NEMATODES ASSOCIATED WITH THE EDIBLE AROID GENERA *XANTHOSOMA* AND *COLOCASIA* AND THEIR EFFECTS ON YIELD[1]

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ABSTRACT

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The plant-parasitic nematodes associated with various aroid species are reviewed. Species of *Meloidogyne,* particularly *M. incognita* (Kofoid & White) Chitwood and *M. javanica* (Treub) Chitwood, are the most widely reported nematode pests of both *Colocasia* and *Xanthosoma* but the severity of crop damage varies widely, depending on plant cultivar, growing conditions, nematode population, and geographical location. *Rotylenchulus reniformis* Linford & Oliveira is also widely reported on the aroids, and low initial populations built up to high levels on *Xanthosoma caracu* Koch et Bouche, *X. atrovirens* Koch et Bouche, *X. violaceum* Schott, and *Colocasia esculenta* (L.) Schott in field tests in Florida. With preplant populations of 56 *R. reniformis*/100cm^3 of soil and final populations of about 400/100cm^3 of soil, a significant (P=0.05) reduction of 26% in marketable dry cormel weight of *X. caracu* occurred in nontreated plots when compared to fumigated plots, but yield of *X. atrovirens* was not affected. Yield of taro (*C. esculenta*) grown under plastic mulch culture was not increased by fumigation treatment, even though very high levels of *R. reniformis* built up in nontreated control plots.
Additional key words: cocoyam, taro, Meloidogyne incognita, Meloidogyne javanica, Rotylenchulus reniformis, Hirschmanniella, tannia, dasheen, eddoe.

RESUMEN

McSorley, R., S. K. O'Hair, y J. L. Parrado. 1983. Los nematodos asociados con los géneros comestibles de las Araceae *Xanthosoma* y *Colocasia* y sus efectos en los rendimientos. Nematropica 13:165-180.

Se revisaron los nematodos parasíticos asociados con varias especies de la familia Araceae. La plaga de nematodo más extensamente reportada tanto en *Xanthosoma* spp., como en *Colocasia* spp. fue *Meloidogyne* spp., particularmente *M. incognita* (Kofoid & White) Chitwood y *M. javanica* (Treub) Chitwood, pero la severidad del daño a la cosecha vario mucho dependiento de la variedad, las condiciones de crecimiento, la población de nematodos y la localización geográfica. También fue extensamente reportado *Rotylenchulus reniformis* Linford & Oliveira. En pruebas de campo realizadas en la Florida las poblaciones iniciales de *R. reniformis* aumentaron a niveles altos en

Xanthosoma caracu Koch et Bouche, *X. atrovirens* Kosh et Bouche, *X. violaceum* Schott y *Colocasia esculenta* (L.) Schott. Con una población de *R. reniformis* antes de plantar de 56 y final de 490 por 100 cm³ de suelo se experimentó una reducción significativa (P = 0.05) del 26% de tuberculos comerciales (peso seco) de *X. caracu* en los lotes no fumigados comparados con los fumigados, pero los rendimientos de *X. atrovirens* no fueron afectados. Los rendimientos de las coronas de taro (*C. esculenta*) cultivadas con plástico no fueron afectados por los tratamientos de fumigación a pesar que la población de *R. reniformis* aumentó a niveles muy altos en los lotes no fumigados.
Palabras claves adicionales: cocoyam, taro, Meloidogyne incognita, Meloidogyne javanica, Rotylenchulus reniformis, Hirschmanniella spp.

INTRODUCTION

A number of different plant species in the aroid family (Araceae) are used throughout the tropics as energy-food crops, since they store starch in enlarged underground stem structures called corms and cormels. Particularly important are cocoyams (certain species of *Xanthosoma*) and taro (*Colocasia esculenta* (L.) Schott), which have many different common names.

