Crop Profile for Taro in American Samoa

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The 1999 Census of Agriculture (http://www.nass.usda.gov/census) for the calendar year 1998, has substantially changed production information for American Samoa, mainly due to a broader farm definition. In the 1990 census, a minimum of $100 in sales was necessary for a place to be considered a farm. The new census considered "any place that raised or produced any agricultural product for sale or consumption", a farm, which fit 75% of all households. The $100 sales minimum now defines a commercial farm. A second reason for differences between this and the previous censuses is this census was strictly agricultural and conducted by USDA National Agricultural Statistics Service (NASS). Previously, agricultural information was collected by the US Department of Commerce, Bureau of the Census, at the end of each decennial census questionnaire.

Discrepancies in reported taro production between the 1990 and 1999 censuses, however, are puzzling (Table 1). Taro leaf blight disease destroyed Samoan taro in 1993-1994 and resistant varieties were not introduced until early 1997. Even with its rapid rate of asexual reproduction, census figures for *Colocasia*-type taro in 1998 appear high to this author. Knowing produce is usually not weighed nor farm records kept in American Samoa, suggests much of the census was based on estimates. This should be considered when evaluating the information.

Table 1. Reported taro production in American Samoa for calendar years 1989 (1990 Census) and 1998 (1999 Census) (21).

Factor	**All Farms**		**Commercial Farms**		**Noncommercial Farms**	
	1989	**1998**	**1989**	**1998M**	**1989**	**1998**
Farms growing taro (ac)	697	1,819	273	798	424	1,020
Area producing taro (ac.)	965	971	529	623	436	347
Quantity sold (lbs.)	254,682	2,938,838	254,682	2,938,808	— [1]	30
Quantity consumed (lbs.)	937,778	5,427,203	381,818	2,994.150	555,960	2,433,053
Value of Sales (US$)	200,671	5,135,551	200,671	5,135,491	—	60
Consumption value (US$)	N/A	9,986,054	N/A	5,509,236	N/A	4,476,818

[1] By 1990 farm census definition, these holdings did not meet the minimum $100 sales required to be designated a farm and their sales, or production for sales, was not counted.

General Production Information

- World taro production (*Colocasia esculenta*) in 1994 was 5.8 billion kg (12.7 billion lbs.); China harvested 1.4 billion kg (3 billion lbs.), Hawai'i 2.8 million kg (6.1 million lbs.) (13).
- US production of taro in 1988 was limited to less than 8 ha (20 acres) in California, 20-40 ha (50-100 acres) in Florida and 175 ha (430 acres) in Hawai'i (29).
- In 1986, more than 21 million kg (45 million lbs.) were imported to the US, mainly for people from the Pacific Islands, Asia and Latin America (29).
- American Samoan families eat most of the taro they produce (2);the rest is sold in markets or roadside stands, to the government school lunch program, prepared for major social events (fa'alavelaves), or given as gifts.
- Record keeping among growers is uncommon, agricultural statistics are imprecise, costs of production are not measured by most farmers.
- In 1993, American Samoa produced 357,000 kg (786,000 lbs.) of taro; this declined to 21,900 kg (48,185 lbs.) in 1994 and 5,000 kg (11,000 lbs.) in 1995 due to taro leaf blight disease (*Phytophthora colocasiae*) (3).
- Leaf blight resistant taro cultivars from Micronesia were introduced in early 1997 (A. Peters, pers. comm.) and production rapidly increased following the fallow years (Table 1; 21).
- Before the leaf blight disease, taro sold for $1.10/kg ($.50/lb); when it returned to the market in 1998, taro sold for $4.95/kg ($2.25/lb). In July 2001 taro sells for less than $2/kg ($1/lb).

