# Crop Profile for Taro in Hawaii

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## General Production Information

### Introduction

In Hawaii, taro (*kalo*) is a vital part of the cultural and agricultural traditions of the Hawaiian people. Prior to western contact, when the population of Hawaii consisted exclusively of Hawaiians, taro was the major food staple. There were more than 300 recognized forms. Today, although taro shares its role as a staple with rice, potatoes, pasta, and bread, it remains an important crop to the many cultures of Hawaii. Its starchy corm, or underground stem, is eaten principally as *poi*, prepared by mashing the cooked corm. Its steamed leaves (*luʻau*) and flowers (*pua*) can be eaten alone, but are generally used in dishes with meats, fish, coconut milk, and other vegetables.

Taro is a perennial herb consisting of a cluster of long-petioled, heart-shaped leaves that often reaching 30 cm or more. Plants referred to as taro may come from four genera (*Colocasia*, *Xanthosoma, Alocasia, and Crytosperma)* belonging to the family Araceae. Although species from all of these genera are grown in Hawaii, *Colocasia esculenta* is the only commercially important one.

There are two types of production methods: "Upland" taro production (also known as "dryland") and "wet" taro production (also known as "wetland," "lowland," paddy or "flooded").

### Taro Production in Hawaii

In 1999 there were 190 taro farms in Hawaii, the majority of which were on the island of Hawaii, the Big Island. Taro is grown on all islands but is concentrated on the islands of Hawaii and Kauaʻi. Many farms are about one acre although farms on Kauaʻi tend to be larger than those located elsewhere.

The three segments of the taro industry in Hawaii are *poi*, table and *luʻau* production. Most taro is grown for *poi* (420 acres). The remainder (80 acres) is table taro served as slices or chunks. Japanese, Chinese, or Samoan taro cultivars as well as some Hawaiian cultivars are used as table taro. A very small area is devoted to *luʻau,* or leaf production. While Bun Long, a Chinese cultivar, is the major *luʻau* cultivar, some of the Hawaiian cultivars are superior in quality.

Unlike most crops, the cost of pest control (30.6%) represents a significant portion of gross receipts. Labor to hand-weed accounts for nearly 80% of the total pest control costs.

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Taro production (6.8 million pounds) increased 13% from the 1998 total, reversing a downward trend that began in 1995 (Statistics of Hawaii Agriculture on-line 26 June 2000). The price per pound for *poi* taro has shown a slight increase over the past five years. Hawaii cannot produce all the taro it consumes, and in 1997 imported nearly 500,000 pounds of taro, primarily for the table taro segment of the industry (Statistics of Hawaii Agriculture 1997). The culinary differences between the various varieties of taro are discussed in *Taro, Mauka to Makai: A taro production and business guide for Hawaii Growers* (1997).

**Upland vs. Wet Taro Production Practices**

Taro can be grown under upland conditions, which means that the fields are rain-fed or irrigated but not flooded. Most of the taro in the world is grown under upland (dry) conditions. In Hawaii, upland taro (*kalo malo'o*) has been grown for hundreds of years.

"Wet" taro (*kalo wai*; literally, "water taro") is grown under frequently or constantly flooded conditions. Flooded taro production, a technique practiced by Hawaiians for centuries, is also used in Okinawa, Taiwan, the Philippines, the Cook Islands and other countries. Banked, flooded plots for taro production are called *lo'i*. Wet taro can take 9 to 15 months to mature, depending on the variety.

**Upland Taro Production**

Good yields begin with good sanitation. Growers are advised to avoid using planting material that has been exposed to diseases such as dasheen mosaic virus, *Pythium* root rot, or *Phytophthora* leaf blight, or to pests such as nematodes, taro root aphids, or leafhoppers. (For additional information on taro pests and diseases, see Ooka (1994) and Sato and Hara (1997)).

The number of plants grown in a given space (the planting density) affects taro disease prevalence and yield. The planting material, or *huli*, for the next crop comes from the crop being harvested. If *huli* are planted close together (both within and between rows), the crop will yield more corm (makua) but have fewer cormels *('oha*). Conversely, the further apart the *huli* is planted, the more *'oha* produced. However, high plant density may make it easier for insect pests to move among them, and if sunlight and air circulation are too restricted, diseases can occur more readily. Spacing *huli* too far apart, on the other hand, will make it difficult for the leaves to form a complete weed-suppressing canopy. The best spacing involves a trade-off among these factors.

