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Plant-parasitic Nematode Problems in the Pacific Islands[1]

JOHN BRIDGE[2]

Abstract: The Pacific islands have a diverse range of food and cash crops with indigenous and introduced nematode problems. The staple food crops have serious nematode pests, such as *Meloidogyne* spp. on sweet potato, *Hirschmanniella miticausa* causing corm rot of taro, and *Pratylenchus coffeae* and *Radopholus* sp. producing tuber dry rot of yams. Bananas are infested with *P. coffeae* or *R. similis*, citrus with *Tylenchulus semipenetrans*, rice with *Aphelenchoides besseyi*, and ginger with *Meloidogyne* spp. and *R. similis*. *Rotylenchulus reniformis*, *P. zeae*, *P. brachyurus*, and *Helicotylenchus* spp. are important on all of these and other crops, such as sugarcane, passion fruit, pawpaw, and cassava. *Meloidogyne* spp. cause serious damage to local and introduced leaf and fruit vegetables and other crops, such as tobacco, sugarcane, pawpaw, black pepper, and pyrethrum. Many other plant-parasitic genera and species, some undescribed, occur in the Pacific, and there are many islands still to be investigated.

Key words: Pacific islands, plant-parasitic nematode.

The multitude of islands that constitute the island groups and countries in the Pacific hold a fascination for most scientists because of their diversity in crops and peoples, their unusual flora and fauna, and especially because of their many unknowns. They have in common an isolation by distance and water from the main land masses.

Nematology is in its infancy in this part of the world; few of the islands have been surveyed for plant-parasitic nematodes (Table 1), most of this work being done during the past decade. Some islands, such as those of Fiji, have been studied in detail, but many are as yet untouched by nematological hands and many nematode problems are still to be discovered. Therefore, the following compilation on plant-parasitic nematodes in the Pacific is not the definitive work but only the end of the beginning of our nematological knowledge.

This review covers the islands north of New Zealand and west to New Guinea, excluding Hawaii which has been dealt with separately. It consists of both published and unpublished information collected during survey work and provided by other nematologists and scientists working in the Pacific islands. The complete list of nematode genera and species identified from the region (Table 1) is derived from surveys and taxonomic publications of nematodes collected in the Pacific (4,5,11,21,23,29,30, 37–43,52,56,62,63).The nematodes discussed are those known to cause crop damage, those to which evidence clearly points as being important plant parasites, and those that pose a potential threat to crops in the Pacific islands. They are dealt with on a crop basis and listed in Table 2. Full host lists and extensive lists of nematodes catalogued under their hosts can be found in Bridge and Page (5), Fliege and Sikora (11), Khair (23), Kirby et al. (30), and Orton Williams (39).

ROOT AND TUBER CROPS

Root and tuber crops play an important part in the agricultural and traditional life of the South Pacific islands. Many, such as yams (*Dioscorea* spp.), taro (*Colocasia esculenta*), tannia (*Xanthosoma sagittifolium*), giant swamp taro (*Cyrtosperma chamissonis*), sweet potato (*Ipomoea batatas*), and cassava (*Manihot esculenta*), are important staple food crops; some, such as ginger (*Zingiber officinale*), are cash crops; and one, kava or yaqona (*Piper methysticum*), is used for a narcotic beverage.

Yams, Dioscorea spp.: Grown mainly for their underground tubers, yams suffer from

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[2] Tropical Plant Nematology Advisory and Research Unit, CAB International Institute of Parasitology, St. Albans AL 4 0XU, UK.

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TABLE 1. Plant nematodes of the South Pacific.

