OCCURRENCE AND SEASONAL VARIATION OF *HEMICRICONEMOIDES MANGIFERAE* FROM TROPICAL AND SUBTROPICAL ORCHARDS IN PENINSULAR INDIA

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ABSTRACT

Ashokkumar, P., S. Vadivelu, U. K. Mehta, R. Jeyarajan, and A. Regupathy. 1991. Occurrence and seasonal variation of *Hemicriconemoides mangiferae* from tropical and subtropical orchards in peninsular India. Nematropica 21:167–176.

Hemicriconemoides mangiferae was prevalent in the major mango (*Mangifera indica*) and sapota (*Achras zapota*) growing tracts in peninsular India. Prominence of *Hemicriconemoides* spp. increased in sandy loam soils (Prominence value = 108.31). Relative prominence of *Hemicriconemoides* spp. from nine geographical locations was 41%. *Hemicriconemoides mangiferae, H. gaddi,* and *H. cocophillus* were found to be associated with 21 plant species among 19 genera in 17 families. Fourteen of the 18 plant species harboring *H. mangiferae* are reported to be associated with the nematode from South India for the first time. New additions of host-parasite associations of *H. mangiferae* are *Rosa* spp., *Artabotrys odoratissimus*, and *Vitis vinifera*. Seasonal variation of *H. mangiferae* was studied in a 5-year-old sapota field. The population was abundant in October 1986 following monsoon and below detectable levels during a dry winter period in January 1987. Monthly rainfall and mean soil moisture were correlated positively ($P < 0.01$) and mean soil temperature was correlated negatively ($P < 0.01$) to population level of *H. mangiferae*. Soil moisture was more critical than soil temperature for the survival of the nematode. Highest population densities were found in the dripline zone at a depth of 20–25 cm in a 5-year-old sapota orchard.

Key words: Achras zapota, Artabotrys odoratissimus, Hemicriconemoides cocophillus, H. gaddi, H. mangiferae, host-parasite association, *Mangifera indica, population dynamics, Rosa* spp., seasonal variation, *Vitis vinifera.*

RESUMEN

Ashokkumar, P., S. Vadivelu, U. K. Mehta, R. Jeyarajan y A. Regupathy. 1991. Presencia y variación estacional de *Hemicriconemoides mangiferae* en huertos tropicales y subtropicales en India peninsular. Nematrópica 21:167–176.

Hemicriconemoides mangiferae se encontró presente en las principales áreas de producción de mango (*Mangifera indica*) y zapote (*Achras zapota*) en la India. La prominencia (densidad × $\sqrt{}$ frecuencia) de *Hemicriconemoides* spp. incrementó en suelo franco arenoso (valor de prominencia = 108.31). La prominencia relativa de *Hemicriconemoides* spp. en nueve localidades geográficas fue de 41%. *Hemicriconemoides mangiferae, H. gaddi* y *H. cocophillus* se encontraron asociados a 21 especies vegetales comprendidos entre 19 géneros y 17 familias. Se registra la asociación de 18 especies vegetales atacadas de *H. mangiferae* en el sur de la India por primera vez. Nuevas asociaciones parásito hospedador de *H. mangiferae* son *Rosa* spp., *Artabotrys odoratissimus* y *Vitis vinifera*. Se estudió la variación estacional de *H. mangiferae* en una parcela de zapote de 5 años. Después de los monsones, la población fue abundante en Octubre de 1986 y por debajo de los niveles de detección durante el período seco de invierno de enero de 1987. La lluvia mensual y la humedad media del suelo se correlacionaron positivamente ($P < 0.01$), mientras que la temperatura promedio del suelo se correlacionó negativamente con el nivel poblacional de *H. mangiferae*. La humedad del suelo fue más crítica que la temperatura del suelo para la sobrevivencia del nematodo. En el huerto de zapote de 5 años, las densidades poblacionales más altas se encontraron en los 20–25 cm de profundidad.