Production Regions

Taro is grown on all islands in the territory, mainly by the 'dry land' method. 'Wetland' taro is grown on Aunu'u and the outer islands of Ofu, Olosega and Ta'u; the taro fields are not flooded, however, as is typical in most lowland or wetland production (see cultural practices). In 1990, 3,320 ha (7,966 ac) were farmed in American Samoa, 79% of which were on the main island of Tutuila: 400 ha (965 ac) of this area was planted in taro (2).

Taro Classification and Anatomy

Taro is a member of the family Araceae, which includes philodendron, caladium, anthurium and pothos (10). Three taros are commonly grown in American Samoa: *Alocasia macrorrhiza* (giant taro, ta'amu), *Xanthosoma* sp. (talo palagi) and *Colocasia esculenta* (talo, kalo). *C. esculenta* is sometimes divided into two varieties: var. *esculenta*, with a large central corm, is the taro of the Pacific region; and var. *antiquorum*, with a smaller central corm and numerous cormels, is known in the Pacific as dasheen (23, 29). *C. esculenta* var. *esculenta* is the favored eating taro and the one referred to in this profile. The taro plant is a collection of long-stemmed leaves growing from a swollen underground stem, or corm. The heart-shaped leaves vary in size from 20-30 x 30-60 cm (8-12 x 12-24 in) for most varieties of *C. esculenta* and 50-60 x 75-100 cm (20-24 x 30-40 in) for *Alocasia* spp. Leaf stems, or petioles, emerge from the top of the corm at ground level and vary in length from 30-150 cm (1-5 ft). The corm, is a nutrient storage organ similar to the yam or potato. It is eaten baked in a traditional rock oven (umu) or boiled. Taro reproduces vegetatively by forming either cormels (suckers) or stolons (runners), both called lauvai in Samoan. The inflorescence is a spadix of closely packed, small, male and female flowers surrounded by a yellowish-green spathe (27).

Cultural Practices

Taro is grown in more than 65 countries worldwide. It is one of the oldest crops and was the 14th most-produced vegetable in 1987 (13). It is a subsistence crop and an important source of carbohydrate in the diet of many developing countries. Taro corms provide approximately 20 g carbohydrate, 525 mg potassium and 90 calories per 100 g (3.5 oz.) edible portion (26). Young taro leaves, harvested and cooked (luau), are the only 'greens' in the diet of some Samoans. In American Samoa, taro is a part of the culture with more than 20 local varieties, including taro Niue, Manu'a, Pa'epa'e, Pula Sama Sama, Fa'ele'ele and Tusi Tusi. These cultivars, however, are susceptible to taro leaf blight (TLB) and severely damaged during weather conditions that favor the disease— they have not been planted on a large scale since the TLB epidemic of 1993 (see Diseases). A number of TLB-resistant cultivars, originally from the Republic of Palau, are now being grown and harvested throughout American Samoa, returning taro to the diet of the people. Taro is often interplanted among banana mats, ta'amu, coconut or breadfruit trees, or in the forest. Plot sizes vary from a few square meters near a house to several hectares: In a survey of 15 taro growers in 1999, the number of plants per farm ranged from 600 to 35,000. Taro may be planted on level ground or slopes up to 60%. Land is usually cleared with a bush knife (machete). Herbicide (Gramoxone, Roundup) is used by an increasing number of farmers for pre-plant weed eradication; it is not used during the growing season (A. Peters, pers. comm.). Planting material, or setts (tiapula), are initially obtained from neighbors or family or are purchased ($.50 to $1.00 ea. in early 1999). Planting areas expand rapidly as most taro varieties form suckers or runners (lauvai), which are replanted along with the tops (tiapula) from harvested corms. A pointed wooden pole or metal bar (oso) is used to make a hole 15-25 cm (6-10 in) deep, the tiapula is inserted and a small amount of soil tamped around its base. Some farmers apply coconut or banana leaves as mulch but most post-plant weed control is done by hand. Fertilizer and pesticides are not usually applied. Plant spacing is commonly 1 x 1-1.5 m (3 x 3-5 ft). When the mother plant is mature in 6-9 months, it is pulled from the soil and the corm and outer leaves removed. The remaining leaf stems are cut approximately 30 cm above the removed corm, producing a tiapula. Cut surfaces of tiapula may be allowed to dry for several days before replanting or they may be replanted immediately. In many fields, taro is continuously cultivated unless pests, disease or poor yields force temporary abandonment of the site. Dry land taro is not irrigated in American Samoa. Wet land taro is not routinely or continually flooded, as it is in Hawai'i or other countries (7). The taro fields of Aunu'u Island, for example, were once below the high water table but years of accumulated vegetation have created a deep, spongy mat into which tiapula are planted. Deep trenches around and through the fields keep them from flooding. The resulting taro is prized by the Samoans for its taste and texture. The most common pests and diseases of taro in American Samoa are: weeds, taro leaf blight, planthoppers, cluster caterpillar and root and corm rot.