Nematode	Distribution in island groups†
Amphisbaenema amicorum	TO
A. paradoxiger	S
Aphelenchoides besseyi	F, NG
A. bicaudatus	F, K, N, NG, S, TO, TU
A. fragariae	NO
A. minor	F
A. ritzemabosi	F
Caloosia longicaudata	F
Criconemella curvata	NG
C. denoudeni	F
C. onoensis	F, NG
C. ornata	S
C. sphaerocephala	F, NG
C. xenoplax	K, NO, TO
Crossonema civellae	NG
C. fimbriatum	NO
Discocriconemella caudaventer	F
D. discolabia	F, NG, TO
D. limitanea	S, TO
Ditylenchus dipsaci	NO
Gracilacus aculenta	NG
G. aonli	F
G. enata	F
G. solivaga	F
Helicotylenchus californicus	F
H. crenacauda	F, NG, S
H. dihystera	F, N, NG, NO, S, SO, TO, V
H. egyptiensis	F
H. indicus	F, NG, S, SO, TO
H. microcephalus	F, NG, S, TO
H. mucronatus	F, N, NG, S, SO, TO
H. multicinctus	F, K, N, NG, NO, S, SO, TO, TU, V
H. paracanalis	F
H. pseudorobustus	F
H. pteracercus	F
H. retusus	F, NG
Hemicriconemoides cocophillus	F, K, NG, S
H. gaddi	F, N, S, TO
H. mangiferae	F, S, TO
Hemicycliophora vitiensis	F, S
Heterodera spp.	F, K, NG, S, TO
H. graminis	F
H. mothi	F
Hirschmanniella miticausa	NG, SOL
Hoplolaimus indicus	NG
H. seinhorsti	F, NG, S
Longidorus laevicapitatus	NG, S
Meloidogyne arenaria	F, N, NG, S, SO, TU
M. hapla	NG, NO
M. incognita	F, K, N, NG, NO, S, SO, TO, TU, V
M. javanica	F, K, N, NG, NO, S, TO
Nothocriconema mutabile	NO
N. polynesianum	NG, S, TO
Ogma gracile	F, S
O. octangulare	S

TABLE 1. Continued.

Nematode	Distribution in island groups†
Paralongidorus sacchari	F
Paratrichodorus acutus	F
P. minor	F, NG
P. porosus	NG, NO
Paratylenchus gabrici	V
P. humilis	F
P. leptus	F
P. nawadus	F
P. tui	T
Pratylenchus brachyurus	F, N, S, TO, TU
P. coffeae	F, K, N, NG, P, S, SO, TO, V
P. crenatus	F
P. penetrans	NO
P. zeae	F, NG, S, TO
Quinisulcius curvus	K, N, S, TO
Radopholus similis	F, G, N, NG, NO, P, S, SO, TO, Y
R. williamsi	F, NG, S, TO, TU, V
Rotylenchoides valdeclarus	S
Rotylenchulus reniformis	F, K, N, NG, S, SO, TO
Rotylenchus breviglans	NO
R. gracilidens	NO
R. robustus	NO
R. unisexus	NO
Scutellonema brachyurum	F, S, TO
S. incisicaudatum	NG
S. insulare	NG
Sphaeronema sp.	F, K, S, TO
Syro hughdavidi	NG
S. melanesicus	S, NG
S. orphreyifer	NG
S. vexillatrix	NG
Trichodorus cylindricus	NG
Trophotylenchulus sp.	NG
Trophorus lomus	TO
Tylenchorhynchus annulatus	F, NG
Tylenchulus semipenetrans	F, N, NG, NO, S, TO
Xenocriconemella macrodora	NG
Xiphinema americanum	NO, S
X. bacaniboia	F
X. basiri	F
X. brasiliense	F, NG, S
X. brevicolle	F, K, N, S, TO
X. elongatum	F, S
X. ensiculiferum	F, N, NG, NO, S, SO, TO, V
X. guirani	NG
X. insigne	F, NG, S
X. krugi	F, S
X. loosi	NO
X. opisthohysterum	NO
X. orthotenum	F, NG
X. pachtaicum	NO
X. papuanum	NG
X. rivesi	S, TO
X. simillimum	V

† F = Fiji, G = Guam, K = Kiribati, N = Niue, NG = New Guinea, NO = Norfolk, P = Palau, S = Samoa, SO = Solomon Islands, TO = Tonga, TU = Tuvalu, V = Vanuatu, Y = Yap.

TABLE 2. Crops of the Pacific islands and their associated nematode pests.

