

NEMATOLOGICAL PROBLEMS IN TROPICAL AND SUBTROPICAL FRUIT TREE CROPS<sup>†</sup>

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ABSTRACT

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Plant-parasitic nematodes cause problems on a number of tropical fruit tree crops. Root-knot nematodes (*Meloidogyne* spp.) can severely damage fig (*Ficus carica*), guava (*Psidium guajava*), papaya (*Carica papaya*), acerola (*Malpighia glabra*), and pomegranate (*Punica granatum*), and injure seedlings of date (*Phoenix dactylifera*) and olive (*Olea europaea*). *Hemicriconemoides mangiferae* is associated with serious decline of lychee (*Litchi chinensis*) and mango (*Mangifera indica*), and is pathogenic to sapodilla (*Manilkara zapota*) and tamarind (*Tamarindus indica*). *Rotylenchulus reniformis* is associated with many fruit species, and can be damaging to papaya. The fig cyst nematode, *Heterodera fici*, severely damages fig seedlings. Biotypes of *Tylenchulus semipenetrans* can cause damage to olive or persimmon (*Diospyros* spp.). *Pratylenchus vulnus* can stunt growth of young olive or avocado (*Persea americana*) trees. Since few control measures are available for nematode problems on existing trees, it is critical to examine potential planting sites for plant-parasitic nematodes, so that planting can be planned to avoid damaging host-parasite combinations.

*Key words:* *Hemicriconemoides mangiferae*, *Heterodera fici*, management, *Meloidogyne* spp., nematodes, *Pratylenchus vulnus*, *Radopholus similis*, *Rotylenchulus reniformis*, tropical fruit trees, *Tylenchulus semipenetrans*, *Xiphinema* spp.

RESUMEN

McSorley, R. 1992. Problemas nematológicos en cultivos frutales de los trópicos y subtrópicos. *Nematropica* 22:103–116.

Los nematodos fitoparásitos causan problemas en varios frutales de los trópicos. Los nematodos agalladores (*Meloidogyne* spp.) pueden dañar severamente el guavo, el papayo, el acerolo y el granado, y pueden perjudicar semilleros de olivo y palmera datilera. *Hemicriconemoides mangiferae* está asociado con una declinación seria del litchi y mango y es patogénico en zapotes y tamarindos. *Rotylenchulus reniformis* está asociado con muchas especies frutales y puede dañar el papayo. El nematodo del quiste de la higuera, *Heterodera fici*, daña severamente los semilleros de la higuera. Biotipos de *Tylenchulus semipenetrans* pueden causar daño al olivo y el dióspiro (*Diospyros* spp.). *Pratylenchus vulnus* puede retardar el crecimiento del olivo y el aguacate (*Persea americana*). Hay pocos métodos útiles para el control de problemas de nematodos en arboles establecidos y por ello es importante el muestreo de los lugares de replante para identificar los nematodos fitoparásitos presentes y así evitar combinaciones parásito-hospedero contraproducentes.

*Palabras clave:* frutales tropicales, *Hemicriconemoides mangiferae*, *Heterodera fici*, manejo, *Meloidogyne* spp., nematodos, *Pratylenchus vulnus*, *Radopholus similis*, *Rotylenchulus reniformis*, *Tylenchulus semipenetrans*.

INTRODUCTION

Plant-parasitic nematodes are important pests on many subtropical and trop-

ical fruit tree crops. Bananas and plantains (*Musa* spp.) and citrus (*Citrus* spp.) are the most studied of these crops, and

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although many nematodes are associated with them and potentially damaging to them, the most important nematode pests of bananas and plantains are probably *Radopholus similis* (Cobb) Thorne, *Helicotylenchus multincinctus* (Cobb) Golden, and *Pratylenchus coffeae* (Zimmermann) Filipjev & Schuurmans Stekhoven (29,75,83,98). *Tylenchulus semipenetrans* Cobb, *R. citrophilus* Huettel, Dickson, & Kaplan, and *P. coffeae* are probably the most serious nematode pests of citrus (15, 83). The little information available on the other subtropical and tropical fruit crops has been reviewed (6,56). Recent surveys have added to knowledge of plant-parasitic nematodes associated with tropical and subtropical fruits in Florida (60), Costa Rica (52), Panama (76), Trinidad (5), Egypt (38), Libya (9), Iraq (97), and India (11). A review of the liter-

ature (28,56,60) reveals hundreds of nematode species associated with dozens of different tropical fruit species, but for the vast majority of combinations, no damage or problems have been documented. The purpose of this review is to update information and to clarify and draw attention to the most serious nematode problems of the most studied tropical and subtropical fruit trees (Table 1), other than bananas and citrus.

