Nematode Pest Management An Appraisal of Eco-friendly Approaches

Editors

Gopal Swarup

D.R. Dasgupta

J.S. Gill

NEMATOLOGICAL SOCIETY OF INDIA

New Delhi

NEMATODE PROBLEMS OF SPICES AND CONDIMENTS

K.V. RAMANA AND SANTHOSH J. EAPEN

National Research Centre for Spices, Calicut-673 012, Kerala, India

Spices are aromatic dried roots, bark, buds, seeds, berries or other plant parts. According to International Organization for Standardization (ISO) there is no clear-cut division between spices and condiments. They get their characteristic odour from volatile constituents in the plant materials. Spices add flavour and taste to food, besides being used in cosmetics, perfumery, confectionery and medicines. Most of the spice crops are grown in humid and tropical regions. They also play an important role in the national economy of many countries. About Rs. 540.1 crore foreign exchange has been earned by the country through the export of 175532 tons of different spices and spice products during 1993-94.

Apart from several abiotic factors, damage by plant parasitic nematodes is a serious problem. Although nematode damage is quite significant in a number of spice crops, nematological investigations have been limited mainly on major spices like black pepper, cardamom, ginger, turmeric, garlic etc. Recently Koshy & Bridge (1990) and Koshy & Geetha (1992) have reviewed the nematological investigations in spices.

Amongst the large number of plant parasitic nematodes reported in association with spice crops, very few like *Meloidogyne* sp., *Radopholus similis, Rotylenchulus reniformis, Helicotylenchus* sp. and *Tylenchorhynchus* sp. are of common occurrence and economic importance in spice crops.

Radopholus similis, Meloidogyne incognita, Trophotylenchulus piperis and *Helicotylenchus* sp. are the four major plant parasitic nematodes associated with black pepper (*Piper nigrum* L.) (Ramana & Mohandas, 1987, 1989). *R. similis* and *M. incognita* are considered as the primary incitant of 'slow decline' disease in black pepper. Slow decline ('Slow wilt' or 'yellow disease'), problem is quite serious in several spice crop growing countries. In Para (Brazil) 91% of black pepper vines are reported to be infested with root knot nematodes, mostly *M. incognita* (Ichinohe, 1975). Though exact crop loss in India is not available, the disease is rampant in all black pepper growing areas in Kerala and Karnataka (Ramana, 1991; Ramana *et al.*, 1994). As mentioned earlier, both *R. similis* and *M. incognita* are associated with the disease. A population level of 250 *R. similis* per gram of roots was consistently recorded with slow decline affected black pepper vines in Kerala (Ramana *et al.*, 1987a). Yield losses varied from 38.5% to 64.6% in *R. similis* inoculated plants, alone or in combination with *M. incognita* (Mohandas & Ramana, 1991). *M. incognita* is also highly pathogenic to black pepper particularly at higher inoculum level (Koshy *et al.*, 1979; Mohandas & Ramana, 1991).

In cardamom (*Elettaria cardamomum* Maton), root-knot nematodes (*Meloidogyne* spp.) pose serious problems in nurseries and also in plantations in India (Ali & Koshy, 1982b; Ali, 1984; 1986b). Microplot studies under simulated field conditions showed 46.6% yield loss in cardamom, at an initial inoculum level of four nematodes/ 100 cm^3 soil (Eapen, 1994). *M. incognita, M. arenaria, R. similis, Pratylenchus coffeae* and *P. zeae* are the major nematode parasites of ginger and turmeric (Routaray *et al.*, 1987a; Kaur & Sharma, 1988; Kaur *et al.*, 1989). *Rotylenchulus reniformis* is widely distributed in turmeric fields of Andhra Pradesh (Mani & Prakash, 1992). The economic threshold levels of root-knot nematode in ginger have been reported variously as one infective juvenile/30g of soil (Sukumaran & Sundararaju, 1986), 50 larvae per 100 ml soil (Kaur, 1987) and two nematodes per gram of soil (Parihar & Yadav, 1986; Routaray *et al.*, 1987b). *P. coffeae* is reported to cause 'ginger yellows' disease (Kaur & Sharma, 1990). An inoculum of 1000 *M. incognita* juveniles or more per plant causes significant reduction in growth of turmeric (Sukumaran *et al.*, 1989).