Crop	Important nematode	Less important or less well known nematode pests
Root and tuber crops		
Yams (*Dioscorea* spp.)	*Pratylenchus coffeae* *Radopholus similis*	*Rotylenchulus reniformis* *Pratylenchus brachyurus* *Meloidogyne* spp. *Helicotylenchus mucronatus*
Taro (*Colocasia esculenta*)	*Hirschmanniella miticausa*	*Meloidogyne* spp. *Pratylenchus coffeae* *Rotylenchulus reniformis* *Radopholus* spp. *Helicotylenchus mucronatus*
Tannia (*Xanthosoma sagittifolium*)		*Pratylenchus coffeae* *Meloidogyne* spp. *Rotylenchulus reniformis*
Giant swamp taro (*Cyrtosperma chamissonis*)	*Radopholus similis*	*Pratylenchus coffeae* *Meloidogyne* spp.
Sweet potato (*Ipomoea batatas*)	*Meloidogyne* spp. *Rotylenchulus reniformis*	*Pratylenchus brachyurus* *P. coffeae* *Helicotylenchus mucronatus* *Radopholus* spp.
Ginger (*Zingiber officinale*)	*Radopholus similis* *Meloidogyne* spp.	*Rotylenchulus reniformis* *Criconemella onoensis* *Pratylenchus coffeae*
Kava, Yaqona (*Piper methysticum*)	*Meloidogyne* spp.	
Cassava (*Manihot esculenta*)		*Meloidogyne* spp. *Pratylenchus brachyurus* *P. coffeae* *Rotylenchulus reniformis*
Potato (*Solanum tuberosum*)	*Meloidogyne* spp.	
Fruit crops		
Bananas (*Musa* spp.)	*Pratylenchus coffeae* *Radopholus similis* *Helicotylenchus multicinctus*	*Meloidogyne* spp. *Helicotylenchus mucronatus* *Rotylenchulus reniformis* *Helicotylenchus microcephalus*
Citrus (*Citrus* spp.)	*Tylenchulus semipenetrans*	
Passion fruit (*Passiflora edulis*)	*Rotylenchulus reniformis*	*Meloidogyne* spp.
Pawpaw (*Carica papaya*)	*Rotylenchulus reniformis* *Meloidogyne* spp.	
Pineapple (*Ananas comosus*)	*Rotylenchulus reniformis*	*Meloidogyne* spp.
Vegetables	*Meloidogyne* spp.	*Rotylenchulus reniformis* *Pratylenchus* spp. *Helicotylenchus* spp.
Field and Other Crops		
Rice (*Oryza sativa*)	*Aphelenchoides besseyi*	*Pratylenchus zeae* *Meloidogyne* spp. *Criconemella* spp.
Sugarcane (*Saccharum officinarum*)		*Meloidogyne* spp. *Pratylenchus zeae* *Radopholus williamsi* *Tylenchorhynchus annulatus* *Hemicriconemoides cocophillus*
Tobacco (*Nicotiana tabacum*)	*Meloidogyne* spp.	
Maize (*Zea mays*)		*Pratylenchus zeae* *Meloidogyne hapla*
Peanut, Groundnut (*Arachis hypogaea*)		*Meloidogyne* spp. *Pratylenchus brachyurus*
Pyrethrum (*Chrysanthemum cinerariaefolium*)	*Meloidogyne hapla*	
Vanilla (*Vanilla fragrans*)		*Pratylenchus brachyurus*
Coffee (*Coffea* spp.)		*Rotylenchulus reniformis*
Black pepper (*Piper nigrum*)	*Meloidogyne incognita*	*Rotylenchulus reniformis*

a serious disease known as dry rot which initially affects the outer tissue layers of the tuber and can result in complete decay of the tubers during storage. *Pratylenchus coffeae* is the principal causal organism of the disease in New Guinea (5), Solomon Islands (2,13), and Vanuatu (12), and is found on yams in Fiji (30,39) and Niue and Tonga (39). *Radopholus similis,* which can also cause rot of tubers, has been isolated from dry rot tissues in New Guinea (5) and was found infesting tubers in Fiji (7) and yam roots in the Solomon Islands (13).

