



## **Pesticides Currently Registered for Use in Taro in Hawai'i (2007)**

**P**esticide regulations change frequently, and some of them may have changed since the date of this publication. Always read the entire pesticide product label and follow its instructions. The Hawai'i Department of Agriculture (HDOA) Pesticides Branch is the regulatory agency with final authority on the use of agricultural pesticides in Hawai'i. If the information in this publication differs from that given on the pesticide label, follow the label.

Use of pesticides to control weeds, insects, and plant pathogens is only one option in an integrated pest management (IPM) approach, which relies on knowledge of the crop and its potential pests to anticipate and, ideally, deflect problems before they reach levels resulting in economic damage. For up-to-date advice on dealing with particular pests, call the CTAHR Cooperative Extension Service or HDOA.

The methods you choose to cope with pests that threaten a taro crop will be based on what is most important to you. The choices may depend, for example, on whether you grow taro commercially, or you grow it for its traditional cultural significance. You may prefer to maintain an "organic" lifestyle, or have health concerns about pesticides. You may need to keep production at profitable levels, balancing constraints on yield with the expectations of your market, and pesticides may be helpful in accomplishing this. Your choices may or may not be influenced by market demand for a pesticide-free or certified organically grown product.

Whether a product can be used in taro may be a matter of interpretation of label language. Restrictions are often more stringent for *lo'i* taro because it is flooded, and applications to the crop can affect aquatic systems beyond the individual site of application (the *lo'i*). It is the responsibility of the applicator to make sure that the use is allowed under HDOA's interpretation of the label.

For taro, pesticide availability is limited by the fact that—in the U.S. at least—it is a very "minor" crop. There is no economic incentive for pesticide manufacturers to

do the research needed to list taro on their products' labels. Such research must generate data showing that the product is effective against the pests it is intended to control, that residues of the product do not show up in harmful levels in the harvested crop, and that label directions for use of the product do not result in risk to the pesticide applicator or the environment. This is why one of CTAHR's programs provides key assistance to growers of various "minor" crops by doing testing to provide data that allows manufacturers to obtain approval for use of their products on those crops in Hawai'i.

Some pesticide labels have broad language that includes use on taro without specific mention of it. Examples include "all fruits and vegetables," "root and tuber vegetables," and "vegetable, root and tuber (Group 1)," the latter referring to a food group classified by the EPA that includes taro. Sometimes the label will refer to "dasheen (taro)" or just "dasheen."

### **Herbicides**

Currently, herbicide use within a taro planting is allowed only in non-flooded ("upland" or "dryland") taro production situations and *not* in flooded taro production. According to the HDOA Pesticides Branch, the following describes what is considered "upland" or "dryland" taro production with regard to pesticide use:

"Dryland taro is taro grown throughout its crop cycle without irrigation or using irrigation practices that do not result in run-off, irrigation return flow, or other loss of irrigation water from the production area. If irrigation water is used, the water applied shall not exceed the field capacity of the soil." (R. Boesch, Pesticide Program Manager, Hawai'i Department of Agriculture, 1997).

Farmers must follow growing practices that conform to this definition of non-flooded taro production in order to legally use registered herbicides. Any water that

enters the field cannot be allowed to leave it except by percolation into the soil. Questions about this definition and its interpretation should be directed to the HDOA Pesticides Branch. In general, great care should be taken to use any herbicide only as directed on the product's label, since any other use is a violation of laws and regulations.

Weed occurrence during the crop cycle can be reduced if the weeds are controlled before the taro is planted. Herbicides absorbed through plant leaves, such as glyphosate, available as Roundup® Ultra Max and other formulations including Honcho® Plus, are most effective when applied to weeds that are actively growing. Glyphosate cannot be used while taro is growing in the field, but it can be applied to weeds at any time before the crop is planted.

To improve the effectiveness of a glyphosate application, it can be followed (after a wait of 10–14 days to allow the herbicide to work) by tillage to break up weed root systems. Repeated cycles of this technique can greatly reduce infestations of perennial grasses and broad-leaf weeds in the current and subsequent crops. However, tillage may bring buried weed seeds to the surface where they will germinate to begin a new weed cycle. Use of the “sterile-bed” technique would avoid tilling after the final round of weed control before planting the crop.

Although glyphosate may not be applied to weeds that are growing after you have planted the taro, other herbicide options for controlling weeds are available.