Insect Pests

Cluster Caterpillar, Armyworm

In a 1999 survey supported by the USDA Pesticide Impact Assessment Program (PIAP), eight of fifteen American Samoan farmers listed cluster caterpillar (*Spodoptera litura*) as the major taro insect pest. These results were similar to a survey of 28 farmers in 1989 (30). Outbreaks tend to be sporadic and vary in location and intensity. *S. litura* is found throughout Asia and the Pacific. It has a wide host range but taro is the most important crop damaged in the Samoas. The female moth lays 200-300 eggs in a cluster on the underside of taro leaves (33). Eggs hatch in 4-8 days and the larvae feed side-by side on the leaf. As larvae grow, they tend to move apart, their feeding producing large holes in the leaf; within a few days, only the skeleton-like leaf veins may remain. Unlike cutworms, larvae do not move into the soil during the day but remain on the leaf. The larval stage lasts from 13-30 days with five instars. Pupae form in the soil and the adult moth emerges in 7-18 days. A complete cycle is approximately 30 days, with up to eight generations per year (33).

Cultural Control: Most taro growers manually smash cluster caterpillars with their hands when infestations are light. Heavily infested leaves are removed and burned. Vargo (30) reported that some American Samoan farmers used a three-month fallow against *S. litura*, believing weed growth hid the taro and caused the pest to leave the field.

Biological Control: On American Samoa, cluster caterpillar eggs are parasitized by *Telenomus* sp. and *Chelonus* sp. (Hymenoptera) and larvae by *Apanteles* sp., *Euplectrus* sp. and *Zele* sp. and by the fly *Palexorista* sp. (33). Due to the sporadic occurrence of pest outbreaks, large populations of predators are unlikely to develop unless they have other hosts. On the other hand, the infrequent, limited infestations of cluster caterpillar may be evidence of an effective predator or parasite population in American Samoa. Braune and Kan (cited in 33) suggested the flowers of *Coleus blumei* may provide food for caterpillar parasites but this has not been documented. Several traditional methods of *Spodoptera* control are used in American Samoa; results are anecdotal. Some farmers believe *C. blumei* (pate) planted around or within the taro field emits an odor that repels the adult moth, others that *S. litura* prefers *Coleus* to taro (30, 32). Chickens are reported to pick caterpillar larvae from taro leaves (8). A. Vargo, entomologist, states Dipel (*Bacillus thuringiensis* subsp. *kurstaki*, Abbott Laboratories) has been used in the past against *S. litura* (pers. comm.). Dipel is ASG EPA registered but there is no recent information regarding its use or effectiveness, including the 1999 PIAP survey

Chemical Control: Pesticides are seldom necessary. One application of malathion is recommended by the extension service for infestations too heavy to control by hand (see taro planthopper, chemical control).

