

Specialty Crops for Pacific Island Agroforestry (<http://agroforestry.net/scps>)

**Farm and Forestry
Production and Marketing Profile for**

Giant Swamp Taro

(Cyrtosperma chamissonis)

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USES AND PRODUCTS

Giant swamp taro is the dominant aroid on the atoll islands of the Pacific. The primary product of this crop is the underground corm, which varies in characteristics with cultivar and age. Plucknett (1977) reports that the young leaves and inflorescences are eaten as vegetables and the petioles yield a fiber for weaving. Merlin and Juvik (1996) wrote that during WWII, starving Chuukese would eat the peeled and chopped stalks in soups. The leaf is used as a food wrapper and cover for the earth oven (*um*, *uhmw*) and the plant has been used in traditional medicine in many of the high and low islands of Micronesia. In Kiribati, Catala (1957) was told that specialists used a yellow mold from sliced and sun-dried corms to treat skin infections.

There is no commercial production of this species and very little international transshipment of the corm. However, cooked and frozen shipments of the corm are often sent by individuals in the Federated States of Micronesia (FSM) to their relatives and friends living in Guam, Hawai'i, and the mainland U.S.

As a food, the corm of the giant swamp taro can be roasted, boiled, or baked whole, or mashed or grated and combined with other starches for eating. According to Merlin et al. (1994) the Marshallese combine the corm with staple foods in preparing:

Wüden—with cooked and pounded breadfruit, *Colocasia* taro, bananas, or nuts mixed with grated coconut

Jebwater—with grated *Colocasia* taro mixed with coconut milk, wrapped in taro leaves and baked in the oven

Totaimon—with *Colocasia* taro grated and mixed with coconut oil and coconut sap

Kōmākij—with mashed taro or potato

Jukjuk—with pounded *Colocasia* taro mixed with coconut.

BOTANICAL DESCRIPTION

Preferred scientific name and author

Cyrtosperma chamissonis (Schott) Merr. after Smith (1979) and Fosberg et al. (1987). This species is often considered synonymous with *C. merkusii* (Hassk.) Schott.

Family

Araceae (aroid family), subfamily Aroideae

Non-preferred scientific names

Arisacontis chamissonis Schott

Arum cordifolium Wilkes et al., nom. nud., pro parte

Arum costatum of Christian, pro parte, non Wall

Arum sagittaefolium Chamisso ex Schott

Arum sagittifolium sensu Chamisso non L.

Caladium cordifolium Hartzler

Caladium sagittifolium Gaud., nom. nud.

Cyrtosperma merkusii var. *giganteum* Nadeaud

Cyrtosperma edule Schott ex Engle

Cyrtosperma edule Schott

Cyrtosperma edulis Schott ex Seem.

Cyrtosperma merkusii sensu Drake

Cyrtosperma nadeaudianum J.W. Moore

Xanthosoma sagittifolium sensu Luke non (L.) Schott

Common names

Caroline Islands: *muen* (Mokil/Moakilloa Atoll), *fulah* (Ant Atoll)

Chuuk: *fanan*, *pashok*, *pashon*, *pula*, *pwula*, *bula*

Tuvalu (Ellice Islands): *brokka brokka*

English: giant swamp taro, swamp taro

Fiji: *via*, *viakana*

French Polynesia: *'apeveo*, *taa faa*

French: *taro des atolls*

Kiribati (Gilberts): *te-babai*, *babai*, *tamu*

Hawai'i: *maota*

Ifaluk: *pulax*

Kapingamarangi: *puraka*, *bulaga*

Kosrae: *pashok*, *pashon*, *pasruk*

Lamotrek: *bulokh*

Marianas Islands: *baba*

Marquesas Islands: *kape taataa*, *ta'ò-kape- taa-taa*

Marshall Islands: *buroro*, *kaliklik*, *iaraj*, *iaratz*, *iarej*, *iarij*, *wan*

Mortlock Islands: *tepuraka*

Nukuoro: *bulaga*

Palau: *brak*

Philippines: *galiang* (Bicol); *palau* (Cebu Bisaya); and *pa-lauan* (Samar-Leyte Bisaya, Panay Bisaya)

Pingelap: *muang*, *mwang*, *muhang*, *muiang*, *mweiang*

Pohnpei: *muang*, *mwang*, *muhang*, *muiang*, *mwang*, *mwahng*, *mwong* Puluwat *pwula*, *bula*

Raiatea, Society Islands: *opevea*

Satawal: *pula*

Solomon Islands: *kakake*

Tahiti: *moata*, *maota*

Tonga: *pula'a*

Ulithi: *bwolok*, *bwolokh*, *pwolok*, *puns*, *pura*

Western Polynesia: *pulaka*, *pula'a*, *puraka*

Woleai: *bwolog*

Yap: *lok*, *lak*

Brief botanical description

Very large, stemless (acaulescent) herbaceous plant, which by one account can reach a height of 5 m and is the largest in the Aroideae family. Vickers (1982) suggests that this species is the largest plant in the world that yields an edible corm. In some varieties, the corm can weigh as much as 100–120 kg if left to grow for a number of years (Untaman



Left: Close up of plant in Yap. June 2007. Middle: Cataphylls, or reduced leaves are found on some varieties of giant swamp taro. This is a two-year-old Palauan variety from the Agana Swamp, Guam. March 2003. Right: A 2- or 3-year-old giant swamp taro plant with inflorescences in various stages of maturity at the Agana Swamp. March 2003.

1982). The leaves are large (reaching a length of 1 m), erect, and sagittate to hastate in shape with two long, acute basal lobes. Petioles are large, sometimes with prickles, spiny toward the base and reaching 3 m in length in some varieties (Pursglove 1975). Cataphylls (reduced leaves) are found on the underside of the leaf in some varieties. The spathe is thick, yellowish with green veins while the spadix is yellow to orange (Smith 1979).

DISTRIBUTION

Native range

According to Pursglove (1975), giant swamp taro grows wild in the Indo-Malesian region and was introduced into many Pacific islands in pre-European times. In contrast to other aroids, e.g., *Colocasia esculenta* and *Xanthosoma* spp., Pursglove (1975:58) considers *Cyrtosperma* an aroid that is cultivated today to a “more limited extent.”

Plucknett (1977) says that this species is probably native to Indonesia. Smith (1979:451) suggests that the origin of the giant swamp taro cultivated in the Pacific islands could be “from wild stock in or around northern New Guinea.” He suggests that New Guinea is a center of speciation.