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Palabras clave: Achras zapota, Artabotrys odoratissimus, asociación parásito hospedador, dinámica de poblaciones, *Hemicriconemoides cocophillus, H. gaddi, H. mangiferae, Mangifera indica, Rosa* spp., variación estacional, *Vitis vinifera.*

INTRODUCTION

India produces 60% of the world's mango (*Mangifera indica* L.) crop where 43% of the land under fruit trees is dedicated to the cultivation of mango (1,4). Tropical and subtropical fruit production is largely restricted to the peninsular region of India receiving an average rainfall of 1 050 mm through both southwest (SW) and northeast (NE) monsoons. Improved and native stocks of mango and sapota (*Achras zapota* L.) are under cultivation in irrigated and in rainfed production systems. *Hemicriconemoides mangiferae* Siddiqi was reported from 90% of orchards earlier surveyed (14, personal communication, T. S. Muthukrishnan). Due to low fecundity and the long periods required to manifest host damage symptoms, the role and importance of criconematids is easily overlooked. Severe damages caused by *H. mangiferae* have been reported in mango orchards in Florida (8,9,10,11) and to litchi (*Litchi chinensis* L.) in Transvaal, South Africa (13). Within a span of 10 years large areas of Florida mango crop declined (9,10). Among the criconematids of warmer regions, *H. mangiferae* is the most cosmopolitan species (19) associated with cultivated crops and weeds (7,20). Data on geographical distribution, seasonal behavior, and host range are necessary to evaluate the importance of the nematode and to design management strategies. Conditions of mango and sapota cultivation in peninsular India are comparable to those in regions where severe damage has been reported (8,13). However, host associations and ecological characteristics are not adequately known from this region. Most commercial orchards are small holdings and information generated in this investigation would supplement information available through plant protection services.

MATERIALS AND METHODS

Seasonal variation of Hemicriconemoides mangiferae: A 2-ha plot at the University Orchard, Tamil Nadu Agricultural University, Coimbatore, India, was planted with CO 1, CO 2, PKM 1, Oval, and Kirthabarthi varieties of sapota on 9 September 1982. All trees were planted in a 9 × 12 m spacing. Each year thereafter, the recommended fertilizer dose of 50 kg farm yard manure (FYM), 0.6 kg nitrogen (N), 0.8 kg phosphorus (P), and 1.4 kg potassium (K) per tree was followed (1). Split application of N and half K before June (SW monsoon) and FYM, P, and half K in October or before flowering was the schedule practiced. Routine plant protection measures were undertaken. Yield was not considered since trees were too young to bear. A preliminary sampling done during June 1986 in the orchard indicated the cluster size of *H. mangiferae* to be > 100 m according to Taylor's Power Law (21). Ten randomly selected trees, two of each variety, were tagged for sampling within a cluster. Sampling was done during the last week of every month from August 1986 to July 1987. Six cores (2.5 cm diam) from each of the 10 tagged trees were bulked (12). Subsamples of 100 g from ten such bulk samples (consisting of 60 sub-cores) were processed for extraction of nematodes by the modified sugar-flotation technique (5) using nested 350-μm-pore and 38-μm-pore seives. Nematodes were viewed and counted with the aid of a stereo zoom microscope. Species identification was done at 990× magnification. *Hemicriconermoides mangiferae* was the predominant plant-parasitic nematode in the plot. Saprophagous forms and *Psilenchus* spp. were additionally encountered, but were not counted. During October 1987 the plot was intercropped with sweet potato (*Ipomoea batatas* L.) and turmeric (*Curcuma longa* L.) with a significant change in irrigation systems. Therefore the seasonal incidence study was not continued thereafter.

Vertical and horizontal distribution of Hemicriconemoides mangiferae: Three sapota (cv. Kirthabarthi) trees in the same orchard as above with sandy loam soil (72% sand, 15% silt, 13% clay) and 1% slope were selected for this study. Drainage properties were good. Each month, August 1986–January 1987, soil samples were drawn to a depth of 30 cm with a 2.5-cm-diam tube (12) and split into six sub-cores of 5 cm. Probes were taken around the tree at each of four horizontal distances (30,60,90,120 cm) from the tree base. The dripline zone for all trees was about 90 cm from the base. The corresponding vertical sub-cores at each distance from each tree were bulked and nematodes were extracted as described (5). Population data were square root (X + 1) transformed for analysis of variance and means were compared by Duncan's Multiple Range Test.