#### NEMATODE PROBLEMS OF SELECTED TROPICAL AND SUBTROPICAL FRUITS

##### *Actinidia chinensis*

The kiwifruit, a vine rather than a tree crop, is increasing in importance in subtropical and warm temperature regions (6,77). Root-knot nematodes are

Table 1. Subtropical and tropical fruit crops included in this review.

Scientific name	Common names
<i>Actinidia deliciosa</i> (A. Chev.) Liang & Ferguson	Kiwifruit, Kiwi
<i>Annona muricata</i> L.	Soursop, Guanábana
<i>Annona reticulata</i> L.	Custard apple, Anona
<i>Annona squamosa</i> L.	Sugar apple, Custard apple
<i>Carica papaya</i> L.	Papaya, Papayo
<i>Diospyros kaki</i> L.	Japanese persimmon
<i>Diospyros lotus</i> L.	Persimmon, Dióspiro, Caqui
<i>Diospyros virginiana</i> L.	American persimmon
<i>Eriobotrya japonica</i> Lindl.	Loquat, Níspero
<i>Euphoria longana</i> Lam.	Longan
<i>Ficus carica</i> L.	Fig, Higuera
<i>Litchi chinensis</i> Sonn.	Lychee, Litchi
<i>Malpighia glabra</i> L.	Barbados cherry, Acerola
<i>Mangifera indica</i> L.	Mango
<i>Manilkara achras</i> (Mill.) Fosberg <sup>2</sup>	Sapodilla, Zapote
<i>Olea europaea</i> L.	Olive, Olivo
<i>Passiflora edulis</i> Sims	Passionfruit, Maracuya
<i>Persea americana</i> Mill.	Avocado, Aguacate
<i>Phoenix dactylifera</i> L.	Date, Palma del dátil
<i>Psidium guajava</i> L.	Guava, Guayaba
<i>Punica granatum</i> L.	Pomegranate, Granado
<i>Solanum quitoense</i> Lam.	Naranjilla
<i>Tamarindus indica</i> L.	Tamarind, Tamarindo

<sup>2</sup>syn. *Achras zapota* L.

the most frequently reported problem on the crop (6), and the pathogenicity of *Meloidogyne incognita* (Kofoid & White) Chitwood to *A. chinensis* was established (14). Damage to kiwifruit can be caused by *M. incognita* (37,99), by *M. arenaria* (Neal) Chitwood (6), or by *M. hapla* Chitwood in locations as diverse as Spain (77), Italy (101), Chile (99), or New Zealand (30).

#### *Annona* spp.

Recently, decline of *Annona squamosa* attributed to *R. similis* was observed in Brazil (78). Symptoms include leaf yellowing, decline, root lesions and decay, and even plant death. Relatively high densities of *Hemicriconemoides mangiferae* Siddiqui (173/100 cm<sup>3</sup> soil) were associated with *A. muricata* in Florida (60), where the nematode was also reported from atemoya, an interspecific hybrid of *Annona* spp. Moderately high densities of *T. semipenetrans* (> 448/250 cm<sup>3</sup> soil) were associated with *A. muricata* in Panama (76). *Meloidogyne* spp. are also reported in association with *Annona* sp. (56,76), as are *Rotylenchulus* spp. (60,76), including *R. reniformis* Linford & Oliveira (60). Inoculation tests resulted in very low levels of galling to roots of *A. squamosa* from *M. incognita*, *M. arenaria*, and *M. javanica* (Treub) Chitwood, but not from *M. graminicola* Golden & Birchfield (71). Low levels (3.3/10 g root) of *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven were found in roots of *A. squamosa* 5 months after inoculation, whereas no *P. zeae* Graham or *P. coffeae* were detected under similar conditions (71). Several recent surveys have expanded our knowledge of other plant parasites associated with *A. muricata* (52,60,76), but no reports of nematode damage on any *Annona* species appear to exist, other than that of *R. similis* on *A. squamosa* (78).