Taro Planthopper

In a 1989 survey of taro farmers (n = 28), planthoppers (*Tarophagus proserpina*) were the second most important insect pest, after cluster caterpillar (30); they were ranked as ‘unimportant’ in the 1999 PIAP survey. *T. proserpina* probably originated in Fiji or Malaysia and is now present in most Pacific Island groups. The female cuts slits in taro leaves and petioles with her ovipositor, usually laying two eggs in each slit. In Hawai’i, the egg stage lasts for about 14 days, followed by five instar stages of 4, 3, 3, 4 and 5 days (33). These stages may be shorter in the warmer climate of American Samoa. There are two adult forms, short- and long-winged, the latter forming during periods of cool weather, plant senescence or over-population (33). Long-distance spread is by the long-winged form and by planting tiapula with planthopper eggs embedded in the petioles. Planthoppers are a sap sucking insect and are mainly found on petioles and the undersides of leaves. On Samoa, formerly Western Samoa, *T. proserpina* was thought to be a problem only after prolonged periods of dry weather (33). Anecdotally, the recent planthopper infestation of a taro research plot at the ASCC Land Grant facility in American Samoa followed a long dry cycle (see Biological Control). Two serious virus diseases of taro, Alomae and Bobone, are transmitted by *T. proserpina* in a persistent manner— once the virus is ingested, the planthopper remains infectious for life (14). These virus diseases, however, have yet to be identified in the Samoas (31).

Cultural Control: Starting with planthopper-free tiapula in uninfested fields could delay the onset of an attack. It is unlikely farmers would adopt this strategy, however, given the planting methods used in taro production and the infrequency of damaging planthopper infestations. American Samoan farmers believe torching or smoking taro plants with smoldering bundles of coconut leaves is effective in controlling *T. proserpina*; either their wings are singed or the smoke drives them from the field (8).

Biological Control: *Cyrtorhinus fulvis* is an egg predator effective in controlling planthopper in Hawai’i, Guam and Ponape. This mirid bug is present on taro in American Samoa and may be responsible for the low incidence and severity of planthopper infestations. In a taro research plot at the ASCC Land Grant facility, however, a severe two-month infestation by *T. proserpina* continued in the presence of a large mirid bug population. A study at ASCC Land Grant in 1990 (Vargo, et al., unpublished) demonstrated a typical biological control scenario between the planthopper host and its mirid bug predator. An increase in the host population was followed by an increase in predators, followed by a decrease in the number of planthoppers and a decrease in predators. As with cluster caterpillar, some farmers believe *Coleus blumei* emits an odor that repels *T. proserpina*, others that the insect feeds on *C. blumei* and is poisoned by its toxic juices (8).

Chemical Control: Insecticides are not commonly used against planthoppers. For serious outbreaks, however, the following are registered for use in American Samoa and recommended by the Land Grant Extension Service.

Malathion: 2 ml/L (1-2 tsp/gal) of 55% a.i.; spray 1-2 L (1/4-½ gal) per 100 ft^2 (6).

Diazinon: 0.5-1 ml/L (½-1 tsp/gal) of 48% concentrate or 4.5 g/gal of 50% WP (6).

Weeds

The persistent, competitive ability of weeds in general makes them a problem in taro production. This problem is greatly reduced in the field after 3-4 months, however, when large taro leaves form a complete canopy over the soil. Numerous weed species affect agriculture throughout the Pacific Islands. Two of the most problematic weeds in the Pacific region, including American Samoa, are mile-a-minute vine, *Mikania micrantha*, and nutgrass or nutsedge, *Cyperus rotundus* (33, 34). General weed control methods used in taro fields on American Samoa are hand clearing, mulching and crop canopy management. Chemical use is increasing.

Cultural Control.

Hand clearing: Most American Samoan taro growers use bush knives to clear their fields before planting. Weeds are cut to the ground and holes are punched directly through the stubble with an oso. Weeds are pulled by hand until approximately one month before harvest. Farmers believe allowing weeds to grow during the last month makes the corm firm; trials at ASCC Land Grant facility do not support this. Weed-eaters are popular but used mainly for cutting lawns. Rototillers are occasionally used for clearing small vegetable plots but not in taro fields.