Soil moisture was measured gravimetrically every three days from 10 locations in the field. Daily mean soil temperature was measured with a Venus soil thermometer placed 20 cm deep and 90 cm away from the tree trunk. Monthly rainfall data was obtained from the Meteorological Division (Agronomy), Tamil Nadu Agricultural University, Coimbatore.

Prominence and host associations of Hemicriconemoides spp.: A representative area of 984 ha was surveyed from nine major mango and sapota growing regions in peninsular India between October 1986 and August 1987. Overall, these regions span a distance of 530 km from east to west and 500 km from north to south. Perennial trees apart from mango and sapota were also sampled at every orchard. A general sampling plan of one sample/ha consisting of no less than 15 soil cores was followed. A minimum of 15 samples were collected per orchard. Mango trees were divided into three age groups (< 5, 5–15, and > 15 years). Regression analysis was performed for age of trees and nematode population levels. Samples from other perennial trees consisted of a minimum of 10 cores. All samples were drawn from a depth of 20–25 cm in the dripline region. Trees harboring weeds beneath them were not sampled to avoid ambiguous associations. Samples were stored at 10–15 C and processed within 10 days of sampling by the modified centrifugal-flotation technique (5). Root material from each sample was separated and weighed. Extraction of nematodes from roots was attempted (2) but was discontinued after the first 100 samples due to very poor recovery of nematodes.

Simple community analysis parameters, including relative density, relative frequency, prominence value, and relative prominence were used to interpret data (15). Data from each location were individually analyzed. The importance value (15) was not calculated because most samples contained juvenile stages of the phytonematodes present and biomasses for all stages were not available. The international pipette method (16) was followed to determine the textural class of soils from all locations. Criconematids recovered from the samples were identified by the keys provided by Drs. D. J. Raski and U. K. Mehta and verified with the Criconematid Collection of Dr. T. S. Muthukrishnan at Tamil Nadu Agricultural University, Coimbatore, India.

RESULTS

Seasonal variation of Hemicriconemoides mangiferae: An abundant population in the sapota field during October 1986 declined significantly ($P < 0.05$) during January 1987 to below detectable levels (Fig. 1A). The SW monsoon (May–July) was unusually low during 1986–1987 (31.2 mm), resulting in no significant population peak. Soil moisture was greatest (23.4%) in October 1986 when the rainfall was also the highest (558.6 mm). Since the soil was sandy loam with good drainage properties, rainfall probably did not reduce the activity of *H. mangiferae* through inundation. In contrast, retention of adequate soil moisture helped enhance population levels of *H. mangiferae.* During the study period the soil moisture fluctuated between 7.3 and 23.4%. Although soils do not cool considerably during winter in the tropics, the cooler months (December–January) received little rainfall, which severely upset population size. Soil temperature varied from 20.2–29.4 C. In 1987, high temperatures during February and March did not reduce nematode numbers to the extent that drought conditions in January did. During February soil temperature was higher (29.4 C) than in January (25.5 C) but due to adequate retention of moisture through precipitation in February (11.5 mm) population level was significantly ($P < 0.05$) higher than in January (Fig. 1B). Since *H. mangiferae* does not undergo anhydrobiosis during dry spells, dry soil conditions directly affect its survival. Soil moisture and rainfall were positively correlated ($P < 0.01$) and mean soil temperature was negatively correlated ($P < 0.01$) to population levels of *H. mangiferae* (Table 1.)

Horizontal and vertical distribution of Hemicriconemoides mangiferae: From August 1986 to January 1987 greatest aggregation of *H. mangiferae* occurred at a depth of 20–25 cm (Fig. 2A) in the dripline region (90 cm) of the trees (Fig. 2B). Fluctuations of *H. mangiferae* in the soil profile followed the same trend as seasonal variation. The population varied significantly ($P < 0.001$) between months and depths.