#### *Carica papaya*

Although many plant-parasitic nematodes are associated with papaya (28,52, 56,76), serious damage is only reported from *R. reniformis* and *Meloidogyne* spp. Damage to papaya by *R. reniformis* is well documented (6,56), and the benefits of soil fumigation in decreasing nematode density and increasing papaya yield have been known for more than 30 years (51). Results of preplant fumigation for *R. reniformis* on papaya depend on initial density and on the length of time the crop is to be maintained (63). In a pathogenicity test (1), plant size and nematode reproductive rate were inversely related to *R. reniformis* inoculum density. Some range in numbers of mature females of *R. reniformis* was observed among four *C. papaya* cultivars evaluated in a screening test (73). Although at least four species of *Meloidogyne* are associated with papaya (56), more reports of damage involve *M. incognita* or *M. javanica* (6,56). Pathogenicity tests (4,33) have related plant stunting to inoculum levels of *M. incognita*. Most papaya cultivars tested have been susceptible to *M. incognita* (4,81), but 'Pusa 22-3' was considered resistant (81). At present, most attempts to counteract *M. incognita* infection have involved application of nematicides (6,32,84) or organic amendments (84).

#### *Diospyros* spp.

Both *D. kaki* and *D. virginiana* are hosts of *R. similis* (79), and *Meloidogyne* spp. are also associated with both plants (28,56). However, damage to persimmon is reported only for *T. semipenetrans*. In Israel, decline of four persimmon varieties on *D. virginiana* rootstock was reported in a site infested with *T. semipenetrans*, and gravid females of this nematode were obtained from 90% of persim-

mon root samples (7). *Diospyros lotus* is also a reported host for *T. semipenetrans* (69), and yield loss is associated with this nematode (6).

#### *Eriobotrya japonica*

No field damage to loquat by nematodes is reported. Inserra and Vovlas (39) described the life cycle and histopathology of root damage for *Rotylenchulus macrorodatus* Dasgupta, Raski, & Sher on this host. Loquat is recorded as a host of *R. similis* (79), and *T. semipenetrans* has been found associated with this fruit (91).

#### *Euphoria longana*

Little is known of the nematode fauna of longan (56) but it is a reported host of *R. similis* (79). *Hemicriconemoides mangiferae* is associated with the crop (60,92), and may reach relatively high numbers (60). No damage to longan is reported, but lychee, a close relative in the family Sapindaceae, is damaged by *H. mangiferae*.

#### *Ficus carica*

Reports of damage by *Meloidogyne* spp. to fig are frequent and from many countries (6,56). *Meloidogyne javanica* and especially *M. incognita* and *M. arenaria* are associated with problems to this crop. Control efforts have focused on preplant fumigation, application of systemic nematicides, and host plant resistance (6). In some locations, cultivars of *F. carica* resistant or tolerant to various species of *Meloidogyne* have been identified (6,56). Other *Ficus* species resistant to *Meloidogyne* spp. could be used as rootstocks or to develop interspecific hybrids with *F. carica* (6,56). The cyst nematode, *Heterodera fici* Kirjanova, is damaging to figs, especially seedlings, and is reported from many countries where the crop is grown

(6). This nematode is relatively host specific, with egg hatching dependent to some degree on root leachate from fig (13). The histopathology and feeding habits of *Xiphinema index* Thorne & Allen on fig roots has been much studied (6), but plant damage in the field is not documented. There have been a few reports of association of other nematodes with damaged or declining fig trees, including *Pratylenchus* spp. and *Paratylenchus hamatus* Thorne & Allen (6,56).

#### *Litchi chinensis*

Decline of lychee trees in South Africa has been attributed to *H. mangiferae* and *Xiphinema brevicolle* Lordello & da Costa (65). Economic damage has not been associated with the many other nematode species associated with this crop (6,56). The host status of *Radopholus* spp. on lychee is unclear (56). Probably it is not a host of *R. similis* (70), but its host status to *R. citrophilus* should be re-evaluated since lychee was reported as a host of the "citrus race" of *R. similis* (70).