Current distribution worldwide

This species is most widely distributed and cultivated in Micronesia and the western Pacific, in particular, on atoll islands where it is either the first or second most important cultivated aroid. It is less common in the eastern Pacific, although recent archaeological evidence shows that the species was introduced about 1451 CE to Henderson Island (24° 22' S, 128° 19' W) of the Pitcairn group in southeastern Polynesia (Hather and Weisler 2000). Much of the species' current distribution can be inferred from the list of common names presented earlier. The species is grown in Indonesia, the Philippines, Papua New Guinea, Solomon Islands, Fiji, Tahiti, Cook Islands, Tokelau, Samoa, Palau, Yap, Chuuk, Pohnpei, Kosrae, Marshall Islands, Guam, Kiribati, Tuvalu, the Marquesas Islands and most, if not all, of the inhabited atolls of Micronesia and Melanesia. It is a major crop in most atolls and low islands of the Pacific, but other than in Yap, Pohnpei, Chuuk, and Palau, it is a minor crop today in the high islands of the Pacific. The species is an aboriginal introduction to most Pacific islands except for French Polynesia where Plucknett (1977) says that it is probably a post-European discovery-era introduction. In Tonga, giant swamp taro is now very scarce. The species was not cultivated, but was used for food only during times of food shortage (Prescott and Folaumoetu'i 2004).

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

This species is well adapted to moist tropical climates. It also does well in warm, seasonally moist climates that have a short dry season and variable precipitation. In Koppen's classification, the species does well in the A climates where precipitation exceeds evapotranspiration on an annual basis. A main factor for its growth is a continuous supply of water, although it can tolerate short periods of dryness.

Based on temperature information from the Marshall Islands, this species easily tolerates maximum temperatures of 35–38°C. The discovery of subfossil leaf fragments from Henderson Island indirectly suggests that swamp taro is able to withstand a minimum monthly mean temperature of approximately 15.5°C.

Soils

Giant swamp taro is a water loving plant (hydrophyte) adapted to fresh to brackish water conditions in coastal marshes, natural and man-made swamps, and pit depressions. Deep soils are preferable, as local taro experts stress that giant swamp taro grows both upward and downward in contrast to *Colocasia* taro which grows upward only (Englberger 2009). Few, if any studies, have focused on the soil tolerances of giant swamp taro. An idea of the pH tolerance range of this species can be inferred by referencing the location of this species with known soils. In Yap, for example, giant swamp taro is cultivated in a bottomland soil known as Mesei (which is also the Palauan word for a taro patch). Mesei soil is a very deep, poorly drained mucky peat derived from organic materials overlying a silt loam or silty clay loam of alluvial origins (Smith 1983). The pH of the topsoil and subsoil are 4.5–5.5 and 5.6–6.5 respectively. Both horizons are very permeable, with low shrink-swell potential. The organic matter percentage in the topsoil is almost 100%. Another bottomland soil in which giant swamp taro is cultivated is the Dechel soil, which is a deep, poorly drained mucky silt loam. The pH range of the Dechel soil is between 5.1 and 7.3. *Dechel* is also a Palauan word for a marsh as well as a less intensive system of cultivation in which the vegetation is cleared, but not turned under as in a *mesei* system. In the Agana Swamp on Guam, Palauan taro growers use the *dechel* system to cultivate taro.

On Ulithi Atoll, giant swamp taro is cultivated in depressions in marshy lands dominated by a soil called the Ngedebus Variant. The Ngedebus Variant is a very permeable, gravelly loamy sand with a pH range of 6.6–8.4 for the topsoil and subsoil, respectively.

In comparison to *Colocasia* taro, giant swamp taro is reputed to be more salt tolerant (Plucknett 1977), although

Elevation, rainfall, and temperature

Elevation range	<p>lower: sea level</p> <p>upper: Untaman (1982) indicates that the species can grow up to an elevation of 200 m in Yap. French (2004) says that this species grows up to an elevation of 150 m in Papua New Guinea. However, based on the temperature/elevation relationships, this species can grow at even higher elevations, up to about 600 m, although the required conditions for growth may not be available. This species is a component of some Papua New Guinea agricultural systems that extend from sea level to 600 m elevation (although the species may not be planted at the higher elevations).</p>
Mean annual rainfall	<p>lower: It probably cannot survive where annual rainfall is unable to support a more or less constant fresh water supply. For atoll islands, the rainfall and size of the islet must be able to maintain a freshwater lens despite tidal fluctuations and evapotranspirational losses.</p> <p>upper: Upper and lower amounts of rainfall are not relevant as the species must grow in marshy or swampy land where the water table is near the surface (where there is a continuous supply of water). It can grow in swiftly flowing streams or even on stream banks that are subject to swiftly flowing water, but it is more commonly found where stream flow and erosion potential are less.</p>
Rainfall pattern	A continuous water supply is required either from rain or other sources.
Mean annual temperature	<p>lower: 23°C</p> <p>upper: 31°C</p>
Mean maximum temperature of hottest month	38°C
Mean minimum temperature of coldest month	15°C
Minimum temperature tolerated	10°C, on the basis of minimum temperature at Henderson Island (Pitcairn group)

evidence for its greater tolerance is not readily available. Mourits (1996) found giant swamp taro crop failure and pit abandonment in at Kiebu and Butaritari, Kiribati at conductivities of about 3300–5000 $\mu\text{S}/\text{cm}$ (electrical conductivity of water is directly related to its concentration of dissolved salt ions). Webb (2007) provides a photograph of a possibly salt tolerant variety of *Colocasia* taro growing in the Fongafale *pulaka* pits on Funafuti, where giant swamp taro cultivation was abandoned because of chronic problems with saline incursion during “natural high water events.” Webb’s (2007) survey of salinity and observations of *pulaka* in Tuvalu found similar results as shown in the following table.

More problems with salinization of taro pits are anticipated because of global warming and sea level rise.

Table 1. A guide for salinity tolerance ranges for giant swamp taro in Tuvalu *pulaka* pits (Webb 2007)

Conductance ($\mu\text{s}/\text{cm}$)	Condition of <i>pulaka</i>
$\leq 1,000$	Ideal Growing Conditions
1,000–2,000	Tolerable growing conditions
$\geq 3,000$	Crop decline and failure

Webb (2007) concluded that continuous monitoring of the taro pits should provide greater technical accuracy and understanding of the relationship between salinity and the growth conditions of giant swamp taro.

GROWTH AND DEVELOPMENT

There are few details about the growth rate of this species. In all likelihood, the rate of growth is cultivar dependent. Most varieties mature between one and 2 years of age. The Chuukese variety *Onou maram* is said to be harvestable after its name-sake, in 6 months. The Kiribati cultivar *Te ikaraoi* can remain in the ground for up to 12–15 years at which time the corm can weigh up to 90 kg. Koch (1986) says that the maximum time in the ground is 10 years, at which time the corm has become fibrous and acrid. Citing others, Englberger (2009) reported that in Pohnpei, giant swamp taro can be kept in the ground for 10–15 years or longer and that on Mwoakilloa Atoll some corms are reported to be more than 20 years old. In Yap, the plant is said to be mature and harvestable when flowers appear or when new leaves are reduced in size and the main corm rises above the surrounding cormlets (Untaman 1982). Time to flowering depends on the variety. For many, flowering occurs between one and two years.