## Insect Pests

There are relatively few insect pests of upland taro. However, if left unchecked, some can destroy the

entire crop. The most important pests are the taro root aphid and leafhoppers.

**The taro root aphid** *(Patchiella reaumun)* is a tiny sucking insect found primarily on roots and corm. When populations are high it can also be found on the above ground portions of the plant around the base of leaf sheaths and on young leaves. Plants infested with root aphid appear stunted, the leaves may be yellow and the roots and corm may rot. The aphids produce masses of fine, cottony, waxy threads that cover them on the roots and leaf stalks (petioles).

Currently, taro root aphids are found only on the Big Island and Oʻahu. There is a quarantine on transport of planting materials, *huli* and *ʻoha*, from the Big Island (see References, p. 96, for the publication by D. Sato et al.). A taro crop planted with *huli* infested with taro root aphid will never provide adequate yield, especially if periods of drought occur

Heavily infested taro must be removed and destroyed, with care being taken to include all culls and unharvested cormels. The field must be given a thorough and deep cultivation to drive away ants and to promote root degradation. After cultivation, the field must be left fallow or planted to non-taro crops for at least one year.

Leafhoppers suck sap from the petioles and leaf blades. Oviposition wounds cause dark spots on the petioles.

Other less economically damaging insect (and related) pests include **mealybugs, green aphids, earwigs, rose beetles, whiteflies, snails, and slugs. Ants** are an occasional pest but are important because of their symbiotic relationship with aphids. The aphids provide a sweet food-source for the ants. In return, the ants protect the aphids from their natural enemies. Ants "herd" mealybugs, taro root aphids, and green aphids, thus contributing to the spread of these destructive pests.

**Non-chemical insect pest management**

Growers routinely use several non-chemical insect pest management practices. As with disease management, growers are advised against spreading pests from one patch to another on planting material, in water, and on vehicles, equipment, tools, footwear, or clothing. They are also advised to use compost to increase soil organic matter and soil "health" making their taro more resistant to pests. Maintaining the proper moisture requirements also helps. When possible growers plant taro in areas unaffected by pests. Some growers try to maintain wide strips of open land between taro plots. However, the high cost of land and the limited amount of land suitable for taro production, makes this management option somewhat limited. Growers must sometimes leave their fields fallow or plant non-host crops. Some growers have used trap crops to draw pests away from taro (this may also permit pest control with insecticides not approved for use in taro, but approved on the trap crop). There are a few natural predators of the insect pests and growers are encouraged to promote or protect them.

**Insecticides**

Other than a few insecticides containing *Bacillus thuringiensis*, there are no insecticides specifically

registered for use on taro. The taro root aphid's waxy covering confers some resistance to insecticidal soaps. Also, the aphid's habit of living mostly on the roots makes it difficult to reach with insecticides. However, insecticidal soaps may sometimes be used to disinfest *huli* of taro root aphids before planting. When used, the concentration of active ingredient in the product is usually about 1 percent.

## Diseases

There are three major diseases caused by microbes and one major disease caused by nematodes, microscopic roundworms that live in the soil. **Pythium** root rots cause stunting. Infected taro plants have a fringe of roots at the base of the petioles. They are easy to pull out or knock over and usually smell bad. In its early stages, **Phytophthora** leaf blight occurs as small dark brown or purple lesions with an amber ooze in the center. Older lesions are zonate with white fuzz of sporangia on the outer edge. The sporangia are prominent in the morning. **Pythium** and **Phytophthora** are the major diseases of upland taro. The loss of green coloration in the leaves and a feathery pattern or other distortions of the leaf can be used to identify the third disease, Dasheen mosaic, caused by a virus.

**Cultural Control of Diseases**

Because taro is vegetatively propagated, the quality of the next crop depends on carefully selecting and handling planting material from the current harvest. In order to avoid crop loss and poor quality taro, farmers only use *huli* from healthy, pest-free corms. *Huli* from diseased or pest-weakened plants can result in yield loss and quality reduction of the subsequent crop.