#### *Malpighia glabra*

Severe damage to the acerola or Barbados cherry from *Meloidogyne* spp., especially *M. incognita*, is reported from Florida (56), Puerto Rico (3), and Brazil (25). Results from recent inoculation tests (24) suggest that acerola is a host of *M. incognita* race 1, *M. javanica*, and *P. brachyurus*, but is a non host to *R. reniformis*, *T. semipenetrans*, and *M. graminicola*. A few *R. similis* were recovered from roots of acerola following the inoculation test with that species (24); currently, acerola is listed as a host of *R. similis* (79).

#### *Mangifera indica*

Recent surveys have increased our knowledge of the nematodes associated

with mango in Costa Rica (52), Panama (76), and Egypt (26,38). Of the many nematode associates of mango, damage has been most consistently attributed to *H. mangiferae* (6,56). This species is widely distributed in mango throughout the world (6,56,92), and is prevalent in mango orchards in India (2), where population levels are correlated with soil moisture (42). The nematode has been shown to be pathogenic to mango (86), and the damage symptoms of a mango decline in the field are described (59) and correlated with density of *H. mangiferae* (64). In South Africa, *H. mangiferae* and *X. brevicolle* occur together on declining mangoes (66). In Egypt, a yield response was obtained by chemical control of *Hoplolaimus columbus* Sher and *Xiphinema* spp. on mango (88). Many other plant-parasitic species are associated with mango, but no adverse effects from them are known (56). Mango is a host for *R. similis* but not for *R. citrophilus* (79).

#### *Manilkara achras*

*Hemicriconemoides mangiferae* is reported to be pathogenic to sapodilla (86), and it is widely distributed in sapodilla orchards in India, although its economic effects are unknown (2). Its seasonal population fluctuations are closely linked to rainfall patterns in India (2) and Pakistan (87), and other nematodes may show some decline following peaks in *H. mangiferae* abundance (87). Recent surveys in Florida (60) and India (11) have added to our sparse knowledge of the nematode fauna of this crop.

#### *Olea europaea*

The nematode parasites associated with olive have been reviewed by Lambert (46) and Hashim (34). Recent surveys of nematodes associated with this

host have been conducted in Italy (40), Spain (74), Jordan (35), Libya (19), and Egypt (38). *Meloidogyne incognita* and *M. javanica*, though localized in distribution, are important pests damaging olive (34). Both were shown to be pathogenic to olive in greenhouse tests (47), whereas 'Ascolano' and 'Manzanillo' olive trees were resistant to *M. hapla* and *M. arenaria*. There are some differences in response of olive cultivars to *M. incognita* and *M. javanica*, with 'Manzanillo' olive having some tolerance to *M. javanica* (34,47). *Pratylenchus vulnus* Allen & Jansen has been associated with olive decline in the field (34), and its pathogenicity to olive has been demonstrated (48). *Tylenchulus semipenetrans* is pathogenic to olive (34, 49), although results depend on the olive cultivar and biotype of the nematode. *Xiphinema* spp. are associated with damage to olive in the field (12,34). *Xiphinema elongatum* Schuurmans Stekhoven & Teunissen and *Helicotylenchus dihystera* (Cobb) Sher reduced growth of olive seedlings in inoculation studies (12), although no statistical analysis of plant growth data was provided. No damage to olive in the field from *Rotylenchulus macrorodatus* is reported, but the histopathology of root damage by this parasite on olive is described (39).

#### *Passiflora edulis*

A recent survey (76) and pathogenicity test (82) have examined the nematodes associated with this important vine crop. Damage from *M. incognita* and *M. javanica* are widely reported (6,56), but there is evidence that *P. edulis* f. *flavicarpa* Degener may be a poor or non host to *M. arenaria* (44,82). However, host response of passionfruit to *M. incognita* and *M. javanica* is a complex and depends on the passionfruit variety and the local nematode population (6,44,56). For example,

a range of response in passionfruit cultivars was observed to *M. incognita* race 1 in Brazil (95). With some passionfruit varieties and nematode populations, root galling is observed without nematode reproduction (44). *Rotylenchulus reniformis* is associated with damage to passionfruit in the field and the greenhouse (44). Passionfruit appears to be a non host of *R. similis* (67), *Heterodera glycines* Ichinohe (82), and *Paratrichodorus minor* (Colbran) Siddiqi [= *Paratrichodorus christiei*] (82). Fairly high densities of *T. semipenetrans* were associated with passionfruit in Panama (76).