Within cocoyam, Purseglove (33) lists four main corm-producing species: *X. sagittifolium* (L.) Schott, *X. caracu* Koch et Bouche, *X. atrovirens* Koch et Bouche, and *X. violaceum* Schott. Much confusion in their separation has developed, and *X. sagittifolium* and *X. caracu* are probably synonymous in many cases. Since most seldom flower, separation is generally accomplished by noting corm color and type of cormel production. Purseglove (33) lists two main varieties of taro, *C. esculenta* var. *esculenta* and *C. esculenta* var. *antiquorum* (Schott) Hubbard & Rehder. The separation between these two is that the latter, known as upland taro, produces many edible cormels, while the former, known as wetland taro, produces one main edible corm with few cormels. Again there is some confusion between these because flowers are seldom produced.

Generally grown as annuals, these herbaceous, perennial plants, bearing edible underground stems and large leaves, are well adapted to moist soils. In the humid areas of the tropics they are grown in soils where other food crops will not flourish. They are often the only remaining food source after a hurricane has passed. World edible aroid production is estimated at 4.4 x 10^6 mt/annum (2). Major production regions include Nigeria, Ghana, Japan, Papua New Guinea, and Ivory Coast with 40, 28, 13, 5, and 4% of the world production, respectively. Little data is available about specific methods of crop production.

Species of *Meloidogyne* are the most widely reported nematode pests of the edible aroids. Damage to *C. esculenta* was first reported in 1917 by Byars (8) in Florida. Typical symptoms on taro include plant stunting (8, 29) accompanied by typical galls on the roots (8, 29, 41) and some-times by crop failure (8, 29). The nematodes also attack the corms and cormels, producing malformations and irregular swellings on the surfaces (8, 29, 41). Growth of dasheen (*C. esculenta*) in a *Meloidogyne*-infested field improved following fumigation with DD (15, 26).

Reports of the severity of *Meloidogyne* damage to *C. esculenta* vary considerably, probably due to the many cultivars grown (43). Root-knot nematodes are reported to be particularly serious on upland taro (29, 41). *M. javanica* (Treub) Chitwood is reported to seriously damage *C. esculenta* var. *antiquorum* in India, causing yellowing and dieback of infested plants (36). Heavy infestations resulted in galls on the corms (27). These galls varied in size from 2-15 mm and caused deformation of the corms and accelerated rotting during storage (36). *M. javanica* has also been found in association with *Colocasia* in East Africa (42) and in Florida (21), exhibiting mature egg masses in the latter case. *M. javanica* did not reproduce on the taro cultivar Dodare in an inoculation test in Japan (16), and the cultivar Samoa was reported to be only moderately susceptible to *M. javanica* in a test in Fiji (19).

Taro is also a host of *M. incognita* (Kofoid & White) Chitwood. Although observations in Trinidad found females to be more plentiful in the larger roots of the plant, galling was confined to the feeder roots (5). Similar slight galling is reported from Fiji (19, 43), and the cultivar Samoa was considered only moderately susceptible (19), while the species did not reproduce on 'Dodare' (16). However, severe galling and damage by *M. incognita* on taro has been reported from Niue Island by Williams (43), who observed that this apparent contradiction likely resulted from the many different varieties of taro grown, many of which are not well documented horticulturally. The existence of physiological variation and races with *Meloidogyne* species may also contribute to the differential responses observed in different parts of the world.

Other reports of root-knot nematode species on *Colocasia* are from the South Pacific (43), from *Colocasia* roots and tubers in Tonga (7), from *C. esculenta* in Trinidad (6) and Hawaii (30), from dasheen in Puerto Rico (3), and from soil around the roots of *C. esculenta* var. *antiquorum* in the Philippines (40).