Cutting tools must be disinfected at regular intervals to prevent the spread of pathogens. Collecting *huli* in batches is a practical compromise for lowering the probability of transferring pathogens with cutting tools and the need for efficient harvesting. Knives used for a given amount of harvest are traded off for knives which have been soaked in a disinfectant such as diluted bleach (0.5% NaOCl), 70% alcohol (ethanol or isopropanol), or 3% hydrogen peroxide. The knives are rinsed of soil and sap before being disinfected.

The healthy appearing *huli* are trimmed further before being thoroughly washed in clean water and dipped in a disinfectant such as 0.5% NaOCl. *Huli* are totally submerged in the disinfectant for a timed minute to prevent damaging the cutting. They are then removed from the disinfectant bath, drained and allowed to air dry in a cool, clean area. The *huli* are cured for 3 to 5 days to allow wound periderm to form over the cut surfaces and to allow culling of diseased *huli*.

**Hot Water Disinfestation**

Hot water may be used for disinfesting *huli* of some insect pests as well. *Huli* are immersed in 120ºF water for six minutes then quickly cooled by immersing it in cool water. Hot water treatments are an

effective way to control nematodes in dormant cormels of dasheen cultivars used for planting.

**Fallows for Disease Suppression**
Fallows are a means of reducing pathogen populations in the field. Fallowing is a general "best management practice" used by most good taro farmers. However, economic realities mean compromises must be made on the fallow's length, soil moisture level, and weed-free status. At least a three-month fallow with two tillings is advised for reducing taro disease pathogens. A year is better. One month might be acceptable if the risk of losing the crop is low or if other factors make taking the risk necessary.

**Other Non-Chemical Management Methods**
In most cases, growers attempt to control diseases by maintaining good production practices. In addition to those practices described above, the following are also recommended:

- Establish plant and row spacing and orientation that allows for quick drying of leaf surfaces.
- Isolate plantings (e.g., three small, separate patches instead of one large patch).
- Prepare the soil well and amend it before planting if calcium, magnesium, or phosphorus are needed. Monitor plant calcium levels by leaf analysis, and maintain calcium at recommended concentrations to prevent development of *Pythium* corm rot. Add lime material before planting to raise soil pH to 6.0-6.8.
- Rotate taro with other crops.
- Intercrop if possible.
- Incorporate compost and apply surface mulch.
- Rogue (kill and remove) diseased plants, taking them far from the planting area and destroying them by burying, burning (if allowed), or composting

**Fungicides**
There are two systemic fungicides registered for use against *Pythium* and *Phytophthora*: Ridomil Gold WSP [EPA Reg. No. 100-802] for use on upland taro only, and Ridomil Gold EC [EPA Reg. No. 100-801] for use on both upland and wet taro.

The Ridomil Gold label limits use to once per crop cycle, either immediately before or after planting. It cannot be used on taro which is also grown for *lu'au*. Ridomil must be incorporated into the driest soil possible. Continuous use of Ridomil can lead to the development of resistant strains of the targeted fungi. (The label does not permit the dipping of taro *huli* in either Ridomil Gold product.)

**Fumigants**
Various formulations of metam-sodium (Vapam, EPA Reg. No. 10182-150; Nemasol, EPA Reg. No. 34704-647; Metam 426, EPA Reg. No. 5481-423) are registered for use as a preplant fumigant on upland taro. They are not widely used.

# Nematodes

Nematode infestations are characterized by swelling of the corm and galls on the feeder roots, causing stunting and unthrifty growth. Nematodes destroy taro corms by damaging tissues that transport water and food. Secondary bacterial or fungal rots are commonly associated with nematode infestations.

# Weeds

Weeds are a constant problem. Farmers attempt to stimulate weed seeds to germinate and grow before the taro is planted and then eliminate them all at once. Several techniques can be used to eliminate weed seedlings before they become firmly established.

**Non-chemical weed management**
Some growers have used a torch applicator on weeds. The flame raises the temperature of the plant tissue to 130ºF (55ºC), destroying the cambium layer of the seedling stems. Shallow cultivation to sever roots is also used. After the taro is planted, 2 inches of organic mulch may be applied to suppress emergence of remaining weed seeds. Research indicates that coarse-textured mulches provide better weed suppression than fine-textured mulches.