### Herbicide use in flooded taro production

Glyphosate is the only herbicide available for use in flooded taro production systems. It can be used only in dry *lo'i* before production; during production, it can be used only on the *lo'i* banks. When glyphosate is used in a dry *lo'i*, planting preparation must be delayed by at least 30 days after the application. Because this lag period often allows a whole new crop of weeds to sprout, the practice may be of limited use.

Using glyphosate on *lo'i* banks during taro production (that is, while the *lo'i* is flooded) is currently allowed with a supplemental Special Local Needs (SLN) pesticide label. SLN labels are issued for a defined period and must be renewed periodically by a registrant, which could be the manufacturer or a third party (e.g., a taro industry group, or the Hawaii Farm Bureau Federation). A copy of the SLN label must be in the possession of the farmer when the product is applied. SLN

labels are acquired from the registrant or the agrichemical companies or their distributors. The HDOA Pesticides Branch is another source of SLN labels.

The current SLN for Roundup Ultra Max reads, “apply to actively growing labeled weeds on wetland taro paddy banks, ditch banks, and walkways. *Do not apply to weeds growing in water.*” The “labeled weeds” are those that the product label specifies can be controlled.

### Herbicides for non-flooded conditions only

#### **Paraquat**

The herbicide paraquat is sold as Gramoxone® Max and Gramoxone® Inteon; it formerly was sold as Gramoxone® Extra. Gramoxone is a restricted-use pesticide that may be used only by, or under the direct supervision of, applicators certified by the Hawai'i Department of Agriculture. The label prohibits the product's use and storage around the home. Taro fields treated with Gramoxone cannot be harvested for 6 months after the last application. Also, leaves from crops treated with Gramoxone cannot be harvested for consumption.

Paraquat is a non-selective, contact herbicide that kills most annual grass and broadleaf weeds when applied as a foliar spray. It can be very effective at low rates when applied to very small weeds between the cotyledon stage and the first-true-leaf stage. Larger weeds can also be controlled with higher rates of application. It is important to make timely spray applications to maximize effectiveness at the lowest possible application amounts.

#### **Carfentrazone-ethyl**

The herbicide Aim®, a contact herbicide primarily for broadleaf weed control, has a use pattern similar to Gramoxone, but it must be applied with a hooded or shielded sprayer. Unlike Gramoxone, Aim is not a restricted-use pesticide. The Aim label does not mention taro specifically, but the product is allowed in crops within the EPA classification “vegetable, root and tuber (Group 1),” which includes taro. Broadleaf weed control with this herbicide is most effective on young weeds.

#### **Oxyfluorfen**

The herbicide oxyfluorfen, available as Goal® 2XL, Galigan® 2E, and GoalTender™, formerly available as Goal 1.6E, is used primarily as a soil-applied spray for preemergence weed control, but it can also be used as a foliar spray for early postemergence weed control.

Oxyfluorfen is useful against spiny amaranth, common purslane, and garden spurge. It is applied to newly planted non-flooded taro with a broadcast ground sprayer. Complete coverage of the production area should be made so that weed escapes do not occur too soon. Application of oxyfluorfen should provide weed control for 2.5 to 3 months depending on the weed species present. A second application can be made as a directed spray to small weed seedlings in the growing taro crop. Only two applications of Goal are allowable per crop cycle, with a limit on the combined application, as specified on the product label. Spray applications should be made with a minimum of taro leaf contact to avoid injury. Taro leaves and corms cannot be harvested until 6 months after the last application.

There are a few simple guidelines for maximizing the effectiveness of oxyfluorfen. Soil-applied herbicides work by establishing a chemical layer on the soil surface to kill weeds as they germinate and grow through it. Any soil-moving activity that breaks the barrier will allow weed escapes and reduce the effectiveness of the herbicide. Oxyfluorfen applications made at planting should be followed by at least a ¼-inch rainfall or overhead sprinkler irrigation within 2–3 weeks. This spreads the herbicide evenly over the soil surface and activates weed seed germination before any herbicide is lost to photo-decomposition, evaporation, or microbial breakdown. Activation with overhead irrigation can be followed with drip irrigation for the duration of the crop. When oxyfluorfen is applied to living weeds, kill activity is improved by adding 2–4 pints of 80% active non-ionic surfactant per 100 gallons of finished spray solution. Remember, however, that if the herbicide does not reach the soil surface, it will not control weeds.

There is one additional precaution concerning use of oxyfluorfen in non-flooded taro. When water vapor rises from soil treated with oxyfluorfen, some herbicide vapors can move with it into the plant canopy. This phenomenon, called co-distillation, can cause foliar injury to taro even though no actual spray solution has touched the leaves. This problem will usually occur soon after chemical application and will subside with time. Leaves injured by oxyfluorfen vapors will look burned and can drop. Oxyfluorfen, however, does not move within the plant, and this form of injury has not been shown to reduce crop yields. Special precautions should be made to avoid oxyfluorfen applications when environmental conditions favor co-distillation. These conditions are

present when bright sunshine occurs soon after rainfall.