Some information concerning the growth and development of giant swamp taro comes from Catala (1957), who recorded five growth stages, measured by the I-Kiribati with their arms:

Te kunei—a 9-month-old plant. The tuber has a length equal to $\frac{1}{2}$ of a forearm. The corm is very tender at this stage. The variety *Te katutu* is eaten at this stage. Side shoots are cut from the main plant at this time for replanting.

Te namatanibura (forearm length)—at 3 years of age, a fully mature *babai* (plant). Some varieties are relished at this stage while others are too bitter.

Etan tenamatanibura ($\frac{3}{4}$ arm's length)—5 years

Te anga (arm's length)—7 years of age. *Babai* of this size is required for certain rituals.

Te bonaua (breastbone) 10+ years of age. Hard, very large tuber grown mainly for presentations (e.g., by a young man's family to that of the girl he is to marry).

Flowering and fruiting

The giant swamp taro produces inflorescences in the leaf axils of plants beginning around the second year of growth and continuing on for a number of years thereafter. The inflorescence is large, with the open spathe 25–65 cm or more in



Palauan mixed tree gardens on the hillside and taro patches on the stream valley bottom from Arakabesan, Meyungs, Palau, 50 m above sea level. *Colocasia* taro (light gray green in color) is flanked by giant swamp taro. Bananas (*Musa* spp.), coconuts, and betel nut trees can be seen on the opposite slope. June 2006.



Left: Close-up of Palauan taro field showing intercropping of giant swamp taro and *Colocasia* taro, as well as a new planting mulched with banana leaves in the foreground. Right: Giant swamp taro thriving on edge of taro field in Palau. June 2006.

length. The spadix is tubular to cylindric, about 20 cm long, and has both male and female flowers (Plucknett 1977). The seeds are generally infertile.

AGROFORESTRY AND ENVIRONMENTAL SERVICES

The species is often interplanted with *Colocasia* taro. In Yap, after an area is cleared for planting, *Colocasia* taro is planted first at a spacing of 1–1.5 m apart. A day or two later, giant swamp taro is planted between the *Colocasia* plants. Within a year, the *Colocasia* taro is harvested and replanted in the emptied space. After harvesting of the second *Colocasia* crop, it is replanted again. No replanting of *Colocasia* occurs after the third *Colocasia* harvest (Untaman 1982).

Giant swamp taro is often planted as a fringe species between an open field or patch of *Colocasia* taro and the forest as giant swamp taro tolerates shade quite well. On atolls, the smaller taro depressions are heavily shaded by adjacent trees.

PROPAGATION AND PLANTING

This species is propagated using setts, which are suckers, the top of the corm with about 30 cm (12 in) of petiole, or cormlets, which are young, immature corms produced by a more mature plant.

Planting methods and techniques vary greatly depending on the habitat. The simplest systems can be found in the freshwater marshes of high islands. At the Agana Swamp in Guam, Palauan migrants/residents use the *dechel* cultivation system. In this method, the marsh is cleared of its vegetation (mainly a reed, *Phragmites karka*) and then planted with setts from previously harvested giant swamp taro. The plantings may be single plants, short rows of 6–10 plants, or interplanted among *Colocasia* taro. In Palau, a more labor intensive *mesei* system was used to cultivate *Colocasia* taro. This system in which the marshy soil was overturned and mulched is rarely practiced today.

If marshes were not available, streams were diverted and taro patches similar to the Hawaiian *lo'i* were constructed. Taro swamps were also created adjacent to streams and giant swamp taro planted in the slower flowing water.

In the atolls, more elaborate systems of cultivation were used. Giant swamp taro and *Colocasia* taro were planted either in mulched depressions, raised beds of organic matter, or as in Kiribati, the “bottomless basket,” which may be one of the most complex systems of cultivation devised. Descriptions of this system have been presented by many (e.g., Catala (1957), Koch (1986), Vickers (1982), Loumala (1974) and Lambert (1982)). Briefly, according to Vickers (1982), after a pit was excavated down to the water table, the soil in the pit was prepared by digging a hole about 60 cm³ in vol-



Palauan taro cultivation at the Agana Swamp, central Guam. Top: Palauan residents of Guam have cultivated *brak* (Giant swamp taro) and kukau (*Colocasia esculenta*) in the peaty soil of the swamp for more than 25 years. April 2001. Middle: Paluans refer to the taro patch as the *mesei*, even though the *dechel* method of cultivation is practiced there. In a traditional Palauan *mesei*, the soil is overturned to bury organic matter. In the *dechel* system, the vegetation is cut and cleared; the soil is not overturned prior to planting. March 2006. Bottom: Only women cultivate the swamp. Men are responsible for digging the ditches, lining the pathways with old roofing tin or wood to ease walking in the mucky soil and for building the small shacks. Each cultivator has a shack for resting, talking, and eating lunch. March 2006.



Top: Roadside giant swamp taro cultivation in a small stream in the periurban area of Kolonia, Pohnpei, FSM. The edge of the bridge can be seen in the lower left. October 2001. Middle: Counting the number of giant swamp taro plantings on a *ma'a* or taro islet, Puluwat, FSM. These islets are created in both natural and excavated depressions in an islet's interior. A wide range of culturally useful plants are grown on these islets. June 1988. Bottom: Repairing a *ma'a*, Puluwat Atoll. The anthropic organic origin of the soil is evident in this photo. The woman's pride in her taro is evidenced by the care and attention to details. Note, for example, the woven coconut frond which helps keep the islet intact. June 1988.

ume. The hole was filled with chopped *Guettarda speciosa* and *Tournefortia argentea* leaves, then covered with whole *Guettarda* leaves and a layer of black humic sand. This was all trodden upon. A *babai* plant or sett was placed in the middle of this so that its upper roots were at the water level. Each plant was surrounded by a circlet of woven pandanus or coconut fronds in the form of a bottomless basket, then covered with several layers of chopped leaves and soil. The circlet basket was held in place by *Guettarda* stakes (Koch 1986). Compost was added as the mixture rotted and more organic matter was added as each new leaf emerged. Each plant was supplied with compost at least four times a year until the corm was harvested.

On Ulithi Atoll, FSM, in addition to being grown in taro pits, this species is also grown either alone or in combination with *Colocasia* taro in rectangular cement block tanks of variable dimensions. On the upraised limestone island of Fais in Yap, giant swamp taro is grown only in these tanks because the freshwater lens is 20 m or so below the surface.

CULTIVATION

Variability of species

On atolls, the number of cultivars is high and new cultivars are often introduced. Luomala (1974) states that there are 40 native named varieties of giant swamp taro in Kiribati. At Eita on Tabiteuea, 10 of the 14 varieties were brought there after the arrival of the British in 1892. For Puluwat, Elbert's (1972) Puluwat dictionary listed 33 varieties; Manner and Mallon (1989) found 24 varieties on the atoll, of which 11 had been introduced after 1972. Elsewhere Raynor (1991) listed 24 for Pohnpei and Englberger et al. (2004) reported 22 for Mwoakilloa Atoll. At a workshop, Mortlock Islanders helped identify 32 varieties of giant swamp taro and donated 21 varieties for planting in the taro genebank on Pohnpei (Wagner 2008). No commercial varieties have been identified, although a cultivar said to be originally from Yap is currently being exported from Palau to Guam.