Reports of root-knot nematode damage to *Xanthosoma* species are few. In Puerto Rico, damaged plants were yellow and stunted and exhibited galling at the root tips. This situation was found in only one case, however, and was not widespread on the island (34). The reaction of *X. sagittifolium* to various levels of *M. incognita* (Race 2), was studied in a microplot test in Nigeria (9, 17). Five different initial populations ranging from 0-500 *M. incognita*/100cm^3 of soil were used, but only the preplant level of 500/100 cm^3 resulted in a significant ($P = 0.05$) reduction in corm weight. Mean final populations of only 1.4/100cm^3 indicated that *X. sagittifolium* was a very poor host, since *M. incognita* could not maintain its population levels on the crop. It was recommended as a possible rotation crop since damage by *M. incognita* from the initial attack would be likely in only the most severely infested sites. In Puerto Rico, *M. incognita* has been found in tannier (species of *Xanthosoma*) corms, with the cortex exhibiting galls and a rough appearance (1). *M. arenaria* has been reported on *X. sagittifolium* in Cuba (11), and *M. javanica* on *Xanthosoma* in Florida (21). *Meloidogyne* spp. have also been reported on *X. sagittifolium* in Trinidad (6) and on an unidentified species of *Xanthosoma* by Steiner (38).

Root-knot nematodes that have been reported on related aroid species include *M. arenaria* and *M. incognita* on *Alocasia macrorhiza* Schott (13), and *M. javanica, M. arenaria,* and *M. incognita* on other *Alocasia* species (13, 20).

At present, control of root-knot nematodes by preplant soil fumigation is possible for infested planting sites (29, 41). A soil drench of 3.6 liters/ha of DBCP gave the best control of *M. javanica* on *C. esculenta* var. *antiquorum* (37). Since root-knot nematodes can enter and reproduce on corms and cormels, care must be taken to use nematode-free planting material. Control in infested cormels can be achieved by treatment in hot water at 50°C for 40 min. (8).

A species of *Hirschmanniella* has been considered damaging to the edible aroids, since it is associated with miti-miti disease of *C. esculenta* corms in the South Pacific (25). Symptoms of miti-miti include wilting and chlorosis of leaves, premature death, and necrosis of the corms. Red streaks are apparent in the corm when it is cut longitudinally. In a survey in the Solomon Islands (25), all plants having miti-miti top symptoms had red streaks in the corms, and in all cases, *Hirschmanniella* was isolated from the vicinity of these streaks in numbers up to 1000/10 g of tissue. Hot water treatment and/or paring of planting material were considered as possible control measures. *Hirschmanniella* is also reported from *C. esculenta* in Taiwan (14).

Problems with *Hirschmanniella* are generally confined to crops grown under very moist or flooded conditions, but these are the conditions under which wetland taro is grown in many parts of the world. Fewer problems with this nematode on upland taro would be expected. On the other hand, the very moist or flooded conditions are undoubtedly of some benefit in suppressing *Meloidogyne* populations on wetland taro, while the improved soil drainage and better root-knot survival may account for the increased damage from *Meloidogyne* on upland taro.

The reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira is frequently reported on edible aroids. *Xanthosoma sagittifolium* is reported as a host from Puerto Rico (4), and high nematode numbers (100-1000/100 cm^3 soil) were associated with this plant species in Trinidad (6). In heavy infestations, small root lesions may be evident (6), and numerous mature females can be found on the roots (21). High numbers of *R. reniformis* have been reported on both *Xanthosoma* and *Colocasia* in Florida (21). A survey of *C. esculenta* in Fiji revealed this nematode at about 2/3 of the sites sampled (43). *Rotylenchulus* has also been reported from *Xanthosoma* and *Colocasia* in Puerto Rico (3, 34), and from *C. esculenta* in Taiwan (14) and Fiji (12). The effects of reniform nematodes on aroid crops are unknown.

Other nematodes reported in association with edible aroids are shown in Table 1. In addition, *Pratylenchus* and *Helicotylenchus* are reported from dasheens and tanniers (a *Xanthosoma* species) in Puerto Rico (3). In general, the nematode fauna of *Xanthosoma* and *Colocasia* are similar, with more species reported from the latter, since it has been examined more often, particularly in the South Pacific (Table 1).