In the few studies where nematode-induced losses have been determined for grain spices, *Meloidogyne incognita* reduces yields of coriander, cumin and fennel by 52%, 43% and 42% respectively (Midha & Trivedi, 1991). An inoculum level of 100 *M. incognita* larvae per pot reduced the plant growth of coriander (Midha & Trivedi, 1988a). Fenugreek is highly susceptible to *M. incognita* (Pant *et al.*, 1985) and *P. zeae* (Shafshak *et al.*, 1985). However, a vacuum exists in the literature on the economic significance of many nematodes reported on tree spices.

Before management approaches are elaborated, it might be worthwhile to review briefly the nature of damage by nematodes, especially the root-knot nematodes. On black pepper, root-knot galls are seen on secondary or fibrous roots and elongated swelling on thick primary roots. Adult female with egg masses are generally enclosed deep within these roots. In cardamom the galls are seen only in young seedlings but not on the roots of mature plants in the plantation. The fleshy roots of ginger evidently are more sensitive to root-knot nematode infestation than fibrous roots. Root-knot nematodes produce brown, water soaked areas on rhizomes of ginger. Because of galling and rotting, turmeric rhizomes loose their bright yellow colour. Burrowing nematode (*R. similis*) produces typical dark brown lesions and rotting in roots of black pepper, while in ginger and turmeric yellow, sunken, water soaked lesions are seen on the surface of rhizomes.

Root-knot nematodes cause dense yellowish discoloration of the interveinal areas (interveinal chlorosis) in leaves of black pepper vines, narrowing of leaves and poor tillering in cardamom. In cardamom nurseries, they cause significant reduction (more than 50%) in seed germination and the infested seedlings fail to establish on transplanation. In ginger and turmeric also, stunting, chlorosis, poor tillering and necrosis of leaves are the common symptoms of nematodes infestation. The affected plants mature and dry faster than healthy ones, resulting in a poor crop stand.

In addition to parasitism on their own, the nematodes are also involved with other microorganisms causing disease complexes. Several reports are there on the possible involvement of a nematode-fungus complex for the black pepper 'yellows disease' in Indonesia (Bridge, 1978). An Indonesian isolate of *R. similis* has been recorded to predispose black pepper seedlings to attack by a weak pathogenic isolate of *Fusarium solani*, causing severe root damage (Freire, 1982). *M. incognita* and *Fusarium* species together are reported to cause more damage than when either of them are alone (Sheela & Venkitesan 1990). Recent studies in India show that feeder root loss caused by *R. similis, M. incognita* and *Phytophthora capsici* either alone or in combination lead to slow decline disease in black pepper (Anandaraj *et al.*, 1994).

In cardamom, *M. incognita* is the predisposing factor for *Rhizoctonia solani* infection, damping off and rhizome rot, prevalent in cardamom nurseries (Ali & Venugopal, 1992; 1993). There are reports that incidence of rhizome rot in ginger is much severe when the rhizomes are infected by nematodes and fungal pathogens like *Pythium* spp. and *Fusarium* spp. (Dohroo *et al.*, 1987). Basal sheath rot, a new disease of ginger is suspected to be caused by the combined infection of *Aphelenchus* spp. and a *Fusarium* sp. (Magar& Mayee, 1988). Bacterial wilt of ginger, caused by *Pseudomonas solanacearum* is also influenced by *M. incognita* (Samuel & Mathew, 1983).

In black pepper, *Rotylenchulus reniformis* inhibits mulitiplication of *M. incognita* and its damage (Ferraz & Sharma, 1979). The root gall development and population build-up of *M. incognita* are suppressed in black pepper on inoculation with *R. similis* (Sheela & Venkitesan, 1981). However, cardamom plants infected with 'Katte' mosaic virus supported 5-10 times more *M. incognita* population (Ali, 1989).

Control Measures

Realising that nematodes cannot be eliminated, the overall goal should be to bring down the nematode population to below the economic threshold or non injurious level. This can be achieved by a variety of means that are either preventive or curative. Nematode management practices are more difficult to carry out and need to be considerably modified in tropical agriculture because of the cropping patterns and perennial nature of many of these crops.

Various nematode control methods developed for management of nematodes in spices are broadly classified into four groups viz., 1) cultural practices, 2) use of host plant resistance, 3) biological control and 4) chemical control.