Mulching: Weeds pulled by hand or cut during hand clearing are usually left lying on top of the root stubble as mulch. In the wet climate of American Samoa, however, weeds pulled by hand often root again, making it necessary to turn them regularly (8). This thick layer of mulch inhibits weed germination, helps moderate the soil temperature and prevents erosion. The latter is especially important on steep slopes and in heavy, persistent rain: American Samoa receives 3,000-7,500 mm (125-300 in) of rainfall per year, depending on location. One of the most effective mulches is coconut leaves. On Aunu'u, they lay the leaves between rows in opposite directions, loosely plaiting the ends of the fronds around the bases of the taro. This not only inhibits weeds, it allows stolons, or lauvai, to emerge from between the fronds.

Crop canopy: Most weeds thrive in full sun and even partial shading by the plant canopy inhibits their germination and growth. Top growth and tuber formation of nutgrass is also reduced by shading (33). When the large taro leaves begin to shade the soil, hand weeding is decreased. Close planting, for example, 0.5 m (20 in) instead of 0.75-1 m (30-40 in), will form a closed canopy more quickly but the higher relative humidity may increase the severity of taro leaf blight disease. Yield loss due to TLB, however, is usually offset by the increased number of corms harvested (16).

Biological Control: Various insect species have been introduced to control weeds in American Samoa but few have provided meaningful results. Our laboratory has isolated two plant parasitic fungi, one from mile-a-minute vine (*Colletotrichum* sp.) and one from nutsedge (*Puccinia* sp.) but their effectiveness as control agents is minor. No biocontrol measures are recommended at present.

Chemical Control: Gramoxone (paraquat) and Roundup (glyphosate) are used by some taro growers before planting. If not included in the herbicide formulation, a 'spreader-sticker', usually Agral, is added to the spray tank to increase efficiency.

Gramoxone Extra: REI 12 hr., 1.5-2.5 pints/acre. Labeled for use on dryland taro in Hawai'i only but used in American Samoa. Taro not to be harvested within six months of last application (6).

Roundup (glyphosate): Class III, REI 12 hr. Mix 78 ml/3.8 L (2.7 oz (5 tbsp)/gal) in a backpack sprayer (6); add 2 ml spreader-sticker. Pre-plant only.

Agral LN: This ionic surfactant, or spreader-sticker, is a wetting agent containing nonylphenyl ethoxylates. It is commonly mixed with herbicides, insecticides and fungicides at a rate of 2 ml/L (1.2 fl oz/gal) (6).

Diseases

Taro Leaf Blight

An epidemic of taro leaf blight (TLB) struck American Samoa and (Western) Samoa in 1993-1994. All Samoan taro cultivars were susceptible to the fungus, *Phytophthora colocasiae*, and production was devastated. At the time, taro was the main agricultural export of Samoa— in six months, taro production was reduced to almost zero in both Samoas (24). *P. colocasiae* is a 'water mold', most damaging in cool, wet weather when wind-driven rains spread its sporangia from leaf to leaf and plant to plant (12, 22). Sporangia either germinate directly and penetrate the plant leaf, or form zoospores that swim in a film of free water on the leaf surface before penetration. TLB is similar in symptoms and epidemiology to Phytophthora rot of breadfruit and potato late blight, also caused by airborne species of *Phytophthora*. Potato late blight is the major limiting factor in potato production worldwide and is controlled by integrated management practices that include crop sanitation, resistant varieties and disease forecasting to optimize fungicide application. Of these control methods, only resistant varieties have been effective in American Samoa.