GoalTender has been formulated to reduce the incidence of co-distillation. Where damage from oxyfluorfen vapors produced during co-distillation is a problem, GoalTender is the recommended choice over Goal 2XL and Galigan 2E.

### **Clethodim**

Select® 2EC Herbicide is a selective postemergence herbicide for control of annual and perennial grasses; it is not labeled for control of sedges or broadleaf weeds. Taro corms or leaves cannot be harvested for 30 days after the last application.

## **Insecticides**

### **Against taro root aphid**

The insecticide imidacloprid, available for use in taro as Admire® 2 Flowable and Admire® Pro, offers systemic protection against root aphids in non-flooded taro plantings. The current Admire label allows for one application per taro crop season. It can be applied at planting as an in-furrow spray over planting material or shanked in 1–2 inches below huli depth at planting. Alternatively, it can be applied later as a side-dress, but no later than 45 days after planting. Corms cannot be harvested for at least 125 days after the application (the “preharvest interval”), but taro leaf may be utilized for food or feed after a 3-day preharvest interval. The key to effective use of Admire is to get it into the zone of active root growth, where the plant can absorb it. Too much rain or irrigation after its application can wash the material beyond reach of the roots.

### **Against leaf pests**

Insects that can feed on taro leaves, particularly in non-flooded crops, include aphids, hoppers, mealybugs, whiteflies, and the Chinese rose beetle (*Adoretus sinicus*). The planthopper that is most likely to cause crop damage is the taro delphacid, *Tarophagus colosasiae*. The most common aphid species found on taro leaves is the melon aphid, *Aphis gossypii*, although rarely one can also find the banana aphid, *Pentalonia nigro-nervosa*. Feeding by aphids on leaves and petioles stunts the plant’s growth and adversely affects the quality of harvested taro leaf.

If a systemic insecticide such as Admire has been applied to control taro root aphid at the time of planting

non-flooded taro, there will also be some control of leaf-feeding pests during the period that the chemical is active in the plant.

Various products are currently licensed for sale in Hawai'i that may provide some control of foliar insect pests in non-flooded taro:

- pyrethrins (e.g., Pyronyl™ Crop Spray)
- neem (*Azadirachta indica*) seed oil products such as Trilogy®, labeled as a fungicide/miticide/insecticide for ground or foliar application or in chemigation
- products containing azadiractin (a triterpenoid isolated from neem seeds) labeled for use against insect pests such as leafhoppers, aphids, whiteflies, thrips, and others; these include Azatin® XL Botanical Insecticide, Agroneem® Emulsifiable Concentrate, and Neemix® 4.5.

The extent to which foliar pests damage taro crops and reduce yields is not well studied, so the economic advantage of applying pesticides in any particular instance is not clear. Also, the efficacy of the licensed insecticides against taro leaf pests in Hawai'i has not been verified.

One situation where preventive foliar insecticide applications might be justified is when a new planting is being installed near an established planting that has some foliar pests. While the pests may not be measurably limiting growth of the established plants, they may have a severe effect on the new planting if they move into it to feed and proliferate on the young, developing crop.

For taro being grown in ornamental landscapes, where the plant will not be consumed, imidacloprid formulations are available that may keep the leaves free of unsightly pests or minimize leaf chewing by Chinese rose beetles.

### **Insecticidal soaps**

Some farmers seeking alternatives to pesticides such as imidacloprid may consider using insecticidal soaps, such as M-Pede®. Soaps are made of various salts of the fatty acids of natural oils and fats; insecticidal soaps have potassium salts of fatty acids as their active ingredient. When sprayed on some types of insects, usually soft-bodied ones including aphids, mealybugs, and whiteflies, the fatty acid content of an insecticidal soap attacks and disrupts normal membrane permeability and cellular physiology, resulting in leakage of cell contents and death of the insect. Insects most susceptible to control in this way are soft-bodied, and the best results are

obtained on newly hatched insects.

Growers should exercise caution when applying insecticidal soaps to taro leaves during hot, sunny weather, because it may result in some "scarring" damage to the leaf surface. It is always advisable to test pesticides on a small area of a crop and then look for symptoms of adverse effects before making large-scale applications.