1. Cultural practices: The existing agricultural practices can be modified in several ways to suppress nematode population levels. Among these, plant hygiene has a vital role. Use of healthy and nematode-free planting materials can ensure better establishment, survival and higher yield. Mass production of disease free planting materials can be achieved by raising seedlings in disinfected nursery beds. Soil fumigation or soil solarization of nursery sites or potting mixture and random rotation of nursery sites are reported to be effective in black pepper, cardamom and tree spices (Ali & Koshy, 1982a; Sarma *et al.*, 1987; Anonymous, 1993). Soil solarization has been successfully employed in ginger fields also (Balakrishnam *et al.*, 1993). Frequent application of nematicide is also recommended for this purpose. Hot water treatment of ginger and turmeric rhizomes reduce the nematode problems (Anonymous, 1971; Chen *et al.*, 1986). Multiplication and distribution of healthy planting materials are to be regulated through certification.

Crop rotation is an effective and cheaper mean for preventing nematode problems but is not relevant in many perennial crops. However, for ginger cultivation in Fiji, a ginger-taro-fallow rotation has been recommended. In perennial crops, suitable crop combinations can be decided based on the host suitability of various intercrops, shade trees or live standards to the important nematode fauna. Arecanut, coconut, black pepper, cardamom, banana etc. are the major components in high density multispecies cropping systems prevalent in India. All these crops are susceptible to *Meloidogyne incognita* and *Radopholus similis* and therefore aggravate nematode problems. *Artocarpus heterophyllus, A. hirsutus, Ailanthes malabarica, Mesopsis emini, Peltophorum pterocarpum, Swietenia macrophylla, Tamarindus indica, Garuga pinnata* and *Macaranga peltata* are resistant to *M. incognita* and can be used as live standards for black pepper (Koshy *et al.* 1977; Ramana, 1986; Ramana *et al.*, 1994).

Organic amendments improve the soil structure and fertility so that plant growth is improved and plants can withstand the nematode attack. The activity of natural enemies of nematodes is also enhanced and chemicals that are toxic to nematodes are released during the decomposition process. Mulching has been recorded to reduce the slow decline incidence in black pepper gardens in Bangka (de Waard, 1979). Growing a non host cover plant, siratro (*Macroptilium artopurpurens*) in the interspace and mulching with Guatemala grass (*Imperata cylindrica*) reduces populations of *M. incognita* on black pepper in the Amazonian region. Application of well-decomposed cattle manure on compost or saw dust or green leaves of neem cake helps in reducing the nematode multiplication in ginger (Mohanty *et al.*, 1992). In black pepper and cardamom also, *neem* cake application reduces nematode populations followed by increase in yield (Ali, 1987a; Ramana *et al.*, 1992).

Leaf products of *Aegla marmelor, Withamia somnifer, Hibiscus rosasinensis, Murraya koenigi* and stem of *Cuscuta reflexa* significantly enchanced plant growth and reduced root galling in fenugreek (Sharma & Trivedi, 1992a). *In vitro* studies showed that crude methanol extracts of leaves of *Piper colubrinum*, a related species of *Piper nigrum*, which is resistant to both *R. similis* and *M. incognita*, exhibited nematicidal property aganist root knot-nematodes of black pepper.

2. Host resistance: Use of resistant or tolerant lines is the best solution to most of the nematode problems, particularly in the light of recent advancement in gene transfer research. A review of literature on spices showed that several cultivars or lines were identified as resistant or immune to nematodes. Moderate resistance to root-knot nematodes is observed in several other selections of coriander (Patel *et al.*, 1989), cumin (Patel *et al.*, 1986) fenugreek (Thaker *et al.*, 1987), turmeric (Mani & Sri Hari, 1989) and black pepper (Raman *et al.*, 1987b; Paulus *et al.*, 1993). Sources of resistance are also available in related species or allied genera in black pepper and turmeric. However, no resistant/tolerant lines have been identified so far for cardamom and ginger. Earnest efforts should be made to identify new sources of resistance in all these crops and to find out their specificity with respect to nematode species; race or pathotype. A multidisciplinary approach is needed to develop systems of transferring resistance genes to commercially acceptable cultivars.

3. Biological control: Biological control of plant parasitic nematodes is in the early stages of its development in many spice crops. It has the potential to form an integral part of a complete management programme. Tropical soils under perennial cropping systems are fertile sources of potential antagonists of nematodes. A good degree of natural control already exists in these soils. *Paecilomyces lilacinus, Verticillium chlamydosporium* and *Bacillus* spp. give good control of root-knot nematodes of black pepper (Ramana & Sarma, 1993; Sheela *et al.*, 1993). However, none of them are effective against *R. similis.* Recently, *Trichoderma* spp. have been found effective against *Meloidogyne incognita* on cardamom (Eapen & Venugopal, unpublished).