Variety trials at the ASCC Land Grant facility in 1999 and 2000 rated average taro leaf blight severity at 11 percent for resistant cultivars P16, P20 and Rota, the latter a taro from the Northern Mariana Islands. Control plots treated with Ridomil 2E (metalaxyl) had a 6% disease incidence but yields were not significantly different between treated and untreated plots (Brooks, unpublished). Disease severity island-wide seems to have decreased since the introduction of resistant cultivars. Currently, we are locating farmers growing P20 and P16 in order to assess differences in disease levels over the past three years.

Cultural Control: Crop sanitation and roguing, removing infected plant parts or whole plants from the field, are possible measures against TLB. Used early in the season or during mild infections, they can limit disease severity (16). During moderate to severe infections, however, removing infected leaves becomes counter-productive, reducing corm yield even more effectively than leaves lost to the disease. Increased spacing between plants may slow disease spread by lowering relative humidity and wetness in the field and by decreasing spore transfer due to leaf contact. The movement of spores in a field during heavy rains and wind, however, quickly leads to the same level of disease. Total yield is reduced with wider spacing as fewer plants are grown in the same area (16).

Biological Control: In 1997, tiapula (planting setts) of 13 taro cultivars resistant to TLB were sent to American Samoa from the College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa. The ASG Department of Agriculture in cooperation with American Samoa Community College Land Grant Program distributed thousands of tiapula to farmers in early 1997 (A. Peters, pers. comm.). Twenty resistant cultivars were originally collected from the republic of Palau and numbered for testing (28). Due to the continued use of numbers during tissue culture production, initial screening trials in Hawai'i and plant distribution, the cultivars are still known on American Samoa by their numbers; the most popular among farmers are P1, P5, P7, P10 and P20. An existing taro breeding program in Samoa focused its attention on leaf blight resistant varieties in 1995 and introduced six new hybrid taro varieties in 2000 and 2001. The parents were probably taro Phili (PSB G2, a taro from the Philippines, and one of the Palauan taro, possibly P10). Given the movement of planting material between the two island groups, we expect to see some of the new taro hybrids in American Samoa soon.

Chemical Control: Chemicals are not used against TLB in American Samoa for several reasons. First, spraying every two weeks for 3-5 months is neither cost-effective nor compatible with a subsistence agriculture system. Second, sprays are not effective when applied just before, or during, the frequent periods of heavy rainfall common in many parts of the territory. Under epidemic conditions, such as occurred in 1993-1994, chemical treatments are unable to control the disease. On small islands and atolls, contamination of the underground aquifer is easy to accomplish and difficult to reverse. Finally, only one chemical is registered with the ASG EPA, Ridomil 2E (a.i. metalaxyl), and prolonged use of one fungicide against *Phytophthora* spp. may lead to pathogen resistance.

Pythium Root and Corn Rot

Like *Phytophthora*, *Pythium* is another 'water mold'. Belonging to the family Pythiaceae, they have many of the same characteristics, including sporangia, swimming zoospores and increased pathogenicity under wet conditions. *Pythium* species and most species of *Phytophthora*, are soilborne (the airborne *Phytophthora* diseases mentioned above are exceptions) and cause root and crown rots. *Pythium* is probably best known as the "damping off" fungus of nursery seedlings but taro root rots and corm rots are major diseases throughout the South Pacific and Hawai'i (15).Root damage caused by *Pythium* interferes with water and nutrient uptake and plants show slowed leaf production, poor color and wilting of the outer leaves. Plants not killed before harvest are usually stunted and produce small corms. Root rot may enter the corm from the base or sides and turn the insides into a stinking, mushy mass of decayed tissue. If the corm rot moves up into the growing point, the plant is killed. Neither previously published records nor a collection of fungi made by McKenzie in 1989 (20), mention this pathogen or disease. This is understandable— plant pathologists visiting an area on a short contract will not usually collect unsuspected or difficult to isolate pathogens. Local taro growers state that corm rots have been a problem, however, and *Pythium* sp. was isolated from a taro corm by the Land Grant plant pathology laboratory in early 1999. The taro fields of American Samoa are going back into continuous production and populations of *Pythium* spp. in the soil are expected to increase, along with complaints of root and corm rot.