Many other endoparasitic nematodes have been recovered from yams and yam soils. Of these, the potentially important ones are *Rotylenchulus reniformis* in Fiji (30,39) and Tonga (39); *Pratylenchus brachyurus* in Fiji and Tonga (39); *Meloidogyne* spp. in Fiji (30,39), New Guinea (5), Kiribati, Niue, and Western Samoa (39); and *Helicotylenchus mucronatus* in Niue, Tonga, and Western Samoa (39).

Taro, Colocasia esculenta: A rot of taro corms, known locally in the Solomon Islands as "mitimiti" disease, is caused by *Hirschmanniella miticausa.* The nematodes feed endoparasitically in the corm tissues, producing irregular red or brown necrotic zones which normally precede complete secondary brown soft rot of the basal portions of the corms. *H. miticausa* has been found causing the disease in the Solomon Islands (2,4,13,35,44) and New Guinea (4,5).

Other nematodes of possible economic importance found with taro are *Meloidogyne* spp. causing root galling in Fiji (30,39), New Guinea (5), and Niue and Solomon Islands (11,39); *Pratylenchus coffeae* causing corm and root necrosis in New Guinea (5) and also found in Fiji (30,39); *Radopholus* spp. endoparasitic in root and corm tissues in New Guinea (5), Fiji (30,39), and Western Samoa (39); *Rotylenchulus reniformis* in Fiji (30,39), Western Samoa (11,39), Solomon Islands, and Tonga (39); and *Helicotylenchus mucronatus* in Fiji, Niue, Solomon Islands, Tonga, and Western Samoa (39).

Tannia, Xanthosoma sagittifolium: Pratylenchus coffeae has been found associated with corm rot of tannia in Fiji (39). *Meloidogyne* spp. (*M. incognita* and *M. javanica*) are found in New Guinea, Fiji, and Tonga causing slight to severe galling of tannia roots and corms, and *Rotylenchulus reniformis* is commonly associated with the crop in the same three island groups (5,39). Both *Meloidogyne* spp. and *R. reniformis* are thought to be involved with "Xanthosoma root-rot disease" in interrelationships with pathogenic fungi (5), but that has not been confirmed.

Giant swamp taro, Cyrtosperma chamissonis: The giant swamp taro, as the name implies, is mainly grown in flooded conditions, and there are few records of plant nematodes on the crop, apart from low numbers of *Pratylenchus coffeae, Meloidogyne* spp., and others in Fiji (39). A recent finding, however, has shown that an important dry rot disease of *Cyrtosperma* corms in the islands of Yap, Palau, and Guam is almost certainly caused by *R. similis* (22; Jackson and Bridge, unpubl.).

Sweet potato, Ipomoea batatas: Three species of root-knot nematodes, *M. arenaria, M. incognita,* and *M. javanica,* are known to cause significant damage to sweet potato in New Guinea (5) and Fiji (25), and *Meloidogyne* spp. have been recorded with the crop in other island groups of Kiribati, Niue, Western Samoa, Tonga (39), and Tuvalu (12). Large numbers of the nematodes can be found in roots without the obvious galling symptoms. In tubers, nematodes are embedded deep in necrotic tissues associated with small and distorted tubers that often have cracks in the surface layers.

Rotylenchulus reniformis can infect and severely affect sweet potato growth. It has been found on the crop in Fiji, Western Samoa, and Tonga (11,30,39); at high population levels it can greatly reduce tuber weight (58).

Helicotylenchus mucronatus has been found in New Guinea as an endoparasite in sweet potato roots and tubers, associated with leaf chlorosis and severe cortical root necrosis (5). Other species that could be causing

damage to the crop are *Pratylenchus brachyurus* in Fiji and Tonga, *P. coffeae* in Tonga, *Radopholus williamsi* in Tonga and Fiji (39), and undescribed *Radopholus* spp. in New Guinea (5).