Current research in Florida

In Florida, edible aroid production in 1982 is estimated to cover 2,000 ha in Dade county. Most of this is devoted to the white-fleshed *X. caracu*. The cormels of this crop are marketed under the Cuban name "malanga". The yellow-fleshed *X. atrovirens* and taro are limited to a few hectares; however, there is a potential for greatly expanding production of taro (28). Nematodes associated with edible aroids in Florida have received little attention. *M. javanica* has been found on both *Colocasia* and *Xanthosoma* in southern Florida, as well as very high numbers (500-600/100cm^3 of soil) of *R. reniformis*. These high populations have caused concern about the potential for damage by this nematode.

A series of field experiments were initiated to determine if significant *R. reniformis* populations could build up from low initial populations on these crops, and if yield losses could be prevented by controlling *R. reniformis* and other nematodes on these crops.

MATERIALS AND METHODS

Test 1: R. reniformis population buildup on four aroid species. Four species of edible aroids were used in this test: *Xanthosoma atrovirens*, "malanga amarilla"; *X. caracu*, "malanga blanca"; *X. violaceum*, "malanga violeta"; and *Colocasia esculenta* var. *antiquorum*, "malanga isleña." Experimental plots were established on raised beds of Rockdale fine sandy loam soil (pH = 8.0) at the Agricultural Research and Edu-

Table 1. Nematodes reported on *Colocasia* spp. or *Xanthosoma* spp.; nematode genera *Meloidogyne, Rotylenchulus,* and *Hirschmanniella* not included.

Nematode	References by geographical location and host species[z]	
	Xanthosoma spp.	*Colocasia* spp.
Aphelenchoides spp.	Cuba-XS(11), Puerto Rico(34)	India-CA(39), Taiwan-CE(14)
Aphelenchus avenae Bastian	Cuba-XS(11)	
Aphelenchus spp.	Puerto Rico(34), Trinidad-XS(6)	Taiwan-CE(14), Trinidad-CE(6)
Caloosia longicaudata (Loos) Siddiqi & Goodey		Fiji-CE(43)
Criconemella curvatum (Raski) Luc & Raski		Philippines-CA(40), Thailand-CA(40)
C. denoudeni (de Grisse) Luc & Raski		Fiji-CE(43)
C. onoensis (Luc) Luc & Raski		Fiji-CE(43)
Criconemella spp.	Honduras-XV(31), Puerto Rico(34), Trinidad-XS(6)	Fiji-CE(12), Taiwan-CE(14), Trinidad-CE(6)
Ditylenchus spp.	Puerto Rico(34)	Taiwan-CE(14)
Helicotylenchus concavus Roman		Philippines-CA(40)
H. dihystera (Cobb) Sher	Florida(21)	Fiji-CE(43), Florida(21), Thailand-CA(40)
H. mucronatus Siddiqi		Fiji-CE(43)
H. multicinctus (Cobb) Golden		Philippines-CA(40)
Helicotylenchus spp.	Fiji-XS(12), Honduras-XV(31), Trinidad-XS(6)	Fiji-CE(12), Taiwan-CE(14), Trinidad-CE(6)
Hemicycliophora penetrans Thorne		Philippines-CA(40)
Hoplolaimus sp.	Puerto Rico(34)	
Longidorus siddiqii Aboul-Eid		India-CE(32)
Longidorus sp.	Puerto Rico(34)	
Paratylenchus sp.	Honduras-XV(31)	
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhoven		Fiji-CE(43)
P. coffeae (Zimmermann) Filipjev & Schuurmans Stekhoven		Fiji-CE(43), Solomon Islands-CE(25)
P. pratensis (deMan) Filipjev		Unknown(13)
P. zeae Graham		Fiji-CE(43)
Pratylenchus spp.	Fiji-XS(12), Honduras-XV(31)	Fiji-CE(12), Taiwan-CE(14), Unknown-CA (13)
Quinisulcius acutus (Allen) Siddiqi		Florida(21)
Radopholus similis (Cobb) Thorne		Fiji-CE(43), Western Samoa-CE(43)
Radopholus sp.		Fiji-CE(12)
Rotylenchus sp.		Trinidad-CE(6)
Tylenchorhynchus spp.	Trinidad-XS(6)	Taiwan-CE(14)
Tylenchus spp.	Cuba-XS(11), Puerto Rico(34)	Taiwan-CE(14), Trinidad-CE(6)
Xiphinema insignis Loos		Unknown(7)
Xiphinema spp.	Honduras-XV(31), Puerto Rico(34)	Fiji-CE(12,43)