Vesicular Arbuscular Mycorrhizae (VAM) are known for their ability to improve the plant growth and suppress several root pathogens. *Glomus fasciculatum, G. etunicatum* and *Acaulospora laevis* reduced root-knot nematodes and enhanced the growth of black pepper (Sivaprasad *et al.*, 1992; Anandaraj *et al.*, 1991b). In cardamom, *G. fasciculatum* and *Gigaspora margarita* were recorded to be effective. These VAM fungi can be incorporated in nursery mixture to promote the plant growth and to reduce root damage due to nematodes and fungi.

4. Chemical control: Although a number of chemicals are effective and are being used for many years without apparent problems, it is now known that there are serious health and environmental risks associated with many of these chemicals. Several of them are no longer available or are for restricted use only. However, they are the immediate choice for rapid kill in crops with zero tolerance to nematodes. Many nematicides, volatile and non-volatile, were tested for their efficacy to control plant parasitic nematodes of spices with some success. As many of them are no longer available in the market, discussion is restricted to those that are currently available. In black pepper application of phorate or carbofuran @ 3 g a.i./vine, twice in a year gives good control of nematodes (Mohandas & Ramana, 1987; Ramana *et al.*, 1993). In nurseries application of phorate @ 0.1 g a.i. per polybag is recommended (Sarma *et al.*, 1987). Application of phorate @ 2.5-5 g a.i./plant or carbofuran @ 5 g a.i./plant (twice a year) reduced root-knot nematodes of cardamom and increased the yield (Ali, 1987a; Eapen, 1994). In nurseries of cardamom, phorate, carbofuran, nemacur and several other chemicals were found effective, apart from soil fumigants (Ali, 1986a; 1987b). Use of nematicide in annual crops like ginger, turmeric and seed spices should be done with utmost care to avoid any residues in the produce.

Future

Many potentially useful cultural and biological methods for nematode control have been neglected in the past because of the pre-eminence of nematicide. Over dependence on chemicals can lead to problems of nematicide residues in these export oriented crops. Therefore, high priority should be given for developing sustainable, non chemical control measures to manage nematode problems of spices. Specific organic amendments that may stimulate the microflora, antagonistic to nematodes should be identified. All efforts should be made to exploit the host resistance already available in many crops. In crops like black pepper where source of resistance is located in some related species like *Piper colubrinum,* attempts may be made to transfer the genes for resistance to cultivated types through biotechnological techniques. The search for new sources of resistance should be an ongoing process and should be based on standardised methodologies common for each crop. Efforts in the field of biological control should not be limited to mere isolation and screening of microorganisms. Procedures for mass production of such organisms, and formulating them into suitable products that allow easy application to soil should also be given importance. More information on nematode population dynamics, economic loss thresholds and nematode-host plant interactions are needed for developing integrated nematode management programmes suitable for each cropping system. Unfortunately, the economic loss threshold as a tool for managing nematode populations has not been developed and not used widely in many spice crops. It is high time that traditional morphological basis of taxonomy is supplemented by the DNA-Probe approaches for accurate identification of nematodes. All these need more funding for nematological investigations and better expertise.

REFERENCES

Ali, S.S. (1984). *Proc. Placrosym-V* 1982. pp 615-620. Kasaragod, India.

Ali, S.S. (1986a). *Indian J. Nematol.* **16** : 48-50.

Ali, S.S. (1986b). *Indian J. Nematol.* **16** : 269-270.

Ali, S.S. (1987a). *Proc. Placrosym-VI* 1984. pp 215-223. Kottayam, India.

Ali, S.S. (1987b). *Nematol. medit.* **15** : 155-158.

Ali, S.S. (1989). *Nematol. medit.* **17** : 121-122.

Ali, S.S. & Koshy, P.K. (1982a). *Indian J. Nematol.* **12** : 147-150.

Ali, S.S. & Koshy, P.K. (1982b). *Nematol. medit.* **10** : 107-110.

Ali, S.S. & Venugopal, M.N. (1992). *Nematol. medit.* **20** : 65-66.

Ali, S.S. & Venugopal, M.N. (1993). *Curr. Nematol.* **4** : 19-24.