Ginger, Zingiber officinale: Ginger was introduced into Fiji at the end of the last century, and cultivation was expanded into commercial production as an export crop in the 1950s (15). The two most important nematode pests of ginger in Fiji are *Radopholus similis* (7,61) and *Meloidogyne* spp., mainly *M. incognita* (14,15). Infection of ginger rhizomes by *R. similis* produces small, shallow, water-soaked lesions that are invaded by secondary organisms, eventually leading to rotting of entire rhizomes (61). *Meloidogyne* spp. cause galling of feeder roots, cracks in the outer rhizome layers, and small, light-brown, water-soaked lesions (15).

Control of both *R. similis* and *Meloidogyne* spp. on ginger in Fiji has been attempted by hot water treatment, chemical dips, nematicide application to soil, soil solarization, crop rotation, and fallow (19,32, 33,57). *R. similis* has not been recorded on ginger from islands other than Fiji, but a *Meloidogyne* sp. has been found on the crop in Western Samoa (39).

Other nematodes implicated in disease of ginger on Fiji are *Rotylenchulus reniformis, Criconemella onoensis,* and *Pratylenchus coffeae* which have been found sometimes in high populations (30,39).

Kava or yaqona, Piper methysticum: Shrubs of kava or yaqona provide a popular narcotic drink for the peoples of Fiji, especially, and other island groups such as Samoa and Tonga. The drink is prepared from the thick roots and underground portions of the stem.

Root-knot nematodes, *Meloidogyne* spp., are reported to be associated with a serious disease of the crop known as "yaqona wilt" in Fiji and Tonga. Although they are not necessarily the only causal organisms, root-knot nematodes alone can cause greatly decreased growth in severely infested yaqona plants. Control of *Meloidogyne* sp. on yaqona by soil application of nematicides markedly increased growth of yaqona plants in Tonga (49). Infestation by the nematode is generally confined to the basal region of yaqona plants and, therefore, is often overlooked (20,47).

Three *Meloidogyne* species, *M. arenaria, M. incognita,* and *M. javanica,* have been found on *P. methysticum* in Fiji (26,30,39), and *M. incognita* is reported to cause severe root galling of plants in Western Samoa (11).

Many other species of plant-parasitic nematodes have been found with the crop, including *Rotylenchulus reniformis* in Fiji, Western Samoa, and Tonga; *Pratylenchus coffeae* in Western Samoa and Tonga; and *Radopholus similis* in Fiji, but none of these have yet been shown to damage *P. methysticum* (30,39).

Cassava, Manihot esculenta: There are no reports of severe root-knot or any other nematode related root diseases on cassava in the field. In controlled glasshouse trials, however, five of the most popular cultivars grown in Fiji were moderately or highly susceptible to both *Meloidogyne incognita* and *M. javanica* and four were moderately susceptible to *M. arenaria* (25). Other pathogenic nematode species frequently found with cassava are *Pratylenchus brachyurus, P. coffeae, Helicotylenchus microcephalus, H. mucronatus,* and *Rotylenchulus reniformis* (39).

Potato, Solanum tuberosum: Potato is a crop of comparative recent introduction which is restricted to the higher altitudes and cooler regions. Potatoes are infested with root-knot nematodes, *M. incognita* in New Guinea (5) and *M. hapla, M. incognita,* and *M. javanica* in Norfolk Island (23). As yet, there are no reports of cyst nematodes on potato in the Pacific islands.

Fruit Crops

Bananas, Musa spp.: Bananas are widely grown in the South Pacific islands, mainly in small holdings. There are few commercial plantations. Dessert and cooking bananas, both triploid and diploid varieties, are cultivated, the latter especially in New Guinea which has the distinction of being the only country where diploids are culti-

vated on a significant scale. In all the island groups that have been examined, bananas are known to suffer severe damage by root endoparasitic nematodes.

The two most important nematode pests of banana in the Pacific are the lesion nematode, *Pratylenchus coffeae*, and the burrowing nematode, *Radopholus similis*. Both species cause identical damage, consisting of root and corm necrosis leading to poor growth, reduced yields, and toppling. *P. coffeae* is reported causing damage to, or present on, bananas in Fiji (30, 39), Solomon Islands and Vanuatu (13), New Guinea (5), and Niue, Tonga, and Western Samoa (39), but is not reported from other islands. *R. similis* occurs on bananas in Fiji (9,24,30,39,53), Tonga (30,51), Niue (39), Norfolk Island (23), Western Samoa (11,39), Solomon Islands (13), and New Guinea (5,10) but not in Kiribati and Vanuatu (13,39).