[z]XS = *Xanthosoma sagittifolium*, XV = *X. violaceum*, CE = *Colocasia esculentum*, CA = reported as *C. antiquorum*. No abbreviation = host specified to genus only.

cation Center near Homestead, Florida. The experimental design was a split plot with two treatments and four aroids, replicated four times. Prior to planting, fertilizer (7-14-14) was incorporated into the beds at a rate of 1176 kg/ha. On 9 July, 1979, 165 liters/ha of 1,3 dichloropropene were applied to one half of the experimental plots by injecting the fumigant into the soil at a depth of 12-15cm through three chisels spaced 0.3m apart. Immediately after fumigation, all beds, both fumigated and unfumigated, were covered with a thin opaque plastic mulch which remained in place throughout the experiment. Holes were burned in the plastic for planting on 7 August, and untreated vegetative seed pieces of all four aroids were planted on 9 August, 1979. Each plot consisted of 10 plants spaced 0.46m apart in a bed 4.6m long. On 24 October, metribuzin was applied to the plots for weed control, but problems with *Digitaria* spp. and *Parthenium hysterophorus* L. persisted in the crop.

Soil samples for assay of plant-parasitic nematodes were collected at planting (8 August, 1979), midseason (24 January, 1980), and near harvest (30 June, 1980). Each sample consisted of soil collected with a hand trowel to a depth of 15cm from ten locations per plot. Each soil sample was passed through a 4.0mm sieve to remove rock, and a $100cm^3$ subsample was processed for nematodes by sieving followed by suspension of residues in modified Baermann funnels (10). Plots were harvested on 15 July, 1980, and the total fresh weights per plot of leaves, corms, cormels, and other root material were determined. Nematode and harvest data were analyzed by an analysis of variance (ANOVA) for a split-plot design, followed by Duncan's new multiple range test where appropriate.

Test 2: R. reniformis buildup on Xanthosoma caracu. Conditions for this test were similar to those of Test 1, except that only *X. caracu* was used and the experimental design was a randomized complete block with two treatments and 14 replications. Plot size was larger, with 20 plants in a bed 9.2m long, but fumigant rates and application times were identical. Similar weed problems were present, and methods for nematode sampling and plant harvest were similar. Nematode sampling dates were 8 August, 1979; 22 January, 1980; and 1 July, 1980; and plants were harvested on 16 July, 1980.

Test 3: Effect of nematodes on two cocoyam species. The two cocoyam species chosen for this test were *X. caracu* and *X. atrovirens*. Experimental plots were established on raised beds of Rockdale fine sandy loam soil (pH = 7.6). The experimental design was a split plot, with soil fumigation treatments as main plots and cocoyam species as subplots, replicated four times. Prior to fumigation, pendimethalin (2.34 liters/ha) was applied to the site and fertilizer (7-14-14) was incorporated into the beds at a rate of 448 kg/ha. On 18 May, 1982, 58.9 liters ai/ha of ethylene dibromide were applied to one half of the experimental plots. The fumigant was injected in the same manner as described for Test 1. All beds, both fumigated and unfumigated, were then covered with a thin opaque plastic mulch until 21 May, 1982. Seed pieces of both cocoyam species, originating from portions of main corms, were planted on 28 May. Ten plants were planted in each 6.1m long subplot, and the distance between rows (main plots) was 1.8m. Weed control in all plots was maintained by an application of paraquat on 10 June and periodically thereafter as needed. Since disease and insect problems did not develop in the plots, no other pesticides were used. Side shoots were trimmed from the base of each plant to maintain one stem per plant.