Prominence and host associations of Hemicriconemoides spp.: Among 304 samples examined from the 984 ha of mango and sapota fields, *Hemicriconemoides* spp. were the most prominent genera of plant-parasitic nematode (prominence value = 40.67) (Table 2). Highest prominence (108.31) was found in orchards of sandy loam soil (Srirangam). Among *Hemicriconemoides* spp., *H. mangiferae* was the most commonly occurring species. *Criconemella* spp. were recovered from six of the nine locations with a mean absolute frequency of 7.7%. Other plant-parasitic

Table 1. Relationship of weather parameters (x) to population levels (y) of *Hemicriconemoides mangiferae* in a 5-year-old sapota orchard during 1986–1987.

Weather factor	Range	*r*	Regression equation
Soil temperature (C)	20.2–29.4	–0.8074**	y = 340 – 11.6x
Soil moisture (%)	7.3–23.4	0.9295**	y = –71 + 7.5x
Monthly rainfall (mm)	0.0–558.6	0.9363**	y = 19 + 0.2x

**Significant at 1% level.

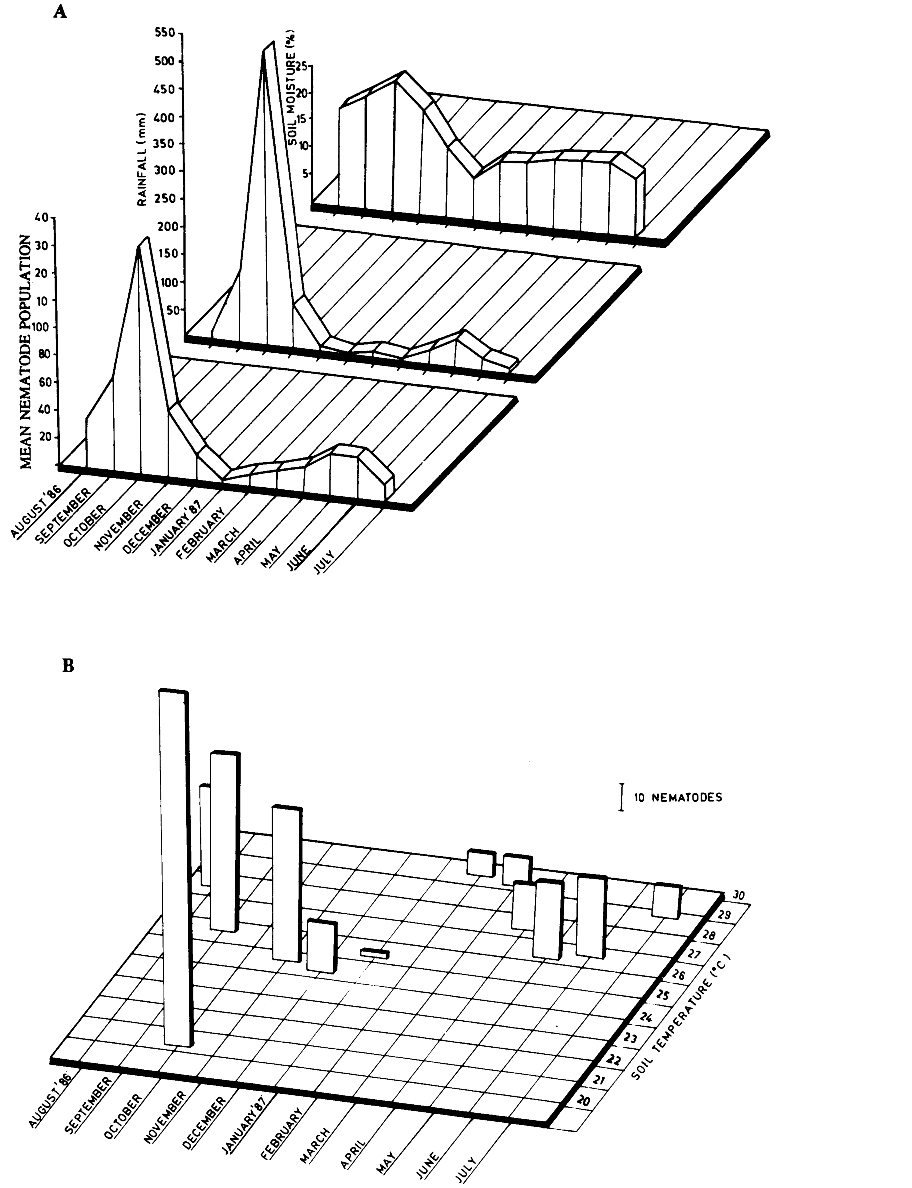

Fig. 1. Seasonal population variation of *Hemicriconemoides mangiferae* (per 100 g soil) in a 5-year-old sapota (*Achras zapota*) orchard in relation to monthly rainfall and soil moisture (A), and daily mean soil temperature (B).

nematodes recorded were *Helicotylenchus dihystera* (Cobb) Sher, *Hoplolaimus seinhorsti* Luc, *H. indicus* Sher, and *H. columbus* Sher. Even though *Hoplolaimus* spp. and *Helicotylenchus* spp. were more frequently encountered, density-wise *Hemicriconemoides* spp. were most prominent. *Helicotylenchus dihystera* and *Hoplolaimus* spp.

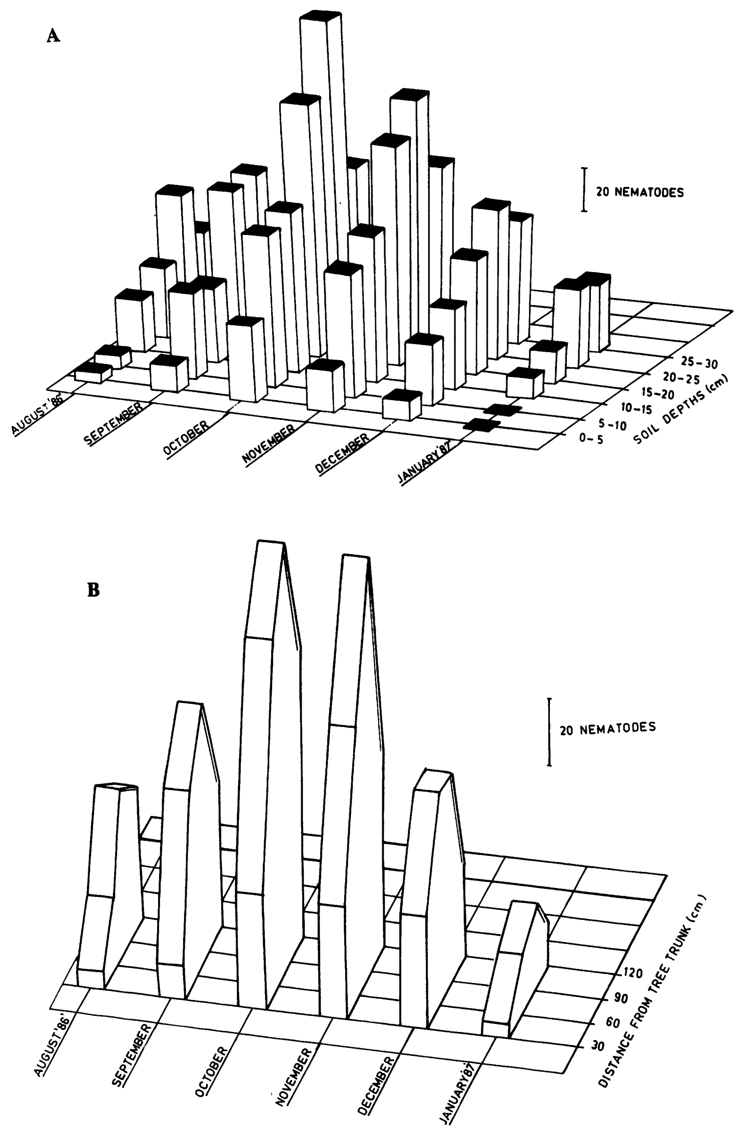

Fig. 2. Vertical (A) and horizontal (B) population variation of *Hemicriconemoides mangiferae* (per 100 g soil) in a 5-year-old sapota (*Achras zapota*) orchard.

were more prominent in finely textured soils than were *Hemicriconemoides* spp.