The relative importance of *R. similis* and *P. coffeae* differs among island groups. In Western Samoa and Tonga, *R. similis* is often found in high root populations in 40–60% of banana planting sites but *P. coffeae* occurs only rarely or in very low numbers (11,39,51). In Tonga, damage caused by *R. similis* has been monitored over a number of years with a root damage rating system (1) which has shown that the damage and yield loss due to *R. similis* is increasing in the banana plantations examined (48). In Fiji, Niue, New Guinea, and Vanuatu, *P. coffeae* is more commonly found on bananas (5,13,39), and an extensive survey of bananas in New Guinea revealed that *P. coffeae* was the main root pest at all planting sites, with *R. similis* occurring in banana roots at only one site, an agricultural research station (6).

Helicotylenchus multicinctus is the most widespread of root nematodes, occurring in all the Pacific islands where bananas have been examined, namely Fiji, Kiribati, Niue, New Guinea, Norfolk Island, Western Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu (5,9,12,13,23,30,39). It is considered to be the major banana nematode in Kiribati in the absence of *R. similis* and *P. coffeae* (39). Two other species of *Helicotylenchus*, *H. microcephalus* and *H. mucronatus*, cause banana root necrosis in New Guinea (5). *H. microcephalus* is also reported from banana in Fiji (30,39) and Tonga and Western Samoa (39), and *H. mucronatus* occurs in Fiji, Niue, Tonga, Western Samoa (39), and Solomon Islands (13).

Root-knot nematodes, mainly *M. incognita* and *M. javanica*, cause some root galling of bananas in Fiji, Kiribati, Niue, New Guinea, Norfolk Island, Western Samoa, Solomon Islands, Tonga, and Tuvalu (5,9,11–13,23,27,30,39). Of the many other nematode species found with banana, the reniform nematode, *Rotylenchulus reniformis*, is the most likely to cause damage. It has been recorded from Fiji, Kiribati, New Guinea, Tonga, and Western Samoa (5,11,30,39).

Citrus, Citrus spp.: The citrus nematode, *Tylenchulus semipenetrans*, has been found in the Pacific but only in a very small percentage of the citrus groves and plantations sampled. Its rare presence, mainly in agricultural research stations and plant introduction centers, suggests that it has been introduced into the Pacific in the relatively recent past. The nematode has been recovered from citrus roots in only 3 of 34 sites in Fiji, one lime grove in Niue and one sample of orange tree roots in Tonga (39), one site in Western Samoa (11), one citrus plantation on the island of New Britain, New Guinea (5), and in the only citrus stand on Norfolk Island (23). Nematodes identified as *T. semipenetrans* have been found around other crops in Fiji (39) and from forest reserves in Norfolk Island (23), but these could be a different species or a closely related genus, *Trophotylenchulus*, as found on forest trees in Papua New Guinea (5).

Large numbers of different nematode species have been recovered from around citrus in Fiji, including *Rotylenchulus reniformis*, *Pratylenchus* spp., *Criconemella* spp., *Helicotylenchus* spp., and *Meloidogyne* spp. (30,39). The burrowing nematode, *Radopholus similis*, is not a parasite of citrus (7,39,61) but was found in citrus soil at one

location in Tonga, although its parasitism on citrus roots is in doubt (39).

Passion fruit, Passiflora edulis: The main nematode pest of passion fruit in the Pacific appears to be *Rotylenchulus reniformis* which occurs in high populations on the crop in Fiji and Samoa (11,26), although it is not recorded from other island groups. *R. reniformis* reduced growth of passion fruit by 23% in glasshouse experiments in Fiji (26).

In the Pacific islands that have been studies (26,39), unlike other parts of the world, passion fruit is not damaged by root-knot nematodes and could even be a nonhost of Pacific isolates, as three *Meloidogyne* spp. (*M. arenaria, M. incognita, M. javanica*) found in Fiji did not reproduce on the crop (26).