A cautionary note

Many traditional Pacific island agroforestry systems are characterized by high species and cultivar diversity, which some experts believe fosters agricultural sustainability and stability.

For example, Altieri (1999: 29) wrote that correct "biodiversification results in pest regulation through restoration of natural control of insect pests, diseases and nematodes and also produces optimal nutrient recycling and soil conservation by activating soil biota, all factors leading to sustainable yields, energy conservation, and less dependence on external inputs." While the relationship between biodiversity and stability is appealing, Lebot's (1992) study is instructive; Ta-



Left: Alex Laungowa and his friend Meldin measuring the dimensions of a community taro tank on Fais Island, FSM. The water table on Fais, an upraised limestone island, lies 20 m below the surface. As giant swamp taro requires a constantly moist soil, it is solely planted in concrete block tanks filled with water and organic matter. June 2008. Right: An example of the “bottomless” Pandanus basket method of giant swamp taro cultivation at Bonriki, Tarawa, Kiribati. September 1982.

ble 2 from his study is a listing of the number of cultivars for the major vegetatively propagated food plants of the Pacific Islands of SE Asian and/or Papua New Guinean origins.

According to Lebot (1992: 310), many of the traditional food plants of the Pacific are losing their positions in the traditional cropping systems because of historical and environmental factors and their genetic vulnerability to pests and pathogens which results in the “rapid deterioration in yield potential and agronomic performance.” These traditional food plants, namely taro (*Alocasia macrorrhiza*, *Colocasia*

esculenta var. *colocasia*, and *Cyrtosperma chamissonis*), sugarcane, yam, seedless breadfruit, and bananas are the clones of vegetatively propagated plants which do not produce viable seeds. The many different cultivars of these traditional plants in Polynesia and Micronesia are the clonal descendants of the very few zymotypes. As an example, only three zymotypes were identified in a group of 149 Polynesian cultivars of *Colocasia* taro, an indication that their morphological variation is controlled by very few genes” (Lebot 1992: 313).

Table 2. Geographic distribution and approximate number of cultivars per species

	New Guinea	Solomon Islands	Vanuatu	Fiji	New Caledonia	Tonga	Samoas	Tuvalu	Cooks	Tahiti	Hawai'i	Pohnpei
<i>Colocasia esculenta</i>	452	262	154	72	82	14	28	13	91	35	82	15
<i>Cyrtosperma chamissonis</i>	NA	NA	1	1	0	0	12	23	0	0	0	24
<i>Alocasia macrorrhiza</i>	2	4	3	2	3	9	19	2	2	1	1	10
<i>Dioscorea alata</i>	159	238	136	89	111	16	12	1	8	4	2	157
<i>Dioscorea esculenta</i>	94	117	17	16	23	1	2	2	1	2	1	13
<i>Dioscorea nummularia</i>	8	31	9	1	12	0	6	0	0	4	1	7
<i>Piper methysticum</i>	4	0	82	12	0	7	6	0	1	4	12	2
<i>Artocarpus altilis</i>	NA	140	132	20	16	10	25	12	8	30	1	50
<i>Musa</i> spp.	420	NA	52	26	NA	25	28	4	28	18	23	55
<i>Saccharum officinarum</i>	244	5	4	13	20	2	2	1	NA	4	31	16

Source: Lebot 1992. NA = Not Available.

Polyculture and intercropping of different crop species provides some protection because pest and pathogens are not able to increase in populations to destructive levels on isolated individuals of a species. Abandonment of the subsistence garden to fallow further keeps pest populations low. However, these pests and pathogens, some of which are polyphagous and have different hosts, remain in relict plants in surrounding the area for future population increase when the garden site is replanted (Lebot 1992). He also argues that the selection of cultivars for disease resistance by traditional farmers is ineffective and inefficient because the planting materials and the agroecosystems themselves are infected by pathogens from previous cultivation cycles. This results in poor agronomic performance of the traditional food plants of the Pacific islands and its replacement by higher yielding crops such as sweetpotato, cassava, and *Xanthosoma taro*. Other factors, including continuous cropping, the loss of natural and socio-cultural barriers, the improvements in inter-island transportation systems, to name a few, also lead to the spread of pathogens and diseases with infected plants. In brief, the majority of Polynesian and Micronesian cultivars of taro which were derived from a narrow genetic base are very susceptible to the pests and pathogens, for example, the viral diseases of *alomae* and *bobone*, which have led to severe disruptions of *Colocasia* taro agriculture in parts of Papua New Guinea and the Solomon Islands (Lebot 1992).

Basic crop management

According to Catala (1957), leaves used for composting and fertilizer were in order of importance: *Sida fallax*, *Guettarda speciosa*, *Messerschmidia* [*Tournefortia*] *argentea*, *Artocarpus* spp., *Boerhavia diffusa*, *Wollastonia biflora*, and *Cordia subcordata*. *Triumfetta procumbens* and *Hibiscus tiliaceus* were used less frequently.

The addition of *Sida fallax* commanded special attention. In most instances, the leaves were used dried as the composting green leaves release heat that can kill the *babai*. Direct contact between the green *Sida fallax* leaves and the *babai* was avoided. A layer of sand was used to top-off the compost, said to reduce the effects of heat released by the decomposing organic matter.

Commercial production

Commercial production of giant swamp taro is unlikely on atolls because of the lack of large, nearby markets, or intra-island transshipment infrastructure, and the work required for production.

For high islands, traditional cultivation methods of proven scientific worth need to be followed, rather than introducing methods and techniques from more commercial/modern economies (e.g., artificial fertilizers), which may cause more instability and problems for the system.

Successful commercial production will require a reduction in the intensity of work effort in order to be economically feasible. This may mean simplifying certain current methods such as planting in bottomless baskets. Ecological factors such as a constant fresh water supply which is free from saltwater intrusion are necessary. Infrastructure such as cheap and reliable transportation facilities, particularly for the atolls, are likewise necessary.

Advantages and disadvantages of growing in polycultures

The ecological advantages and benefits of polycultures (the synergistic interactions between species) apply also to the taro patch. In many atolls, the giant swamp taro pits are fringed with a tree cover of wild and cultivated trees and other species. Often the giant swamp taro planted near the pit edges and in the shade of the trees are taller and more vigorous while those planted in the middle of the taro field are smaller and yellowish brown.

As *Cyrtosperma* and *Colocasia* taros have different rates of maturation, by growing these species in a polyculture, a farmer can have a continuous harvest for up to 3 years from the same plot beginning with an initial harvest after 5–6 months of planting. However, as *Cyrtosperma* and *Colocasia* taros are both aroids and dominate the patch, by their abundance they represent a potential food source for a pest population. Growing a wide range of cultivars may be effective in reducing the effects of pest predation on taro.