Examination of trees for possible damage symptoms of *H. mangiferae* revealed no significant relationship between population level and tree age. The density of *H. mangiferae* was highest (10.3 nematodes/g soil) where mango and sapota were grown in sandy loam soil. However, no severe damage symptoms were observed at any of the locations.

The species of *Hemicriconemoides*, namely *H. cocophillus* (Loos) Chitwood & Birchfield, *H. gaddi* (Loos) Chitwood

Table 2. Prominence of genera of nematodes in orchards of peninsular India.

Nematode genera	Relative frequency	Relative density	Prominence value	Relative prominence
Hemicriconemoides spp.	23.1	36.0	35.533	40.670
Helicotylenchus spp.	26.7	29.8	28.215	32.294
Hoplolaimus spp.	27.9	14.8	10.056	11.510
Xiphinema spp.	17.0	11.7	11.801	13.507
Rotylenchulus reniformis	2.3	3.1	1.057	1.210
Criconemella spp.	1.3	1.3	0.284	0.325
Radopholus similis	1.0	1.5	0.229	0.262
Tylenchorhynchus spp.	0.3	1.0	0.122	0.140
Zygotylenchus sp.	0.1	0.6	0.045	0.052
Pratylenchus sp.	0.1	0.1	0.001	0.001
Tylenchulus semipenetrans	0.1	0.1	0.027	0.031

& Birchfield, and *H. mangiferae* were recovered from the rhizospheres of 21 plant species in 19 genera under 17 families (Table 3). *Hemicriconemoides mangiferae* was recovered from 18 plant species in 16 genera and 15 families. Of these, 14 hosts are reported for the first time from this region: *Anacardium occidentale* L., *Artabotrys odoratissimus* R. Br., *Artocarpus heterophyllus* L., *Carica papaya* Gaertn, *Citrus aurantifolia* Swingle, *C. limonia* Osbeck, *C. paradisi* Macf., *Cocos nucifera* L., *Eugenia jambolana* Lam., *Phyllanthus emblica* L., *Punica granatum* L., *Rosa* spp., *Theobroma cacao* L., and *Vitis vinifera* L. Variable levels of *H. mangiferae* (50–370 nematodes/100 g soil) were recovered from rose (*Rosa* spp.), artabotrys (*A. odoratissimus* R. Br.), and grapes (*V. vinifera*). *Criconemella* spp. were found associated with *Plumaria alba* L., *V. vinifera, A. occidentale, Mangifera indica,* and *P. granatum.*

DISCUSSION

The ability of *Hemicriconemoides mangiferae* to survive on a diverse range of cultivated crops as well as weeds in a variety of climatic zones makes it an extremely polyphagous and adaptable species. Its occurrence and survival on a variety of weeds has been reported by McSorley (8). The nematode changes from a typically ectoparasitic to endoparasitic habit in litchi (13). These factors render the nematode more competitive resulting in almost total elimination of other species from their habitat as was observed in coarsely textured soils during our study. In Pakistan, *H. mangiferae* reduced co-populations of *Pratylenchus* sp. and *Helicotylenchus indicus* Siddiqi (17). The higher prominence of *H. mangiferae* in sandy loam soil may be due to their relatively unhindered movement in sandy soils. Females and juveniles of *Criconemoides xenoplax* Raski in vineyards decreased with increasing clay content (3). Maximal reproduction of *C. xenoplax* was observed in sandy soils (18).

Information on alternate survival sites of nematodes is critical in management approaches. Most tropical perennial trees actively grow year-round, providing continuous feeding sites for nematodes. Intercropping and other cultural practices could also greatly influence the survival of pathogenic species in tropical situations. In the tropics, most fruit trees are intercropped with short-term commercial crops for the first 3-5 years. Choice of intercrops should be based on the host

Table 3. Host plants of *Hemicriconemoides* spp. from peninsular India.