Pawpaw, Carica papaya: Pawpaw is known to be attacked by *Meloidogyne* spp., mainly *M. incognita* and *M. javanica,* in Fiji (30,39), Kiribati and Niue (39), New Guinea (5), and Western Samoa (11,39); these nematodes are often associated with serious root galling.

High populations of *Rotylenchulus reniformis* are found around pawpaw in Fiji, Tonga, and Western Samoa (39). The nematode appears to be a particularly serious root pest in pawpaw seedling nurseries (16) and can significantly reduce growth of young plants (58).

Pineapple, Ananas comosus: Large populations of *Rotylenchulus reniformis* have been found infesting pineapple in Western Samoa and are considered to be a limiting factor in production (11). The nematode has also been recovered from pineapple soils in Fiji and Tonga (30,39). *Helicotylenchus* spp., mainly *H. dihystera,* are common on pineapple in most of the islands that have been examined. *Pratylenchus brachyurus* and *Criconemella* spp. also occur on the crop, as do *Meloidogyne* spp., but no root-knot symptoms or other damage by these nematodes has been observed (23,30,39).

Vegetables

A wide range of local and introduced leaf, fruit and root vegetables, and pulses are grown throughout the Pacific in addition to those mentioned above under root and tuber crops. A high proportion of these vegetables are seriously affected by one or more of four species of root-knot nematodes (*M. arenaria, M. hapla, M. incognita, M. javanica*) in the different islands.

Cultivars of vegetables in the Pacific which have been shown to be susceptible to *Meloidogyne* spp., with moderate to severe galling and related damage symptoms, are aibika or bele (*Abelmoschus manihot*), amaranthus (*Amaranthus tricolour*), beet (*Beta vulgaris*), bitter gourd (*Momordica charantia*), carrot (*Daucus carota*), celery (*Apium graveolens* var. *dulce*), Chinese cabbage (*Brassica chinensis*), common beans (*Phaseolus* spp.), coyote (*Sechium edule*), cowpea (*Vigna unguiculata*), cucumber (*Cucumis sativus*), eggplant (*Solanum melongena*), hyacinth bean (*Lablab niger*), Indian spinach (*Basella alba, B. rubra*), lettuce (*Lactuca sativa*), melon (*Cucumis melo*), mung bean (*Vigna radiata*), okra (*Abelmoschus esculentus*), parsley (*Petroselinum crispum*), pigeon pea (*Cajanus cajan*), pumpkin (*Cucurbita* sp.), snake bean (*Vigna sesquipedalis*), soybean (*Glycine max*), sweet pepper (*Capsicum annuum*), Swiss chard (*Beta vulgaris*), tomato (*Lycopersicon esculentum*), tree tomato (*Cyphomandra betacea*), watermelon (*Citrullus vulgaris*), and winged bean (*Psophocarpus tetragonolobus*) (5,8,11–13,18,23, 25,27,30,34,39,45,46,54,55). In contrast, a number of forage grasses and legumes that could be grown in rotation with vegetables for nematode control are immune to *Meloidogyne* spp. (60).

In comparison to root-knot nematodes, most other nematodes found on vegetables are minor pests, the exception being *Rotylenchulus reniformis* which is very common on vegetables in some of the Pacific islands (30,39). More than 20 different vegetables are known hosts for *R. reniformis* (59), and high populations of the nematode severely reduce growth of mung bean (*Vigna radiata*) and pigeon pea (*Cajanus cajan*) (17,58). *Pratylenchus* spp. (*P. brachyurus, P. coffeae*) and *Helicotylenchus* spp. are frequently associated with vegetables and could be of importance (5,30,39).

Field and Other Crops

Rice, Oryza sativa: The rice white-tip nematode, *Aphelenchoides besseyi,* has been found in all the major rice areas of Fiji, causing chlorosis of leaf tips and other leaf portions, distortion of leaves, stunted growth, reduced numbers of tillers, small panicles, and empty grains (31). It has not been recorded on rice in other islands of the Pacific.