#### *Persea americana*

Although many species of plant-parasitic nematodes are associated with avocado (6,54,56,76), there are few reports of damage. Damage by *P. vulnus* has been established in an inoculation test and a field trial (89). Avocado is a host to *R. similis* and *R. citrophilus* (70), and reports of damage by burrowing nematode to avocado in Florida (103) are likely due to *R. citrophilus*. *Xiphinema brevicolle* was pathogenic to avocado seedlings in an inoculation test (6).

#### *Phoenix dactylifera*

Of the nematode species associated with date palm (31,41,56), *Meloidogyne* spp. are most frequently associated with damage. Damage appears to be most severe on seedlings, and date is susceptible to *M. hapla*, *M. arenaria*, *M. incognita*, and *M. javanica* (31,50,56). *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven was associated with declining date palms in Algeria (45).

#### *Psidium guajava*

Recent surveys have investigated the nematodes associated with guava in South

Africa (102), Costa Rica (52), Panama (76), and especially in Cuba (20), were 72 species associated with the crop were found. *Meloidogyne* spp., including *M. incognita*, *M. arenaria*, *M. javanica*, and *M. hapla* are widespread and very damaging to the crop (6,20,56,68). In Florida, increased fertility and irrigation have helped to alleviate *Meloidogyne* damage to some extent (56,85). In Cuba, treatment of *Meloidogyne*-infested planting sites has been effective (21–23). *Psidium friedrichsthalianum* (Berg.) Nied. was reported resistant to *Meloidogyne* but other species of *Psidium* were highly susceptible (8). However, other workers (27) found only moderate tolerance of *P. friedrichsthalianum* to *Meloidogyne* spp. when investigating its use as a possible rootstock. Pathogenicity to guava in inoculation tests has been demonstrated with *Hoplolaimus indicus* Sher (55) and with *Helicotylenchus dihystrera* (Cobb) Sher (102), but not with *Hemicriciconemoides mangiferae* (86), although guava is a host for *H. mangiferae* (86) and *R. similis* (79).

#### *Punica granatum*

Recent surveys of plant-parasitic nematodes associated with pomegranate in India (10), Libya (94), and Jordan (36), have found *M. incognita* and *M. javanica* to be widespread and damaging on the crop. Of 12 varieties tested in India, all were susceptible to *M. incognita* (100). Application of systemic nematicides reduced population densities of several nematode species on pomegranate (10,36,94), and increased yields were obtained in these tests when *Meloidogyne* spp. were present (10,94), but not when *Meloidogyne* spp. were absent (36). Recently, pomegranate has been reported as a host of *H. mangiferae* (2).

*Solanum quitoense*

Little is known of the nematode fauna associated with naranjilla, but a recent survey of the crop in Panama (76) revealed high numbers of *M. incognita*, *M. arenaria*, *Paratrichodorus minor* and *Pratylenchus brachyurus* reproduced on this host, and treatment with aldicarb reduced nematode numbers and improved plant growth (82).

*Tamarindus indica*

Nematodes associated with tamarind have been surveyed in Panama (76) and Costa Rica (52). Tamarind is host to *R. similis* (96) and *H. mangiferae* (86), with pathogenicity reported for the latter species (86).

#### NEMATODE MANAGEMENT ON TROPICAL AND SUBTROPICAL FRUIT TREES

*Nematode Management on Infected Trees*

Once a serious nematode parasite becomes established on a susceptible host, the problem usually cannot be eliminated. Nematicide usage on tropical fruits depends on regulations of individual countries, and registered materials, if any, are likely to be few in number. In the United States, for example, no nematicides are registered for post-plant application to any of the fruits mentioned in this review. Performance of various nematicides have been investigated recently on several crops, including olive in Italy (34), papaya in India (32,84), and pomegranate in India (10), Jordan (36), and Libya (94). Organic amendments, such as neem cake, have been used to improve performance of *M. incognita*-infected papaya (84) or pomegranate (10). In most cases, the only measure which can be taken with infected plants is to re-

lieve symptoms through favorable management practices such as increased fertility, mulching, or supplementary irrigation (56,85).