Anandaraj, M., Ramana, K.V. & Sarma, Y.R. (1991b). In : *Mycorrhizal symbiosis and plant growth.* (Eds. D.J. Bagyraj and A. Manjunath.) University of Agricultural Sciences, Bangalore, India. pp. 110-112

Anandaraj, M., Ramana, K.V. & Sarma, Y.R. (1994). International Symposium of Plantation Crops, 30 November-3 December, 1994. National research Centre for Spices, Calicut, India. (Abstr.)

Anonymous (1971). Fiji Department of Agriculture-Report for the year 1979. Fiji Parliament 1971. p. 34.

Anonymous (1993). Annual Report for 1992-93. National Research Centre for Spices, Calicut, India. 61pp.

Balakrishnan, P.K., Usman, N.M. & Sarma, Y.R. (1993). In : Symposium on Management of Plant Diseases through Resistance, Bioagents and Chemicals, 25-26 November, 1993. University of Agricultural Sciences, Dharwad, India. (Abstr.)

Bridge, J. (1978). Plant nematodes associated with cloves and black pepper in Sumatra and Bangka, Indonesia. ODM Technical Report on visit to Indonesia, 9-19 July, 1978. UK Ministry of Overseas Development, Imperial College of London University, Silwood Park, Sunninghill, Ascot, Berks, U.K. 19pp.

Chen, C.M., Li, H.Y. & Lii, D.Y. (1986). *Herald of agric. Sci.* **1** : 16-22.

Dohroo, N.P., Shyam, K.R. & Bhardwaj, S.S. (1987). *Indian J. Plant Pathol.* **5** : 24-25.

Eapen, S.J. (1994). *Indian J. Nematol.* **24** : (In press).

Ferraz, E.C.A. & Sharma, R.D. (1979). *Revista Theobroma* **9** : 45-53.

Freire, F.C.O. (1982). Ph.D. Thesis, University of London, U.K. 575pp.

Ichinohe, M. (1975). *Jap. J. Nematol.* **5** : 36-40.

Kaur, K.J. (1987). Ph.D. Thesis, Himachal Pradesh University, Shimla, India. 198pp.

Kaur, D.J. & Sharma, N.K. (1988). *Indian Phytopath.* **41** : 467-468.

Kaur, D.J. & Sharma, N.K. (1990). *Int. Nematol. Network Newsl.* **7** : 15-16.

Kaur, D.J., Sharma, N.K. & Khan, M.L. (1989). *Indian J. Nematol.* **19** : 68.

Koshy, P.K. & Bridge, J. (1990). In : Plant Parasitic Nematodes in Tropical Agriculture. (Eds. M.Luc, R.A. Silora and J. Bridge). CAB International, Wallingford, U.K. pp 557-582.

Koshy, P.K. & Geetha, S.M. (1992). In : Nematode Pests of Crops. (Eds. D.S. Bhatti and R.K. Walia). CBS Publishers & Distributors, New Delhi, India. pp 228-238.

Koshy, P.K., Sosamma, V.K. & Sundararaju, P. (1977). *Indian Phytopath.* **30** : 128-129.

Koshy, P.K., Premachandran, D., Sosamma, V.K. & Premkumar, T. (1979). *Indian Phytopath.* **32** : 221-225.

Magar, L.M. & Mayee, C.D. (1988). *Indian Botanical Reptr.* **7** : 65-67.

Mani, A. & Prakash, K.S. (1992). *Curr. Nematol.* **3** : 103-104.

Mani, A. & Sri Hari, D. (1989). *Indian J. Nematol.* **19** : 272.

Midha, R.L. & Trivedi, P.C. (1988). *Indian J. Nematol.* **18** : 372-373.

Midha, R.L. & Trivedi, P.C. (1991). *Curr. Nematol.* **2** : 159-162.

Mohandas, C. & Ramana, K.V. (1987). *Indian Cocoa, Arecanut and Spices J.* **11** : 10-11.

Mohandas, C. & Ramana, K.V. (1991). *J. Plant. Crops.* **19** : 41-43.

Mohanty, K.C., Mahapatra, S.M. & Patnaik, P.R. (1992). *Indian J. Nematol.* **22** : 70-71.

Pant, V., Singh, S.P., Hakim, S. & Saxena, S.K. (1985). *Indian J. Nematol.* **15** : 33-35.

Parihar, A. & Yadav, B.S. (1986). *Indian J. Mycol. and Plant Pathl.* **16** : 84-86.