Soil samples for nematode assay were collected on 25 May, 1982, and 2 March, 1983. Each sample consisted of soil collected with a hand trowel to a depth of 15cm from 10 locations per subplot. Each sample was passed through a 4.0mm sieve to remove rock, and a 100cm^3 subsample was processed for nematodes by a modified sieving and centrifugation process (18, 23).

All plots were harvested on 14 March, 1983. Leaves were harvested from three plants per subplot and weighed. Subsamples were dried to a constant weight at 80C to determine percent dry weight. Roots from all plants in each subplot were separated into corms and cormels, which in turn were further separated into marketable and non-marketable categories based on size. Three corms and three cormels per plot were dried to determine percent dry weight. Small roots were trimmed from the corms and weighed separately. Nematode and harvest data were analyzed by an ANOVA for a split-plot design.

Test 4: Effect of nematodes on taro. Most agronomic practices, sampling dates, and other experimental conditions for this test with 'Lehua maoli' taro (*C. esculenta* var. *esculenta*) were similar to those described for Test 3, with the following modifications. The plot design was a simple randomized design involving four replications of four plants each per treatment. Plastic mulch was retained on the taro beds, which received supplementary irrigation for 2 hr per day via a drip irrigation system. In addition, side shoots were not removed. Nematode samples were taken from 12 locations per plot (three locations around each of four plants).

Fresh and dry weights of tops and roots were determined for all plants in each taro plot on 14 March, 1983. Root material was divided into main corms, which were all marketable, and the small unmarketable cormels. Data analysis was by a single classification ANOVA (35).

RESULTS

Tests 1 and 2: R. reniformis population buildup on aroid species. In both of these tests, low populations of *R. reniformis* and *Helicotylenchus dihystera* (Cobb) Sher were present in the soil at planting time. Although populations of *H. dihystera* remained very low throughout the season, *R. reniformis* populations built up to high levels in both tests (Table 2). Although *R. reniformis* population levels were greater at midseason on *C. esculenta* than on the *Xanthosoma* species, large populations were present on all aroid species at harvest time. This was also true for fumigated plots, which had very low initial populations ranging from 0-6/100cm^3 of soil, but increased to levels comparable to those of the nontreated plots by harvest. Despite the high populations of *R. reniformis,* yields were not affected by nematicide treatments. Plant yield data showed significant differences only by aroid species in Test 1.

Test 3: Effect of nematodes on two cocoyam species. Besides *R. reniformis,* several other nematode species were present in relatively low numbers. Mean numbers present in unfumigated plots were: *Meloidogyne incognita,* 1/100cm^3 soil, *H. dihystera,* 10/100cm^3, and *Quinisulcius acutus* (Allen) Siddiqi 4/100cm^3. By harvest, all had declined to even lower levels. Galling from *M. incognita* was never observed during this test. Preplant numbers of *R. reniformis* were higher than those of other species, with an average of 16/100cm^3 of soil in fumigated plots and 56/100cm^3 of soil in unfumigated plots. By the end of the growing season, numbers of *R. reniformis* had increased to high levels in unfumigated plots but were at significantly lower levels in fumigated plots (Table 3). Significant ($P = 0.10$ or $P = 0.05$) differences among yield data with treatment occurred in several instances, the most important of which was a 26% reduction in the dry weight of marketable cormels of *X. caracu* in the unfumigated plots. This is the most commonly grown aroid species in southern Florida, and it is grown primarily for its marketable cormels. *X. atrovirens,* which is grown for its marketable corms, did not show any benefits from fumigation. In most cases, results obtained using fresh weights were similar to those obtained with dry weights of the various plant parts. Corms were an exception, since significant effects occurred with fresh weights but not with dry weights (Table 3). This may be attributed to cultivar differences, because of the higher percentage of water in the marketable corms of *X. caracu* (82%) than in *X. atrovirens* (65-66%). The weight of small roots attached to the corms was greater for *X. caracu* than *X. atrovirens,* and root production in fumigated plots of *X. caracu* was significantly greater than in unfumigated plots. Although total corm dry weights were similar, *X. caracu* greatly outproduced *X. atrovirens* in cormel production. Based on total production of corms and