PESTS AND DISEASES

As relatively little research has been conducted on giant swamp taro, our knowledge of the effects of pests and pathogens is incomplete. Various reports indicate:

- “Dry rot” and boring damage of the corm by a nematode *Radopholus similis* on Yap (Murukesan et al. 2005).
- Boring damage by the taro beetle *Papauana huebneri* Faimaire reduces the edible corm and allows for invasion by secondary organisms and eventual death of the plant in Kiribati (Vickers 1982).
- The leaf-eating pests include *Aphis gossypii* Glover, mealybugs *Pseudococcus* sp. Nr. *adonium* L. and *Ferisiana virgata* Ckll., and an unidentified bagworm (Psychidae) in Kiribati (Vickers 1982).
- *Pythium* rot, as has been identified in giant swamp taro in the Trust Territory (Jackson and Firman 1984).
- DMV (Dasheen mosaic virus) infects giant swamp taro on Kiribati (Jackson and Firman 1984).
- Crabs have been reported to cause major damage in the Mortlock Islands of Chuuk (Levendusky et al. 2006).



Left: A giant swamp taro planting next to a washing shack at back of the Mechitiw Elementary School and Community Hall, Mechitiw Village, Weno, Chuuk State, FSM. This patch is located at the base of Atarafar Ridge where runoff and seepage water collect in a coastal swampy lowland. Since 1988 more than 80% of the giant swamp taro plantings in this village have been replaced by housing and other urban functions. October 2009. Right: Homegarden planting in Yap. June 2007.



Left: Reynolds Albert in a Mokilese backyard garden at Sohkes, Pohnpei Island. In this part of the island settlers from the atolls of Pingelap, the Mortlocks, and Mokil have adapted to the high island environment as shown by the composition of their gardens. The giant swamp taro reaches about 4 m in height. August 1989. Right: Typical Yapese planting of giant swamp taro in agroforest of betel nut palm, breadfruit, and banana. June 2007.

For Yap, Untaman (1982: 99) wrote that no insects attacked giant swamp taro. However, he mentioned the presence on Yap of “some kind of worms that bore into the tuber of the *Cyrtosperma* and cause the corm to rot.” Most likely, these “worms” are the burrowing nematode *Radopholus similis*, which is invisible to the naked eye. This nematode causes a wet rather than dry, “loose mass of brown dead tissues and a deep brown necrotic centre housing nematodes inside” and emanates a disgusting odor (Murukesan et al. 2005).

Pest and disease prevention

The market quality of the corm is greatly reduced by nematode damage. The widespread occurrence of the burrowing nematode *R. similis* and the type of damage it causes to the corms pose a serious threat to giant swamp taro production, food security, and the continuation of traditional customs on those islands where *R. similis* occurs.

DISADVANTAGES

Compared to *Colocasia* and *Xanthosoma* taros, giant swamp taro is not a favored aroid. Flesh quality is variable: some varieties are very fibrous and hard, some are tender. Thus it has been replaced by rice and other starches.

Invasive potential

The plant produces mainly non-viable seeds. Its potential for naturalization or invasiveness is low.

COMMERCIAL PRODUCTION

Postharvest handling and processing

The corm needs to be eaten within 2–3 days of harvesting, although corms can be stored in moist ground for up to 6 months (Untaman 1982; Koch 1986). A tuber or corm not cooked immediately after harvesting is said to form bitter spots called *buyub* in Yapese. These spots are cut out during the peeling process prior to cooking (Untaman 1982). In Kiribati, the corm is cut into small pieces (*bwerebwere ni babai*) or grated (*i ni babai*) and sundried for a week; in this form, it can be stored for half a year or longer (Koch 1986).

The recent research by Englberger et al. (2008) has implications for storage of corms. Comparisons of frozen and dehydrated samples showed that frozen samples had a higher concentration of carotenes than dehydrated samples. This showed that dehydration of samples is not a good method to use for maintaining the maximum carotenoid concentrations of the fresh corms.

Methods of processing

In Benguet, Philippines, starches were extracted from various roots, corms and tuber, including giant swamp taro, cassava, sweetpotato, and arrowroot. These starches were



Cooked parcels of the giant swamp taro can be bought from roadside stands and sellers in the high islands of Micronesia. Yap, June 2007.

then mixed with wheat flour at 25 and 50% formulations. Noodles made at the 25% formulation gave excellent results: “They exhibited smooth surface, white color dough, light yellow dry noodles, and very low cooking loss. The dough mixture was moderately soft, was easily hand extruded, and gave firm noodle strength during cooking and drying” (Benguet State University 2005).

Product quality standards

No recognized standards are known.

SMALL SCALE PRODUCTION

Most giant swamp taro is grown in small homegardens and farm plots. The techniques and methods used there can be

readily applied to small commercial operations if the requisite habitat requirements are available, i.e., moist ground, marshy areas, or streams.

Household use

For the atolls, this is by most accounts the major aroid. Most authorities suggest, however, that production and consumption of this species has fallen because of the apparent neglect of the taro pits or caused by the introduction of polished rice, other starches, and other factors (Englberger et al. 2003a). In Tonga and some other islands, this species is considered a famine food.

Nutrition

Recent analyses by Englberger et al. (2003, 2008), indicate that the nutritional values of giant swamp taro vary widely. However, the species has high concentrations of iron, zinc, and calcium and the yellow corm varieties are generally higher in β -carotene than other colored varieties. For example, the Kosraen cultivar *Pasruk siminton* had a β -carotene equivalent of 1893 mg/100 g of edible portion (Englberger et al. 2003) while the Pohnpeian cultivar *Tekatek weitahita* had a β -carotene equivalent of 4486 mg/100 g of edible portion (Englberger et al. 2008). Total carotenoids, which help protect from vitamin A deficiency disorders, anemia and various chronic diseases, are very high in yellow fleshed corms in contrast to white rice which contains no carotenoids (Englberger 2009). A simplified table of the mineral and nutritional information of three taro species is presented in Table 3 below. Readers interested in greater details on the mineral and nutrient composition of giant swamp taro and other edible aroids should read Englberger (2009), Englberger et al. (2003a, 2003b), Dignan et al. (2004), and Bradbury and Holloway (1988).

Early studies on the mineral content of the giant swamp taro by Bradbury and Holloway (1988) showed major dif-

ferences between cultivars from the atolls and high island of Pohnpei as a result of soil mineralogy. They showed that the iron and zinc levels of cultivars grown on the volcanic island of Pohnpei were higher than those same cultivars grown on the Ngatik Atoll (Sapwuahfik). By contrast, cultivars grown on the atoll had a higher calcium content.

Import replacement

Most, if not all, authorities state that this species can replace imported starches. The appropriate incentives need to be in place, however.