The taro root aphid is a particularly waxy type of aphid, which makes it resistant to insecticidal soaps. Also, its habit of living mostly on the roots makes it difficult to reach with soap sprays. At present, it is uncertain that insecticidal soaps are completely effective in disinfecting *huli* of taro root aphids before planting. A hot-water dip (6 minutes in water held at 120°F, followed by immersion in cool water), is a more effective means to disinfect *huli*.

Insecticidal soap products may be available as concentrates or in diluted, ready-to-use forms. The concentration of active ingredient in the product as applied is usually about 1 percent. The label should specify that use is allowed on taro, dasheen, or "root and tuber vegetables."

The label of an insecticidal soap will usually refer to the product's use as a spray, but according to HDOA, unless the label says otherwise, the spray solution can also be used as a dipping solution for *huli*, provided that any remaining unused solution is not dumped on the soil but rather is sprayed over areas bordering the growing area, where pest reinfestation is likely.

### **Fungicides**

Four chemicals currently are registered in Hawai'i for disease control in taro. These chemicals are mfenoxam (Ridomil Gold® EC, Apron XL® LS), dimethomorph (Acrobat®), fludioxonil (Maxim® 4FS) and mono- and dipotassium salts of phosphorous acid (Fosphite®, Fungiphite™, Rampart™). In addition to these, some of the neem-based products mentioned for insect control are also described on their labels as having fungicidal activity.

Ridomil and Acrobat can be soil-applied, while Apron and Maxim are for treating cut-corm seed-pieces and *huli*. The soil-applied products cannot be used in flooded taro.

Apron XL® LS is labeled for *Pythium* damping-off protection. Maxim® 4FS is labeled for protection against seed-borne and soil-borne fungi that cause decay, damping-off, and seedling blight; these include *Rhizoctonia* and *Fusarium* but not *Pythium* or *Phytophthora*.

Ridomil is a systemic fungicide that is highly effective against *Phytophthora* and *Pythium*. Ridomil Gold®

EC can be used only in non-flooded taro and only once during the crop cycle in a soil-injected or soil-incorporated application either before or immediately after planting; it cannot be used as a foliar application, nor can it be used as a pre-plant dip for *huli*. Because leaf blight caused by *Phytophthora* is not a major problem until the fifth or sixth month after planting, efficacy of Ridomil for *Phytophthora* control is questionable. For the same reason, treating *huli* with Apron or Maxim before planting also is unlikely to have much of an effect on disease prevention over the crop cycle.

Because Ridomil cannot be applied directly to water or to areas where surface water is present, it cannot be used in flooded taro fields.

When applying Ridomil, you must have the label in your possession and follow the directions given under its Root and Tuber Vegetable Crop section, which includes “dasheen” (taro). After it is applied, there is a mandatory 48-hour restricted-entry period for treated fields. Label guidelines for incorporating Ridomil into the root zone should be carefully observed, because its uptake by the plant is critical to its effectiveness.

Acrobat® 50WP fungicide *must* be applied in a tank mix with another fungicide, but this *cannot* be mefenoxam (that is, Ridomil). Application guidelines for Acrobat allow five applications per season using not less than 20 gallons of water per acre per application, and application up to 30 days before corms are harvested and 7 days before leaves are harvested. Acrobat cannot be applied directly to water or to areas where surface water is present, which limits its use to non-flooded taro fields.

The reason that Acrobat must be tank-mixed with a second fungicide is to reduce the chance of pathogens developing resistance to its active ingredient, dimethomorph. The reason that Acrobat cannot be mixed with mefenoxam is that pathogen resistance to mefenoxam has commonly developed in crops to which it is applied on the U.S. mainland. Therefore, Ridomil mixed with Acrobat would have little effect in delaying development of resistance to dimethomorph. On O‘ahu and Kaua‘i, isolates of *Phytophthora colocasiae* have been found that show resistance to mefenoxam. How this pathogen was exposed to mefenoxam in the environment is unknown, but resistance evidently has developed.

Another fungicide currently available for dryland taro is mono- and di-potassium salts of phosphorous acid, licensed in several formulations:

- Fosphite® Systemic Fungicide is labeled for control of *Phytophthora*, *Pythium*, *Fusarium*, *Rhizoctonia*, and downy mildew. It can be applied as foliar spray, root dip, or in irrigation against *Phytophthora* and *Pythium* and as foliar spray against downy mildew. No more than 6 applications per crop cycle are allowed.
- Fungi-phite™ is a systemic fungicide labeled for suppression and control of *Phytophthora*, *Pythium*, and downy mildew. It can be applied as foliar spray, root dip, or chemigation against *Phytophthora* and *Pythium* and as foliar spray against downy mildew. No more than 6 applications per crop cycle are allowed.
- Rampart™ Potassium Phosphite is a fungicide labeled for control of *Phytophthora*, *Pythium*, *Fusarium*, *Rhizoctonia*, *Xanthomonas campestris*, anthracnose, downy mildew, powdery mildew, pink rot (*Phytophthora erythroseptica*), and late blight (*P. infestans*). It may not be applied at intervals of less than 3 days.