Table 2. The effect of fumigation treatment and aroid species on *Rotylenchulus reniformis* population buildup and plant yield, 1979-1980.[w]

	R. reniformis per 100 cm^3 soil[x]						Fresh weight at harvest[y]		
	Planting		Midseason		Harvest			Cormels	Leaf
Aroid species	F	C	F	C	F	C	Corms	and roots[z]	weight
Test 1									
Colocasia esculenta	2 a	0 a	42 a	95 a	270 a	230 a	4.23 a	5.88 ab	6.59 a
Xanthosoma atrovirens	3 a	20 a	2 b	42 b	404 a	274 a	1.37 b	2.68 a	3.94 b
X. caracu	6 a	28 a	4 b	39 b	231 a	214 a	5.93 a	8.50 b	3.97 b
X. violaceum	3 a	21 a	6 b	42 b	174 a	239 a	5.50 a	8.84 b	3.76 b
Test 2									
X. caracu	0.4	34	15	116	136	200	7.44	11.26	4.17

[w]Means in columns followed by the same letter are not significantly (P = 0.05) different, according to Duncan's new multiple range test.

[x]F = fumigated with 165 L/ha of 1,3 dichloropropene; C = unfumigated control. Significant differences between fumigated and control plots in Test 1 at midseason (P = 0.01) and in Test 2 at planting (P = 0.01) and at midseason (P = 0.05).

[y]Total fresh weight per plot in kg (10 plants/plot in Test 1; 20 plants/plot in Test 2). Data averaged across nematicide treatments since nematicide treatment effects were not significant for harvest data.

[z]Including immature corms of *C. esculenta*.

Table 3. Effects of fumigation and *Xanthosoma* species on *Rotylenchulus reniformis* population and plant productivity, 1982-1983.

Aroid species[w]	Treatment	*R. reniformis* per 100cm³ soil	Fresh weight (kg/plot) Corms Mkt.[x]	Fresh weight (kg/plot) Corms Total	Dry weight (kg/plot) Corms Mkt.	Dry weight Corms Total	Dry weight Cormels Mkt.	Dry weight Cormels Total	Dry weight Corms + cormels	Dry weight Leaves	Dry weight Roots	Dry weight Total plant	Harvest Index[y]
XC	Fumigated	82	7.87	7.87	1.44	1.44	1.50	2.11	3.55	0.74	0.174	4.46	0.80
XC	Unfumigated	405	5.93	5.93	1.06	1.06	1.11	1.67	2.73	0.80	0.107	3.64	0.76
XA	Fumigated	22	2.82	3.25	0.97	1.12	0	0.85	1.96	0.25	0.059	2.27	0.86
XA	Unfumigated	370	2.67	3.12	0.93	1.09	0	0.93	2.01	0.20	0.041	2.25	0.87
F values for:[z]													
Cultivar effects		n.s.	108***	107***	n.s.	n.s.	175***	54.8***	22.6**	24.9**	34.9***	38.7***	14.4**
Treatment effects		15.5*	5.00(.1)	6.67(.1)	n.s.	n.s.	28.5*	n.s.	7.41(.1)	n.s.	29.3*	n.s.	n.s.
Treatment x cultivar		n.s.	6.14(.1)	6.37*	n.s.	n.s.	3.96(.1)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[w]XC = *X. caracu*; XA = *X. atrovirens*.
[x]Mkt. = marketable; fumigated plots treated with 58.9 L/ha of ethylene dibromide.
[y]Harvest index = total corm + cormel dry weight as percentage of total dry plant weight.
[z]Values shown for significant effects at P = 0.10 (.1), P = 0.05 (*), P = 0.01 (**), or P = 0.001 (***); nonsignificance indicated by n.s.

cormels, the harvest index of *X. atrovirens* was greater than for *X. caracu,* but the *X. atrovirens* plants as a whole were significantly smaller.