This species should be promoted as a superior source of minerals (zinc, calcium and iron), β -carotene, and fiber than many imported starches and therefore a valuable resource for improving the nutritional health of Pacific islanders. Yen (1980) and Thaman (1984) have strongly suggested that for the highly dependent atoll countries such as Kiribati, a return to subsistence production and a more intensive effort on giant swamp taro cultivation may be helpful in reducing the amount spent on imported goods, leaving more money in the local economy to pay for other kinds of needed development.

YIELDS

Yields are highly variable and contingent on the cultivar and age of the planting. In Kiribati, some corms can weigh up to 90 kg. Vickers (1982) suggests on the basis of little evidence that yields of 7.5–10 MT/ha could be obtained from a crop 18–24 months of age. Plucknett (1977) reports yields ranging between 10 MT/ha/yr to 42.5 MT/ha (unspecified cropping period).

Individual corm weights are widely variable. For the Kiribati *Te Ikaroi* cultivar, 25–50 kg is common. Plucknett (1977) suggests that the average weight of corms for Chuuk and Yap are 2 kg and 4.5 kg respectively. A corm of about 180 kg has been recorded for Pohnpei (Plucknett 1977).

Table 3. Comparison of nutrients in 100 g edible portions of boiled taros and white rice (after SPC 2006).

Food item	Kcal*	Fibre (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	β -carotene equiv. (μ g)	Thiamin (mg)	Vitamin C (mg)
Taro corm, <i>Colocasia</i> , white	99	0.8	34	1.0	0.8	38	0.08	5
Taro corm, <i>Colocasia</i> , yellow	126	1.0	44	1.3	1.0	38	0.11	7
Giant swamp taro corm, <i>Cyrtosperma</i> , color unspec.	72	2.5	165	0.6	1.9	27	0.02	7.9
—white/cream colored	na	na	na	na	na	55–300	na	na
—yellow-colored	na	na	240–1,440	1.4–3.6	4.1–63	460–4,486	na	na
Taro corm, <i>Alocasia</i>	79	1.8	169	0.9	na	na	0.10	1.1
Taro leaves, <i>Colocasia</i>	28	2.5	214	1.7	0.3	4,973	0.06	20
Taro stalk, <i>Colocasia</i>	26	0.7	114	1.9	0.4	94	0.00	2
Rice, white	123	0.8	4	0.3	0.6	0	0.03	0

* Energy expressed as kilocalories. Note: one heaped cup of cooked taro corm or rice weighs \approx 250 g



Typical patch of giant swamp taro in the midst of an agroforest, Yap. June 2007.

Recommended planting density

In Kiribati, Vickers (1982) states a planting spacing of 90 cm × 90 cm for large varieties, and 30–50 cm for smaller varieties. Some varieties are planted in pairs. Plucknett (1977) mentions these spacings:

Palau	1.2 × 1.2 m
Pohnpei district atolls	0.4–0.6 × 1–1.13 m
Pohnpei	0.6 × 1 m
Chuuk	1 × 1–1.1 m
Yap	0.6 × 0.6 m

If planted with *Colocasia* taro: the *Colocasia* is planted at a spacing 1–1.5 m apart, and giant swamp taro is planted later in between the *Colocasia* taro (Untaman 1982).

MARKETS

Local markets

Baked or steamed giant swamp taro often appears on the menus of hotel and restaurant buffets and at local community feasts in some Pacific island countries where it is grown (e.g., Palau). In the atoll islands of Micronesia, the market for giant swamp taro is practically non-existent as subsistence crops as a rule are not sold, but are given freely or exchanged in reciprocity. However, in the urban centers of Chuuk, Kosrae, and Pohnpei, cooked and ground giant swamp taro is sold at many small roadside food stands. In Weeno, Chuuk, a 1–1.5 lb packet of cooked giant swamp taro sells for \$1.00–1.50.

Export market

Visitors from Micronesia sometimes bring frozen packets of the giant swamp taro to their friends and relatives in Hawai'i. Residents of the FSM often send shipments of cooked and

frozen giant swamp taro to their relatives and friends in Guam, Hawai'i, and the mainland U.S.

These shipments suggest the possibility of a small export market for this crop. No data on the export of this species is readily available.

Specialty markets

While some yellow-fleshed corm varieties are high in β -carotene, commercial sales and marketing of this species for health and nutritional purposes seems fairly remote.

Branding possibilities

If marketed, given the variability of this species, the place of origin and variety should be identified. Foliaki et al. (1990) note that successful marketing of *Alocasia* taro will have to be identified as to variety because Pacific islanders have particular preferences for certain cultivars. Similarly, preferences for certain cultivars of giant swamp taro is a factor in any commercial marketing.

Potential for Internet sales

Internet sales are unlikely because of the lack of demand, customs and quarantine regulations, small to non-existent market, expense of shipping, general unavailability of Internet and other electronic capabilities in the atolls, to name a few.

To be specific, quarantine requirements for giant swamp taro imports into Guam and the U.S. call for cooked corms. This may also be the case for other destinations in the U.S. and elsewhere. Since cooked corms require refrigeration, this increases the difficulties of shipping. The availability of other aroids and starches also works against the successful export of this crop.

EXAMPLE SUCCESSES

Marianna Chim

Marianna Chim is a subsistence cultivator of the giant swamp taro on Falalop Islet, Ulithi Atoll. She is an 81-year-old widow who lives in Palyow Village. Most of her seven children have migrated to Yap and the U.S. With her daughter Bion, Marianna has three giant swamp taro (*bwolek*) patches totaling 321 m² and three coconut-breadfruit-banana agroforests totaling 5570 m². Within the three agroforests, Marianna and Bion also cultivate sweetpotato, *Colocasia* taro, and *Xanthosoma* taro. These agroforests, gardens, and taro patches provide Ulithi Atoll dwellers with a wide range of subsistence foods. Cash income from the sale of agricultural produce is little. Certain crops such as sweetpotato are sold to the school lunch programs on Ulithi and are a limited source for cash. The high cost of transportation to



Left: Marianna Chim. Top right: One to two-year-old giant swamp taro on Falalop Islet, Ulithi Atoll. Most of the taro patches on Falalop Islet are small. The islet's large taro swamp was filled in during WWII and lies beneath the airstrip. June, 2008. Bottom right: Losap Atoll women (Mrs. Kasko Epelu on the left) preparing a large communal dish of giant swamp taro (*pula*) and coconut cream in the cookhouse. Note: *Colocasia* taro tops on the right. June 1988.



Left: Dying giant swamp taro in a salinized swamp on Falalop Islet. Complaints of salt water intrusion and rising water levels have been more common in this decade than previously. Most of the affected swamps are located on the eastern side of the atoll. June 2008. Right: Healthy, one- to two-year-old giant swamp taro, Falalop Islet. June 2008.

Yap Island and the lack of the larger markets there preclude cash cropping.