Cultural Control: The best control is exclusion of the pathogen by planting disease-free material in an uninfested field. Once *Pythium* spp. become established in the soil, they are difficult and expensive to control and almost impossible to eradicate. In wet, shallow or poorly drained soils, the subsistence farmer may be forced to leave the field fallow for at least five years (15). Gollifer, Jackson and Newhook (9) found that drying tiapula for two to three weeks before planting killed most spores of *Phytophthora colocasiae*. Based on similarities between the two genera, this may be effective in fields infested with *Pythium* spp. Heavy mulching and incorporation of organic matter into the soil can moderate soil temperatures, improve drainage and possibly reduce the severity of root and corm rot. A recent study of *Pythium ultimum* on cotton in California (19), however, showed that saprophytic activity of the fungus on cotton residue incorporated into the soil increased pathogen density. Fertilizing to promote optimum plant health is an important component in disease control. In Hawai'i, the addition of phosphorus appeared to be related to a decrease in root and corm rot (15). Removal of diseased plants and soil when symptoms first appear may reduce the pathogen population during a cropping cycle; it will be of little benefit, however, in a continuous cropping system.

Biological Control: No taro varieties are immune to Pythium rots but several have demonstrated some resistance, including the Samoan varieties Tusi Tusi, Talo Vale, Pule Mu and Pula Sama Sama (15). These varieties are susceptible to taro leaf blight, however, and are not an option in American Samoa at this time.

Chemical Control: Soil drenches with fungicides are not recommended for most of the reasons listed under taro leaf blight. Pre-plant and post-harvest treatments of taro corms with Ridomil (metalaxyl) or Aliette (aluminum phosphonate) (6) are neither sustainable nor cost-effective in subsistence agriculture.

Nematodes

The only published survey for plant parasitic nematodes in American Samoa was by Grandison in 1989, published in 1996. At the time of the survey, approximately 1,600 ha (3,950 acres) were being farmed, of which 400 ha (990 acres) were planted in taro. This was before the 1993 taro leaf blight epidemic, however, and the Samoan taro cultivars grown prior to 1993 have been almost completely replaced by Palauan cultivars. The susceptibility of Palauan taro to the nematodes found in Grandison's survey is unknown. Further, most taro fields were fallow (i.e. produced no taro) for approximately three years before the Palauan taro was introduced in early 1997. This fallow probably reduced nematode populations considerably and changed the dynamics of the soil microbial community. Of five potentially parasitic nematodes isolated from roots and soil by Grandison (11), two were of concern: *Meloidogyne incognita*, the root-knot nematode, and *Pratylenchus coffeae*, the lesion nematode. Root-knot nematode was found in all taro fields surveyed but damage appeared minor; lesion nematodes were isolated in high numbers and Grandison recommended follow-up testing to determine the amount of damage they were causing to Samoan taro (11, 17). Symptoms caused by plant parasitic nematodes are not diagnostic in themselves. They are similar to those caused by other root diseases or environmental factors that reduce water flow to the upper plant: slow plant growth, pale green or yellow-green leaves and possibly wilting in warm weather. Parasitic nematodes may cause yield losses that range from barely noticeable to complete. The damage they cause to roots or corms may create entry points for bacteria and fungi, leading to root rot, corm rot, or plant death.