Species	Family	Location[z]
Hemicriconemoides mangiferae		
Achras zapota L.	Sapotaceae	A,C,J,P,S,Thi
Anacardium occidentale L.	Anacardiaceae	J
Artabotrys odoratissimus R.Br*	Annonaceae	The
Artocarpus heterophyllus L.	Moraceae	C,Tha,S
Bambusa arundinaceae Retz.	Gramineae	Tha
Carica papaya Gaertn	Caricaceae	S
Citrus aurantifolia Swingle	Rutaceae	The
C. limonia Osbeck	Rutaceae	P
C. paradisi Macf.	Rutaceae	P,Tha,The
Cocos nucifera L.	Palmae	C,S
Eugenia jambolana Lam	Myrtaceae	P
Mangifera indica L.	Anacardiaceae	A,C,J,P,T,Tha,The,Thi,S
Musa spp. L.	Musaceae	C,J,Tha
Phyllanthus emlica L.	Euphorbiaceae	S
Punica granatum L.	Punicaceae	S
Rosa spp. Thunb.*	Rosaceae	Thi
Theobroma cacao L.	Sterculiaceae	C
Vitis vinifera L*.	Vitaceae	P
H. cocophillus		
Areca catechu L.	Palmae	S
C. papaya	Caricaceae	S
C. nucifera	Palmae	S
Malpighia punicifolia L.	Malpighiaceae	A
Psidium guajava L.	Myrtaceae	A,C,T
P. acidus L.	Euphorbiaceae	J
H. gaddi		
C. paradisi	Rutaceae	J

*New host parasite association; all hosts reported supported > 100 nematodes per 100 g soil.
[z]A = Annamalainagar, C = Coimbatore, J = Jeyamkondam, P = Periyakulam, S = Srirangam, T = Trichy, Tha = Thadagam, The = Thenkasi, Thi = Thimmapuram.

range of the principal nematode pest present. Our observations supplement and extend earlier data (7,8,9,10) on the host range of *H. mangiferae*. Caution should be exercised in subtropical orchards with regard to the choice of border trees which support off-season populations of *H. mangiferae*. In mango and sapota orchards turmeric (*C. longa* L.) is grown as an intercrop and arecanut (*Areca catechu* L.), cashew (*A. occidentale*), coconut (*Cocos nucifera* L.), pomegranate (*P. granatum*), and casuarina (*Casuarina equisetifolia* L.) are grown as wind breakers. All of these are reported hosts of *H. mangiferae* (19,20). Including these alternate hosts in orchards where mango and sapota are grown can only aggravate the pest situation.

In Karachi, 6 *H. mangiferae*/g soil was found pathogenic to sapota (17). However, no damage symptoms were observed in sapota orchards in Srirangam where 10.3 nematodes/g soil were observed. Differences in host status and maturity, and cultural practices could be the reason for the absence of damage symptoms even at very high levels of population encountered in this investigation. In Aligarh, summer months drastically reduced field populations of *H. mangiferae* (6). Populations of *H. mangiferae* seem to be influenced by soil temperature and soil moisture.

Recommended fertilizer applications in mango and sapota are one split application in October (pre-flowering) and another pre-monsoon (May–June). Control measures coupled with nutrient application should greatly reduce populations of *H. mangiferae*, since population peaks were observed following monsoon. As a practice semicircular rings or shallow trenches are formed in the dripline zone for applying fertilizers and manure. Nematicides applied deeper in this region would reduce the population levels of *H. mangiferae*. Experimental nematicides in litchi vineyards in South Africa significantly reduced *H. mangiferae* populations. However, populations recovered to original levels after 10 months (13). Natural enemies and less preferred hosts should be identified for use in integrated management approaches. Due to irregular monsoons and longer dry periods, the effect of *H. mangiferae* alone in reduction of yield is not known from peninsular India. However, during regular monsoon seasons the nematode might become a serious pest in irrigated orchards in coarsely textured soils. Nematode problems associated with fruit crops previously had been identified only in banana and citrus from peninsular India. The present investigation will help understand the prevalence and seasonal characteristics of *H. mangiferae* from this major fruit growing region.

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