The highest point on Ulithi Atoll is about 3 m above sea level. More than 98% of the Atoll is 1 m or less in elevation, and like most atolls, Ulithi has a limited freshwater lens. One of Marianna's taro patches is dying and has been abandoned. Marianna and other people on Ulithi believe that rising sea levels and saltwater intrusion into the taro patches is responsible (see accompanying photos). Excessive pumping and draw-down of the freshwater lens may also be a factor.

Alii Fish Maket

The Alii Fish Maket at the intersection of Wusstig Road and Route 1 in northern Dededo, Guam is a "mom and pop" grocery store that specializes in food products from Palau. The store is owned and operated by Hilario Rechesengel and his wife Maria Fatima Sakurai. The store has been in business for 5 years and is open daily, 7 days a week, between 8:00 am and 8:00 pm. Most of the clientele are Palauans, Micronesians, and other locals. The store sells fish, *brak* (giant swamp taro) and *kukau* (*Colocasia taro*) imported from Palau, betel nut from Yap, and other fresh, dried, frozen, or canned goods favored by islanders. The Alii Fish Maket imports a variety of *brak* originally from Yap which has a yellow corm flesh.

The mechanics and economics of retailing *brak* and *kukau* are fairly simple. As needed, Mr. Rechesengel places his orders for *brak* and *kukau* with his brother Anastacio in Palau via telephone once or twice a month. Each order is 100 lb (45.46 kg) or more. Anastacio Rechesengel buys taro directly from the farmers for \$1.50–\$1.75/pound (\$3.44–\$3.85/kg), cleans, cooks, freezes and air freights the taro and other goods to Guam at a transport cost of \$1.50/kg. A customs fee of \$5.00 is levied on each shipment. The *brak* and *kukau* are often sealed plastic wrap and sold for \$3.50/lb (\$7.72/kg) and \$3.25/lb (\$7.13/kg), respectively.

Mr. Rechesengel says that his profit margin is small. In many respects, the Alii Fish Maket is a successful enterprise as it one of only two Palauan operated grocery stores on Guam where one can buy products of Palauan origin.

ECONOMIC ANALYSIS

There is little information on the production costs of this species as this is a traditional subsistence, rather than commercial crop. The major costs are selection and preparation of planting material, land preparation, planting, weeding, and harvesting. Land rent, machinery, fertilizers and pesticide costs are minimal to nil.

FURTHER RESEARCH

Potential for crop improvement

Given that relatively little attention has been focused on the aroids in contrast to other root crops (e.g., yam, sweetpotato, and cassava), there is a tremendous potential for increasing the productivity of giant swamp taro for the simple reason that this species is one of the least studied edible aroids.

Chandra (1984), for example, recommended that there needs to be more work on the agronomic problems of the various aroid cultivars, production systems, germplasm and breeding, taro diseases and pests, storage, utilization and marketing. Chandra also recommends breeding cultivars with early maturity, low acidity, and increased salt and water stress tolerance, which could contribute significantly to increasing production in atoll ecosystems.

Englberger et al. (2003a, 2003b, 2008) have advocated further research on the carotenoid nutrient and fiber content of giant swamp taro cultivars, their bioavailability, and implications for the health of Pacific islanders.

Genetic resources where collections exist

The taro genebank at Pilot Farm, Madolenihmw, Pohnpei, a joint project of the Pohnpei Agriculture of the Office of Economic Affairs and the Island Food Community of Pohnpei has more than 40 varieties of giant swamp taro.



A University of Guam geography student reviews her observations on taro cultivation in the Agana Swamp, Guam. Field trips to traditional taro swamps are excellent for integrating concepts in both physical and cultural geography (or the natural and social sciences). March 2003.

CITED REFERENCES AND FURTHER READING

Altieri, M.A. 1999. The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems and Environment*, 74: 19–31.

- Benguet State University. 2005. Snack Food Processing. Technology Generated. Research and Extension Office, Benguet State University, La Trinidad, Philippines. Web: http://www.bsu.edu.ph/key_offices/rde/content/snack.php [accessed December 2, 2009]
- Bradbury, J.H., and W.D. Holloway. 1988. Chemistry of tropical root crops: significance for nutrition and agriculture in the Pacific. Australian Centre for International Agricultural Research, Canberra, Australia.
- Catala, R.L.A. 1957. Report on the Gilbert Islands: Some aspects of human ecology. Atoll Research Bulletin, No. 59. Pacific Science Board, National Academy of Sciences, Washington, D.C.
- Chandra, S. 1984. Conclusions and recommendations for research and development in the edible aroids. In: Chandra, S. (ed.), *Edible Aroids*, pp. 237–242. Clarendon Press, Oxford.
- Dignan, C., B. Burlingame, S. Kumar, and W. Aalbersberg. 2004. The Pacific Islands Food Composition Tables, Second Edition. FAO, Rome, Italy. Web: <http://www.fao.org/docrep/007/y5432e/y5432e00.HTM> [accessed December 2, 2009]
- Elbert, S.H. 1972. Puluwat Dictionary. Pacific Linguistics, Series C, No. 24. Department of Linguistics, Research School of Pacific Studies, The Australian National University, Canberra, Australia.
- Englberger, L. 2009. Personal communication. October.
- Englberger, L., K. Albert, A. Lorens, and A. Levendusky. 2009. Taro: An important Pohnpei staple food. In, Balick, M.J. (ed.), *Ethnobotany of Pohnpei: Plants, People, and Island Culture*. Chapter 5, pp. 132–164. University Of Hawai'i Press, Honolulu.
- Englberger, L., W. Aalbersberg, P. Ravi, E. Bonnin, G.C. Marks, M.H. Fitzgerald, and J. Elymore. 2003a. Further analyses on Micronesian banana, taro, breadfruit and other foods for provitamin A carotenoids and minerals. *Journal of Food Composition and Analysis* 16: 219–236.
- Englberger, L., J. Schierle, G.C. Marks, and M.H. Fitzgerald. 2003b. Micronesian banana, taro, and other foods: Newly recognized sources of provitamin A and other carotenoids. *Journal of Food Composition and Analysis* 16: 3–19.
- Englberger, L., A. Levendusky, K. Albert, E. Johnson, Y. Paul. 2004. Report on the Second Visit to the Mwoakilloa Atoll, Pohnpei, Federated States of Micronesia. October 30–November 7, 2004. Island Food Community of Pohnpei, Kolonia, Pohnpei.
- Englberger, L., J. Schierle, K. Kraemer, W. Aalbersbeg, U. Dolodolotawake, J. Humphries, R. Graham, A.P. Reid, A. Lorens, K. Albert, A. Levendusky, E. Johnson, Y. Paul, and F. Sengebau. 2008. Carotenoid and mineral content of Micronesian giant swamp taro (*Cyrtosperma*) cultivars. *Journal of Food Composition and Analysis*, 21: 93–106.
- Fosberg, F.R., M-H. Sachet, and R. Oliver. 1987. A geographical checklist of the Micronesian monocotyledonae. *Micronesica*, 20 (1 and 2): 19–129.
- French, B. 2004. Food Plants of Papua New Guinea: A Compendium. Self published. Sheffield, Tasmania. Accessed April 18, 2008. Web: <http://www.papuaweb.org/dlib/bk/french/index.html> [accessed December 2, 2009]
- Hather, J.G., and M.I. Weisler. 2000. Prehistoric Giant Swamp Taro (*Cyrtosperma chamissonis*) from Henderson Island, Southeast Polynesia. *Pacific Science*, 54(2): 149–156.
- Jackson, G.V.H., and I.D. Firman. 1984. Guide-lines for the movement of germplasm of taro and other aroids within the Pacific. In: Chandra, S. (ed.), *Edible Aroids*, pp. 194–214. Clarendon Press, Oxford.
- Koch, G. 1986. The Material Culture of Kiribati: Nonouti-Tabiteuea-Onotoa. English translation by G. Slatter. Institute of Pacific Studies, Suva, Fiji.
- Lambert, M. 1982. The cultivation of 'taro' *Cyrtosperma chamissonis* Schott in Kiribati. In: Regional Technical Meeting on Atoll Cultivation, pp. 163–165., South Pacific Commission Technical Paper No. 180. Noumea, New Caledonia.
- Lebot, V. 1992. Genetic vulnerability of Oceania's traditional crops. *Experimental Agriculture*, 28: 309–323.
- Levendusky, A., L. Englberger, R. Teelander, O. Mwarluck, H. Seilo, R. Sorryz, S.L. Relech, J. Salzman, M. Mony, and A. Gustafson. 2006. Documentation of Mortlockese giant swamp taro cultivars and other local foods on Ta, Moch, and Satowan, May 2006. Island Food Community of Pohnpei, Pohnpei, FSM.
- Luomala, K. 1974. The *Cyrtosperma* Systemic Pattern—aspects of production in the Gilbert Islands. *Journal of the Polynesian Society*, 83:14–34.
- Manner, H. I., and E. Mallon. 1989. An annotated list of the vascular plants of Puluwat Atoll. *Micronesica*, 22(1): 23–63.
- Merlin, M., A. Capelle, T. Keene, J. Juvik, and J. Maragos. 1994. Keinikkan Im Melan Aelon Kein: Plants and Environments of The Marshall Islands. East-West Center, Honolulu, Hawai'i.
- Merlin, M., and J. Juvik. 1996. Irá me Neenniier nón Chuuk: Plants and their Environments in Chuuk. East-West Center, Honolulu, Hawai'i.
- Mourits, L. 1996. An assessment of saltwater intrusion in babai pits and some water supply projects on Makin, Bu-