To date, the formulations of mono- and di-potassium salts of phosphorous acid have not been field-tested for efficacy in taro in Hawai‘i. Data have been developed showing that Acrobat can achieve some control of *Phytophthora* leaf blight when timing of its applications is optimal, which is not always possible under the field conditions suitable for disease development (e.g., it can’t be sprayed during rainy periods).

### Finding out about pesticides for taro

“Warning: pesticide availability and pesticide regulations change frequently!” Sometimes products are withdrawn from the market, sometimes new products are developed and registered, sometimes new pests occur for which no pesticide is currently registered, and research must be done to find an effective control.

Up-to-date information on the pesticide products that may be used in taro can be obtained from several sources:

- The Hawai‘i Department of Agriculture’s Pesticides Branch is the agency that licenses registered pesticides for sale in Hawai‘i (808 973-9401). They know what’s licensed and have copies of the labels.
- Local agrichemical distributors are familiar with their products’ labeling.
- The UH-CTAHR Cooperative Extension Service maintains the HPIRS database, the Hawai‘i Pesticide Information Retrieval System. It can be found on the CTAHR Web site, <http://www.ctahr.hawaii.edu>. Or,

you can obtain assistance from an extension agent at UH-CTAHR-CES offices statewide.

### Safe pesticide use

Here are some general guidelines for working with agricultural chemicals:

- Always read the entire label before purchasing a pesticide and *be sure* that you can legally use it for the intended purpose. Follow all instructions when applying pesticides.
- Obey all warnings on the label.
- Positively identify the pest to be controlled.
- Purchase the smallest amount of pesticide that you will need, thus avoiding problems with storage and disposal of excess material. If you have any leftover pesticides, package them and store them where children, pets, and persons not familiar with pesticides cannot reach them. Never store pesticides near food or food preparation equipment, such as a barbecue.
- Do not mix or apply pesticides around children.
- The Hawai‘i Department of Agriculture requires recordkeeping for each application of a restricted-use pesticide, and the federal Worker Protection Standard requires posted notice of applications of agricultural-use pesticides to ensure agricultural worker safety.
- For your own recordkeeping purposes, keep written records of pesticide use in your grower’s log.
- When possible, test pesticides on a small area of the crop and look for adverse symptoms before making large-scale applications.
- Use separate sprayers, one for herbicides and another for other pesticides, and clean the equipment as soon as you finish applications.
- Do not apply pesticides during high temperatures or in windy conditions.
- Always wear the protective clothing/equipment specified on the label.
- Wash skin and clothing if spills occur and after applying pesticides.
- Do not smoke while working with pesticides.
- When you mix chemicals, do it outside or in a well-ventilated area.
- Follow any label cautions concerning applications in drainage areas.
- Store pesticides in a covered container.
- Never apply pesticides during or immediately preceding rainfall.

- Do not tank-mix incompatible pesticides.

### The federal Worker Protection Standard

Procedures for application of pesticides labeled for agricultural use are subject to the federal Worker Protection Standard (WPS) for Agricultural Pesticides. This standard contains requirements for the protection of agricultural workers in farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. The pesticide label may expand on the provisions of the WPS and contain specific instructions and exceptions about personal protective equipment (PPE) and the restricted-entry interval (REI); when the label differs from the WPS, follow the label.

All pesticides labeled for agricultural use have an REI, which may be as short as 4 hours but is often longer. The label may state, for example, “Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours. PPE required for early entry into treated areas that is permitted under the Worker Protection Standard and involves contact with anything that has been treated, such as plants, soil, or water, is:

- Coveralls
- Chemical-resistant gloves
- Shoes plus socks.”

The WPS also requires employers of agricultural workers to have a notification system when agricultural-use pesticides are applied. To ensure worker safety, it requires that any scheduled applications are posted beforehand, and that the notices be kept on display until 30 days after the REI.

### Disclaimer

Mention of a trade name or description of a pesticide use pattern is not intended as an endorsement of the product or a recommendation to the exclusion of other suitable products not mentioned.

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