*Preventive Nematode Management*

*Clean planting material:* Since so little can be done once plants are infected, it is critical to avoid exposure of tropical fruit trees to the nematodes that are most damaging to them. Nematode-infested rootstocks and planting materials remain a potential source of introduction of problems into new planting sites (72,80). There have been efforts to use nematicide dips to disinfest kiwifruit (30) or olive seedlings (34). The safest course of action is to use and maintain nematode-free stock and sterile or nematode-free soil or mix, in all propagation operations (56,76).

*Site selection—sampling:* Soil sampling is usually essential to determine the plant-parasitic nematodes present in potential planting sites, and sampling methodology has been reviewed recently (57). When the site is already planted to trees, it will usually be more efficient to collect a single core from many trees than to collect several cores around each tree, except in measuring *T. semipenetrans* densities (62). Maximum densities of most plant-parasites on tropical fruit trees are detected in the dripline (61) or outer regions near the dripline (53), but not near the trunk (53,61). Information on optimum depth of sampling exists on some crops, such as avocado (53), mango (53), guava (16,17), and jujube (*Zizyphus jujube* Mill.) (16,17). Populations of some nematodes, such as *Hemicriconemoides mangiferae* and *Hoplolaimus indicus*, show seasonal peaks of maximum density, during which chances of detection are improved (18,42,87).

*Site selection—damage potential:* Most potential planting sites will likely contain several species of plant-parasitic nematodes. Many of these are likely reported to be “associated with” a particular fruit crop. In most instances, no damage has been attributed to most of these associates, which simply occur in the rhizosphere at noneconomic levels on tree roots or weeds. For example, mango has been sampled extensively, and many nematodes including *Meloidogyne* spp. have been associated with it, but apparently root-knot does not affect the crop (6) (a non-host?).

The nematode-tropical fruit combinations for which damage is reported are summarized (Table 2), and should be considered when selecting sites for susceptible fruit trees. Of course, degree of damage will depend on nematode density, biotype, fruit tree cultivar, potential interactions, and environmental conditions. The susceptibility of bananas to *R. similis*, *H. multicinctus*, and *P. coffeae* (29, 75,83,98) and of citrus to *T. semipenetrans*, *R. citrophilus*, and *P. coffeae* (15,83) should also be considered if bananas or citrus are to be grown in rotation or interplanted with tropical fruit trees.

Most of the damaging nematode-tropical fruit combinations involve five nematode genera (*Meloidogyne*, *Hemicriconemoides*, *Radopholus*, *Rotylenchulus*, *Tylenchulus*). Numerous associates of *Meloidogyne* spp., *Rotylenchulus* spp., and *R. similis* with other tropical fruit species are mentioned elsewhere (28,39,56,60, 70,79). Although *R. reniformis* and (or) *R. macrodoratus* infect many different hosts, economic damage is reported only for *R. reniformis* on papaya and passionfruit. New hosts of *H. mangiferae* reported recently (2) include *Artocarpus heterophyllus* L., *Eugenia jambolana* Lam., and *Phyllanthus emblica* L. Other nematode genera

which have been shown to be pathogenic or damaging in some instances include *Xiphinema*, *Pratylenchus*, *Helicotylenchus*, and *Hoplolaimus*. *Helicotylenchus multicinctus*, a serious pest of banana (29,75), has not been shown to damage other tropical fruit species, but is reported associated with avocado, fig, citrus, and mango (90). *Helicotylenchus dihystra*, reported pathogenic to guava (102) and olive (12) in inoculation tests, is a widespread associate of tropical fruit trees in Florida (58,60, 64), where damage from this species has never been observed. *Hoplolaimus indicus* is widely distributed in India, where it is associated with banana (11,43), citrus (11,43), mango (43), guava (16,18,43), jujube (16,93), and jambolan [*Syzygium cuminii* (L.) Skeels] (93). Its damage potential on fruit trees is not well known, but it has been shown to be pathogenic to citrus (43) and guava (55) in inoculation tests.

Ideally, sites with potentially damaging nematode-host combinations should be avoided when establishing tropical fruit orchards. Sites with weeds or vegetable crops may contain high populations of nematodes (e.g., *Meloidogyne* spp., *R. reniformis*) that are known to damage some kinds of tropical fruit trees.