- taritari and Abaiang, Republic of Kiribati. SOPAC Technical Report, 229. SOPAC Secretariat, Suva, Fiji.
- Murai, M., F. Pen, and C.D. Miller. 1958. Some Tropical South Pacific Island Foods. University of Hawai'i Press, Honolulu, Hawai'i.
- Murukesan, V.K., E. van den Berg, L.R. Tiedt, P.C. Josekutty, and D. De Waele. 2005. Corm rot of giant swamp taro (*Cyrtosperma merkusii*) caused by the burrowing nematode *Radopholus similis* (Nematoda: Pratylenchidae) in the Pacific. *Nematology*, 7 (4): 631–636.
- Parkinson, S. 1984. The contribution of aroids in the nutrition of people in the South Pacific. In: Chandra, S. (ed.), *Edible Aroids*, pp. 215–224 Clarendon Press, Oxford.
- Plucknett, D.L. 1977. Giant swamp taro, a little-known Asian-Pacific food crop. In: Cock J., R. MacIntyre, and M. Graham (eds.), *Proceedings of the Fourth Symposium of the International Society for Tropical Root Crops Held at CIAT, Cali, Colombia, 1–7 August 1976*, page 36–40. IDRC-080e. IDRC, Ottawa, Canada.
- Prescott, N., and P.S. Folaumoetu'i. 2004. Tonga Biodiversity Stocktaking. Technical Report No. 1. For the Development of a National Biodiversity Strategic Action Plan (NBSAP). Department of Environment, Kingdom of Tonga.
- Pursglove, J.W. 1975, *Tropical Crops. Monocotyledons*. Longman-Group, London.
- Quisumbing, E. 1978. *Medicinal Plants of the Philippines*. Katha Publishing Co.
- Raynor, B. 1991. *Agroforestry Systems in Pohnpei—Practices and Strategies for Development*. Pohnpei, Federated States of Micronesia: RAS/86/036 Field Document 4. FAO/UNDP South Pacific Forestry Development Programme.
- Smith, A.C. 1979. *Flora Vitiensis Nova: A New Flora of Fiji (Spermatophytes only)*. Volume 1. Pacific Tropical Botanical Garden, Lawai, Kauai, HI.
- Smith, C. 1983. *Soil Survey of Yap, Federated States of Micronesia*. Soil Conservation Service, USDA.
- SPC (Secretariat of the Pacific Community). 2006. *Taro. Pacific Food Leaflet No. 5. Healthy Pacific Lifestyle Section*. Noumea, New Caledonia.
- Thaman, R.R. 1984. Intensification of edible aroid cultivation in the Pacific Islands. In: Chandra, S. (ed.), *Edible Aroids*, pp. 102–122. Clarendon Press, Oxford.
- Untaman, V. 1982. 2. The cultivation of giant swamp taro *Cyrtosperma chanissonis* (Schott) Merr. in Yap, Trust Territory of the Pacific Islands. In: Lambert, M. (ed.). *Taro Cultivation in the South Pacific*, pp. 97–100. SPC Handbook No 22 (1982). South Pacific Commission, Noumea, New Caledonia.
- Vickers, M.E.H. 1982. The agronomy of *Cyrtosperma chamissonis* (Schott) Merr. in Kiribati. In: Lambert, M. (ed.). *Taro Cultivation in the South Pacific*, pp. 90–97. SPC Handbook No 22 (1982). South Pacific Commission, Noumea, New Caledonia.
- Wagner, K.. 2008. Green and yellow foods linked to healthier arteries. *Biodiversity International News*. Web: http://www.biodiversityinternational.org/news_and_events/news/news/article/green-and-yellow-foods-linked-to-healthier-arteries.html [accessed December 2, 2009]
- Webb, A. 2007. Assessment of salinity of groundwater in swamp taro (*Cyrtosperma chamissonis*) “pulaka” pits in Tuvalu. EU EDF8-SOPAC Project Report 75. Reducing Vulnerability of Pacific ACP States. SOPAC, Suva, Fiji.
- Yen, D.E. 1980. Food crops. In: Ward, R.G., and A. Proctor (eds.). *South Pacific Agriculture: Choices and Constraints*, pp. 197–234. Asian Development Bank, Manila and ANU Press, Canberra.

Specialty Crops for Pacific Island Agroforestry (<http://agroforestry.net/scps>)

Farm and Forestry Production and Marketing profile for Giant swamp taro (*Cyrtosperma chamissonis*)

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