The use of cover crops after harvest provides good conditions for "no-tillage" taro planting. No-tillage crop establishment requires planting taro into a thick mat of planned vegetation free of weeds. This labor-intensive practice requires the grower to open up small holes or narrow furrows in the cover vegetation to allow sufficient room for the *huli* to grow. At the same time, living vegetation immediately surrounding the new plants must be eliminated, thereby minimizing the potential for competition between the cover crop and the newly planted taro. This method of taro production has been shown to be a viable alternative to conventional practices and can reduce weed pressure while conserving the farmer’s most valuable natural resource, the soil.

**Herbicides**
Two herbicides are used in taro production, Gramoxone Extra (EPA Reg. No. 101 82-280) and Goal 2XL Herbicide (EPA Reg. No. 707-243). Goal 2XL is only registered for use in taro grown in Hawaii.

Gramoxone Extra is a Restricted Use Pesticide applied as a diluted spray with carrier volumes of 30 to 100 gallons of water per acre. All spray solutions are prepared with a nonionic surfactant (e.g., X-77 or Triton AG-98) at a 0.1% volume/volume ratio or 2-4 pints per 100 gallons of spray solution. Gramoxone

Extra is applied to weeds in taro at a rate of 1.5 to 2.5 pints (0.47 to 0.78 lb. a.i.) per acre. Sprays are directed between the rows, because any contact with taro foliage will cause severe injury. Applications are usually made in the late afternoon to maximize penetration of the herbicide. Two applications are allowable during the course of crop growth. Taro leaves from fields treated with Gramoxone Extra cannot be used for *luʻau*.

Goal 2XL has activity as a soil broadcast spray (preemergence) and as a post-emergence directed foliar spray. It is a selective herbicide for use against certain broadleaf weeds, e.g., spiny amaranth. If used as a preemergence spray it is applied at the rate of 2 pints (0.5 lb. a.i.) per acre in a carrier volume of 20 to 40 gallons per acre. At this rate it will provide 2.5 to 3 months of control depending on the weed species. It is applied at 1 pint (0.25 a.i.) per acre when used as a post-emergence directed spray against succulent weed seedlings (2 - 3-leaf stage). Only two applications as a directed spray are allowed on actively growing taro, with the combined applications not to exceed 2 pints (0.5 lb. a.i.) per acre. Taro leaves and corms can only be harvested six months after the last application.

Goal applied to upland taro apparently will co-distill with water vapor from treated soils. Some growers have noticed a slight, but temporary stunting of leaves. Corm size does not appear to be affected. Vapors containing Goal have been known to cause foliar injury even though no actual spray reached the leaves. Injury has not been shown to decrease corm yields but may reduce leaf (*luʻau*) harvests. Co-distillation may occur as the result of bright sunshine following rains. Farmers are advised to avoid such situations whenever possible.

Weed control in wet taro production is a major concern. Weeds in taro *loʻi* can out-compete a taro plant during establishment and slow its growth in the maturation phase. Unfortunately, intermittent draining and drying of the *loʻi* provides conditions for weed growth. Also, high spots and uneven areas of the *loʻi* can create areas where weeds can grow. Therefore, while the taro crop is growing growers must keep the *loʻi* bottom even, flat, and covered with a uniform layer of water to a depth of no less than one inch. There are no herbicides registered for use within flooded taro.

Roundup Ultra (EPA Reg. No. 524-475) is currently available for weed control in the dry *loʻi* and on the banks. Planting preparation is delayed for at least 30 days after the dry *loʻi* is sprayed. Using Roundup Ultra on *loʻi* banks during wet taro production (that is, while the *loʻi* is flooded) is currently allowed with a supplemental Special Local Need (SLN) label. The current SLN for Roundup Ultra reads, "apply to actively growing labeled weeds on wetland taro paddy banks, ditch banks, and walkways. Do not apply to weeds growing in water."

## Vertebrate Pests

Most of the comments provided in the section on *Upland Taro Production* are also applicable to wet taro production with some minor differences. Apple snails *(Pomacea canaliculata)* can be a problem in wet land taro. There are no registered molluscicides. A few farmers have tried baits around their *loʻi* or have tried to force the snails to congregate in small pools where they can be scooped out by hand. Cayuga black ducks have also been used with limited success. Crayfish may also be a problem because they damage the *loʻi* bank. Currently, farmers use traps to reduce crayfish populations. Nematodes and taro root aphids do not attack taro grown under flooded conditions. Metam-sodium (Vapam) is not registered for use for wet taro production.

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