenchus sp.	—	+	—	—	—	—
Radopholus similis	+	—	—	—	—	—
Rotylenchulus reniformis	+	+	+	—	+	+
Rotylenchus sp.	+	—	+	—	—	—
Trichodorus sp.	—	+	—	—	+	—
Tylenchorhynchus brevidens	—	—	—	—	+	—
T. brevilineatus	—	—	—	—	+	—
T. swarupi	—	—	—	—	—	+
T. vulgaris	—	—	—	+	—	—
Tylenchorhynchus sp.	—	+	—	—	—	—
Xiphinema sp.	+	+	+	—	—	—

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21

NEMATODE PESTS OF MEDICINAL AND AROMATIC PLANTS

Akhtar Haseeb

In the recent years, there has been an increased interest in the cultivation of medicinal and aromatic plants to meet the requirements of cosmetics, flavouring, perfumery and pharmaceutical industries and also to earn foreign exchange by way of export. While developing improved agronomic practices and the superior varieties of higher yields, the interest has also been generated in the area of plant protection including infestation of plant parasitic nematodes, specially root-knot species. A perusal of literature indicates that the information available with regard to the problem of plant parasitic nematodes are related to the most important medicinal and aromatic plants specially *Mentha* species. The major work in this crop is being carried out at the Oregan State University, Washington State University, University of Florida, U.S.A. and the Central Institute of Medicinal and Aromatic Plants, Lucknow, India. Very little information is available on the association of these noxious pests with other medicinal and aromatic plants. Recently, root-knot nematodes (*Meloidogyne* species) have been recognized as a serious constraint to the productivity of these crops (Haseeb *et al.*, 1984, 1985, 1986a, b, 1988a; Haseeb & Pandey, 1987, 1989a, b, c). In this chapter the problem of plant parasitic nematodes associated with economically important medicinal and aromatic plants has been reviewed.

I. MINTS

Different mint species, viz., *Mentha arvensis* L. subsp. *haplocalyx* Briquet var. *piperascens* Holmes, *M. cardiaca* (S.F. Gray) Baker, *M. citrata* Ehrh., *M. piperita* L. and *M. spicata* Huds. are important oil bearing plants which are cultivated on a large scale in tropical and subtropical countries of the world. The oils and their principal constituents of these mint species have great demand as they are valued in flavouring, perfumery, cosmetics and pharmaceutical applications. *M. arvensis* oil is being produced and traded in larger quantities than any other mint oil. About two and half decades ago, the entire requirements of Japanese mint oil and menthol in India were met through imports. Owing to the efforts made by CIMAP, Lucknow, at present more than 800 tonnes oil and 400 tonnes menthol are produced annually with the result that the country has not only become self sufficient but foreign exchange to the extent of about Rs. 1200 lakhs per annum is also saved. Second in order is *M. spicata* oil; the current production being 80-100 tonnes valued at about Rs. 300 lakhs per annum. Annual production of *M. piperita* and *M. citrata* oils are however, 20 tonnes and 10 tonnes, respectively.

A. Root-knot Nematodes (*Meloidogyne* spp.)

Buhrer (1938) for the first time listed *M. arvensis* var. *piperascens* and *M. piperita* as a host for *Meloidogyne*. Horner & Jonson (1954) reported that during 1952 and 1953, high population of *M. hapla* have also been found closely associated with or causing disease in mints in Western Oregan. They also reported for the first time, the pathogenic effect of *M. hapla* with Scotch spearmint, *M. cardiaca*. Skotlant & Menzies (1957)