*Preplant fumigation:* If nematode-infested planting sites cannot be avoided, then preplant treatment of sites with nematicides, especially soil fumigants, can be beneficial in the establishment of young trees (21–23,51). Resurgence of nematodes to levels without fumigation is possible after a period of time. In tests with *R. reniformis* on papaya, *R. reniformis* densities in preplant-fumigated plots reached the same levels as those of non-fumigated control plots within 5½ months in one test, but in two of four tests, they did not reach those of control plots even after 11 months (63).



Table 2. Associations, host status, and damage<sup>a</sup> reported for five nematode genera on selected tropical fruit tree species.

Fruit species	<i>Meloidogyne</i> spp.	<i>Hemiericonemoides mangiferae</i>	<i>Radopholus similis</i>	<i>Rotylenchulus</i> spp. <sup>x</sup>	<i>Tylenchulus semipenetrans</i>	Other nematodes associated with damage
<i>Actinidia deliciosa</i>	DAMAGE					
<i>Annona</i> spp.	a	a	DAMAGE	a	a	
<i>Carica papaya</i>	DAMAGE	a		DAMAGE	DAMAGE	
<i>Diospyros</i> spp.	a		host	a	a	
<i>Eriobotrya japonica</i>	a		host	a	a	
<i>Euphorbia longana</i>	a	a	host	a	a	
<i>Ficus carica</i>	DAMAGE			a		<i>Heterodera fici</i>
<i>Litchi chinensis</i>	a	DAMAGE	nonhost <sup>y</sup>	a		<i>Xiphinema brevicolle</i>
<i>Malpighia glabra</i>	DAMAGE		host	nonhost	nonhost	
<i>Mangifera indica</i>	a	DAMAGE	host <sup>y</sup>	a		<i>X. brevicolle</i>
<i>Manilkara achras</i>		DAMAGE		a		
<i>Olea europaea</i>	DAMAGE		a	a	DAMAGE	<i>Pratylenchus vulnus</i> , <i>X. elongatum</i> , <i>Helicotylenchus dibystrera</i>
<i>Passiflora edulis</i>	DAMAGE		nonhost	DAMAGE	a	
<i>Persea americana</i>	a		DAMAGE <sup>z</sup>	a	a	<i>P. vulnus</i> , <i>X. brevicolle</i>
<i>Phoenix dactylifera</i>	DAMAGE	a	host	a		
<i>Psidium guajava</i>	DAMAGE	host	host	a	a	<i>H. dibystrera</i> , <i>Hoplolaimus indicus</i>
<i>Punica granatum</i>	DAMAGE	host		a		
<i>Solanum quitoense</i>	a			a		
<i>Tamarindus indica</i>	a	DAMAGE	host	a		

<sup>a</sup>a = reported association; host, nonhost = reported host status; DAMAGE = damage or pathogenicity reported.

<sup>x</sup>*Rotylenchulus reniformis* and (or) *R. macrodoratus*.

<sup>y</sup>*Litchi chinensis* is nonhost to *R. similis* but host to *R. citrophilus*; *M. indica* is host to *R. similis* but not to *R. citrophilus* (70).

<sup>z</sup>Damage report (103) is likely due to *R. citrophilus*.

*Host plant resistance:* Tropical fruit cultivars resistant to nematodes are very limited. Resistance or tolerance to some species of *Meloidogyne* have been identified in a few fig (6,56) and olive (34,47) cultivars. For fig (6,56) or guava (8,27), it may be possible to develop interspecific hybrids or utilize related species as rootstocks with some resistance or tolerance to *Meloidogyne* spp. A range in response of papaya cultivars to *M. incognita* has been reported (81).

*Management practices:* Maintaining plant health and practicing sanitary management can be beneficial in preventing nematode problems. Sites with poor drainage or excessive slope can be prone to nematode infestation (76). Weed control is essential, since weeds often can serve as alternate hosts (58,76). Interplanting of susceptible hosts in fruit groves should also be avoided. Many vegetables and ornamentals used in interplanting can be hosts to nematode pests such as *Meloidogyne* spp. or *Pratylenchus* spp. (76).

### CONCLUSIONS

Although many species of plant-parasitic nematodes are associated with tropical fruit trees, damage is documented for relatively few host-parasite combinations. These should be recognized by growers of tropical fruits, and such combinations avoided in selecting planting sites. Good management practices and sanitation are essential in all phases of nursery and orchard operations, because once a serious nematode problem is established on a fruit tree, it is very difficult to restore tree health and production.

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