Test 4: Effect of nematodes on taro. Initial population levels (no./100cm^3 of soil) of nematodes in these plots at planting were: *R. reniformis,* 55 in fumigated plots, 110 in unfumigated plots; *H. dihystera,* 10 in fumigated plots, 30 in unfumigated plots; and *Q. acutus,* 20 in fumigated plots and 15 in unfumigated plots. Numbers of *Q. acutus* and *H. dihystera* remained at low levels throughout the season. *R. reniformis* increased to very high levels, and moderate levels of *Criconomella* spp. and *M. incognita* were recovered at harvest (Table 4). Root-knot galling at harvest averaged 0.75 gall/plant in fumigated plots and 18 galls/plant in unfumigated plots. No significant yield and harvest index differences were noted with treatment (Table 4). Taro harvest indices were high, indicating that the plants were near maturity.

Table 4. Effect of fumigation on nematodes and yield of taro, *Colocasia esculenta,* 1982-1983.

Parameter measured	Treatment[x] Fumigated	Treatment[x] Unfumigated
Nematodes per 100cm^3 soil at harvest:		
Criconemella spp.	16*	46
Helicotylenchus dihystera	15	14
Meloidogyne incognita	61	56
Quinisulcius acutus	4*	22
Rotylenchulus reniformis	960*	1767
Dry weight (kg/4 plants) of:		
Tops	0.10	0.10
Corms	0.84	0.65
Cormels	0.85	0.73
Corms plus cormels	1.68	1.38
Total plant (incl. tops and roots)	1.81	1.50
Harvest index[y]	0.93	0.92

[x]Asterisks (*) indicate significant differences from unfumigated plots at P = 0.05; fumigated plots treated with 58.9 L ai/ha of ethylene dibromide.

[y]Harvest index = corm + cormel dry weight as a percentage of total dry plant weight. Harvest data based on total of 4 plants per plot.

DISCUSSION

Population increase of *R. reniformis* and other nematodes in Test 4 was much greater than in Test 3. This was likely due to the more favorable moisture conditions provided by the drip irrigation and plastic mulch used in the taro plots of Test 4. In Test 1 when both aroid genera were grown under similar conditions, population increases of *R. reniformis* on *C. esculenta* and on the three species of *Xanthosoma* were similar. It is apparent that *R. reniformis* can build up to high numbers on edible aroids even from low initial populations. Relatively high populations may be needed to cause plant damage for some cultivars, since initial populations of 56/100cm^3 of soil and final populations of about 400/100cm^3 of soil resulted in damage to *X. caracu,* but not to *X. atrovirens,* in one test. This damage was revealed as a direct reduction in weight of small roots and in the weight of marketable cormels. Nematode control by soil fumigation may be beneficial in sites heavily infested by *R. reniformis,* but not where low populations occur. *R. reniformis* populations are frequently high in the Rockdale soils of southern Florida, but this nematode was found infrequently in a survey of Perrine marl soils in the area (22). Since aroid production is better and more uniform in the high-moisture Perrine marl than in the drier Rockdale soils, and because of the differences in nematode levels in the two soil types, production could be improved by concentrating aroid production in the Perrine marl.

Because of the worldwide reports of damage to aroid species by *Meloidogyne* spp., preplant populations of root-knot nematodes should be determined in any potential planting site. Further studies are needed to determine the impact of various preplant populations on the different aroid species. The present studies indicate that preplant populations of *M. incognita* at or below detectable levels may not influence yield of the edible aroids as they can with tomato (24). At present, it appears that aroids are more tolerant of nematodes than are many other crops, but damage can be experienced where populations are high.

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