Patel, D.J., Patel, S.T. & Jagani, D.K. (1986). *Indian J. Nematol.* **16** : 130.

Patel, D.J., Patel, H.R. & Patel, C.C. (1989). Proc. of the First National Seminar on steell spices 24-25 Oct. 1989 pp 256-265, Jaipur, India.

Paulus, A.D., Eng, L., Teo, C.H. & Sim, S.L. (1993). In : The Black Pepper Industry-Problems adn Prospects. (Eds. M.Y. Ibrahim, C.F.J. Bong and I.P. Ipor). Universiti Pertanian Malaysia Bintulu Campus, Sarawak, Malaysia. pp 132-139.

Ramana, K.V. (1986). *J. Coffee. Res.* **16** (*suppl.*) : 17-21.

Ramana, K.V. (1991). In *Disease of Black Pepper.* Eds. Y.R. Sarma and T. Premkumar pp. 136-157. National Research Centre for Spices, Calicut, India.

Ramana, K.V. & Mohandas, C. (1978). *Indian J. Nemaol.* **17** : 62-66.

Ramana, K.V. & Mohandas, C. (1989). *Int. Nematol. Network Newsl.* **6** : 33-35.

Ramana, K.V., Mohandas, C. & Balakrishnan, R. (1987a). *Indian J. Nematol.* **17** : 225-230.

Ramana, K.V., Mohandas, C. & Eapen, S.J. (1994). Tech. Bull., National Research Centre for Spices, Calicut, India (In press).

Ramana, K.V. & Sarma, Y.R. (1993). *Indian J. Nematol.* **23** : 13-14.

Ramana, K.V., Mohandas, C. & Ravindran, P.N. (1987b). *J. Plant. Crops* **15** : 65-66.

Ramana, K.V., Sarma, Y.R. & Anandaraj, M. (1993). In : The pepper Industry: Problems and Prospects. (Eds. M.Y. Ibrahim, C.F.J. Bong and I.P. Ipor). Universiti Pertanian Malaysia Bintulu Campus, Sarawak, Malaysia. pp. 118-131.

Ramana, K.V., Sarma, Y.R. & Mohandas, C. (1992). *J. Plant. Crops* **20** (*suppl*) : 65-68.

Routaray, B.N., Sahoo, H. & Das, S.N. (1987a). *Indian J. Nematol.* **17** : 122-123.

Routaray, B.N., Mohapatra, M.P. & Das, S.N. (1987b). *Indian J. Nematol.* **17** : 327-329.

Samuel, M. & Mathew, J. (1983). *Indian Phytopath.* **36** : 398-399.

Sarma, Y.R., Premkumar, T., Ramana, K.V., Ramachandran, N. & Anandaraj, M. (1987). *Indian Cocoa, Arecanut and Spices J.* **11** : 45-49.

Shafshak, S.E., Shokr, E., Salem, F.M., El-hosary, A.A. & Barakat, A. (1985). *Ann. agric. Sci., Moshtohor* **23** : 1003-1011.

Sharma, A. & Trivedi, P.C. (1992a). In Proc. of the 3rd International Conference on Plant Protection in the Tropics. **6** : 25-28. Malaysian Plant Protection Society, Kuala Lumpur, Malaysia.

Sheela, M.S. & Venkitesan, T.S. (1981). *Indian J. Nematol.* **11** : 105.

Sheela, M.S., Venkitesan, T.S. (1990). *Indian J. Nematol.,* **20** : 184-188.

Sheela, M.S., Venkitesan, T.S. & Mohandas, N. (1993). *J. Plant. Crops* **21** (*suppl.*) : 218-222.

Sivaprasad, P., Jacob, A., Sulochana, K.K., Visalakshy, A. & George, B. (1992). In : Proc. of the Third International Conference on Plant Protection in the Tropics. **6** : 34-37. Kuala Lumpur, Malaysia.

Sukumaran, S. & Sundararaju, P. (1986). *Indian J. Nematol.* **16** : 258-259.

Sukumaran, S., Koshy, P.K. & Sundararaju, P. (1989). *J. Plant. Crops.* **16** : 293-295.

Thaker, N.A., Patel, H.R. & Patel, C.C. (1987). *Indian J. Nematol.* **17** : 143-144.

de Waard, P.W.F. (1979). *J. Plant. Crops* **7** : 42-49.