Root-Knot Nematode

Root-knot nematode species attack over 2,000 cultivated and non-cultivated plants worldwide. Of these species, *Meloidogyne incognita* is the most widespread and economically damaging. Typical damage to taro roots and corms by M*. incognita* is less noticeable than on tomato, cucumber or carrots. Taro roots tend to be stunted and swollen (18, 25), rather than festooned with the large, bead-like galls found on the roots of many crops. These mild reactions by *C. esculenta* suggest it may be less susceptible to root-knot nematode than other crops (17). Male root-knot nematodes are worm-like, 1.2-1.5 mm long by 30-36 mm in diameter. The adult female is pear-shaped, 0.4-1.3 mm long by 0.27-0.75 mm wide. The 2nd stage larva of *Meloidogyne* sp. enters a taro root and begins feeding on cells around its head by inserting a sharp mouth-part called a stylet. The larva injects saliva, which stimulates cell enlargement, forming large nurse cells from which the larva continues to feed. The nematode goes through three molts, at which time the adult male leaves the root. The 5th stage female swells to visible size and lays as many as 500 eggs in a gelatinous coating just outside the root. Larvae go through one molt inside the eggs, then enter the soil as 2nd stage juveniles. The life-cycle can be completed in 25 days at 27°C (1).

Cultural Control: There is no specific effort to use nematode-free planting material in American Samoa, though farmers inadvertently do so by planting tiapula with no roots and less than a centimeter of corm tissue. Under conditions where nematode infestations are known, tiapula bases may be treated with hot water (51°C) for 10 minutes (18).

Biological Control: Rotation with crops bred for resistance to M. *incognita*, or nematode-resistant cover crops planted during periods of fallow can lower nematode populations and decrease root and corm damage in subsequent taro plantings. Fields must be kept free of weeds and other plants that may act as hosts for this polyphagous parasite. Varieties of tomato, bean, cowpea, sweet potato and other nematode resistant crops are available and the Secretariat for Pacific Communities (formerly the South Pacific Commission or SPC) recommends *Panicum maximum* var *trichoglume*, or a mixture of *P. maximum* and *Macroptilium atropurpureum* (18). Most farmers, however, do not rotate crops but grow taro in a year-round cycle with no distinct planting or harvest times.

Sipes et al. (25) tested 59 taro cultivars against *Meloidogyne javanica*, a root-knot nematode species found in old sugar cane and pineapple fields in Hawai'i. Almost all cultivars were severely affected. The cultivars Mana Ulaulu and Piko Ulaulu, however, had less nematode reproduction in their roots and corms and produced higher yields. They could become part of a breeding program for root-knot nematode resistance.

Chemical Control: None recommended.

Lesion Nematode

Like the root-knot nematode, lesion nematodes (*Pratylenchus* spp.) have a wide host range, including field, cereal and vegetable crops, fruit trees and ornamentals (1). The species affecting taro, *Pratylenchus coffeae*, attacks most plant families (17). Plants tend to be slow-growing and pale green due to a lack of water and nutrients. Yields decrease as the amount of root parasitism increases throughout the growing season. Initial root lesions are small and water-soaked but quickly become black and necrotic. These lesions predispose plants to bacterial and fungal infection. Lesion nematodes are 0.4-0.7 mm long and 20-25 μ m in diameter (1). *Pratylenchus* spp. are a stubby nematode with a stout stylet for boring into roots. Adults and larvae enter, move within, and leave taro roots during their life cycle. The female lays her eggs, with or without fertilization, within the root. Eggs either hatch within the root, or in the soil if the root decays before hatching. The first larval stage and molt occurs in the egg. The 2nd stage larvae move around in the soil or root, depending on where they were hatched and go through three more molts to the adult stage. The life cycle of the lesion nematode is relatively slow, taking 45-65 days to complete: it is probably near the minimum in the warm, wet climate of American Samoa.

Cultural Control: Like the root-knot nematode, *P. coffeae* has a wide host range and control by crop rotation, fallow, or cover crop is difficult. Fallowing has long been a traditional method of 'revitalizing' heavily cropped soil in American Samoa. The field is essentially abandoned for months or years and reverts to weeds. If any of the weed species are host plants, the nematode population will be maintained.

Biological Control: None recommended. There are no known resistant taro varieties.

Chemical Control: None recommended

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