No other nematodes have been observed causing damage to rice but some species, also found in Fiji, that could be important are *Pratylenchus zeae, Meloidogyne* spp., and *Criconemella* spp. (39).

Sugarcane, Saccharum officinarum: Sugarcane is an important plantation crop in a few island groups, such as Fiji where surveys have shown 23 species of plant nematodes in 16 genera to be associated with the crops (28,36). The relative damage caused by these nematodes on sugarcane has not been established but those rated of possible importance in Fiji are *Pratylenchus* spp. (particularly *P. zeae*), *Meloidogyne* spp., (*M. arenaria, M. incognita, M. javanica*), *Tylenchorhynchus annulatus, Hemicriconemoides cocophillus, Radopholus williamsi, Criconemella* spp., and *Paratrichodorus minor.* In Papua New Guinea, four genera and species of nematodes are endoparasitic in sugarcane roots, namely *M. javanica, P. zeae, Hoplolaimus seinhorsti,* and an undescribed genus with swollen females (3). These nematodes are of limited distribution, confined mainly to areas or layers of lighter soils, but where they occur, they are associated with severe root damage in the form of root galling, surface lesions, or general necrosis of the root cortex. *Meloidogyne* spp. and *R. williamsi* are commonly found in Tonga and also occur on sugarcane in Western Samoa, together with *R. similis, P. brachyurus,* and *P. coffeae* (39).

Tobacco, Nicotiana tabacum: Root-knot nematodes, *M. incognita* and *M. javanica,* are known to be a problem on tobacco in Fiji (14,39) and New Guinea (5).

Maize, Zea mays: Maize is grown only on a small scale in most of the Pacific islands, but its cultivation is increasing where it is used as an alternative food source and for livestock feed. *Pratylenchus* spp. (*P. brachyurus* and *P. zeae*), *Helicotylenchus* spp. (mainly *H. microcephalus*), and *Rotylenchulus reniformis* are commonly found around maize plants in Fiji and Tonga (30,39). In New Guinea, *P. zeae* was endoparasitic in maize roots and associated with chlorosis and stunting of plants and *Meloidogyne hapla* was observed causing root galling (5).

Peanut or groundnut, Arachis hypogaea: Chlorosis of peanut plants is associated with obvious root galling by *Meloidogyne hapla* in the highlands of New Guinea (5). *M. javanica* is also found on peanut in New Guinea (5), and both *M. javanica* and *M. incognita* have been recovered from peanut roots in Fiji (30).

Many other genera and species have been identified from peanut, but the lesion nematode *Pratylenchus brachyurus* is the dominant species on the crop in Fiji (30,39), occurring also on peanut in Western Samoa (39).

Pyrethrum, Chrysanthemum cinerariaefolium: Pyrethrum, introduced into the highlands of Papua New Guinea as a cash crop for local farmers, suffers serious damage from *Meloidogyne hapla* which occurs in large numbers and causes root galling, stunted growth, and poor flower yield (5). This example demonstrates the need to determine the presence of plant nematodes and to understand their importance as crop pests before large-scale introductions of new crops are made into a region.

Vanilla, Vanilla fragrans: The lesion nematode *Pratylenchus brachyurus* is reported to be pathogenic to vanilla in Tonga, causing reduced growth of vines (50), although its economic importance under field conditions has not been determined.

Coffee, Coffea spp.: There is no clear evidence of nematodes causing damage to coffee in the Pacific islands, but *Rotylenchulus reniformis* is recorded in association with leaf chlorosis and wilting in New Guinea (5). It also occurs on coffee in Fiji, Tonga, and Western Samoa (11,39).

Black pepper, Piper nigrum: Black pepper

is not widely grown but has been introduced into some of the islands. Root galling and associated leaf chlorosis and defoliation caused by *Meloidogyne incognita* has been observed in Western Samoa (11) and the island of New Britain in New Guinea (5); *M. incognita* also occurs on the crop in Fiji (26,30). *Rotylenchulus reniformis* has been found, often in high populations, on black pepper in Fiji and Western Samoa (11,39).

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