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Pest Management Strategies for Anthuriums

Arnold H. Hara, Marcel M.C. Tsang, Christopher M. Jacobsen, Julie Ann T. Yogi-Chun, Trent Y. Hata, and Ruth Y. Niino-DuPonte

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Arnold H. Hara[1], Marcel M.C. Tsang[2], Christopher M. Jacobsen[1], Julie Ann T. Yogi-Chun[1],
Trent Y. Hata[1], and Ruth Y. Niino-DuPonte[1]
[1]CTAHR Beaumont Agricultural Research Center, Hilo;
[2]College of Agriculture, Forestry and Natural Resource Management, University of Hawaii at Hilo

Anthuriums are the most valued cut flower in Hawaii. Today, over 60 active growers form the Hawaii Anthurium Industry Association (HAIA), a member association of the Hawaii Tropical Flower Council (HTFC). These growers commercially produce more than 11 million stems of about 40 anthurium varieties annually, driving a $7 million industry on the Island of Hawaii (Statistics of Hawaii Agriculture 2001, http://flower-web.com/anthuriums/).

Producing anthuriums requires the management of numerous pests and diseases with chemical pesticides. This report presents results of our pest management research, including effectiveness of selected chemical and non-chemical treatments against the major insect and mite pests of anthuriums (Table 1). Results of this research will assist the grower in implementing an integrated pest management (IPM) program for anthuriums by minimizing the use of pesticides and maximizing the use of non-chemical control treatments. IPM will lower cost of production while reducing any negative effects to the environment, and therefore sustain anthurium production in Hawaiʻi for the next century.

In this report, the summary for each efficacy or phytotoxicity trial begins with a list of results, followed by a graph of the data and a description of the treatments, location, time of year, cultivars, and procedures. The efficacy trials are grouped by the targeted pest, and the phytotoxicity trials are categorized by treatment type. Finally, non-chemical and chemical control strategies are summarized to assist the grower in implementing an IPM program for anthuriums.

On the cover:
These newly planted 'Tropic Sunrise' anthuriums were disinfested of burrowing nematodes with hot water (120°F, 49°C) for 15 minutes before planting. No heat injury or signs of burrowing nematodes or anthurium bacterial blight were observed during 12 months after treatment.

Topics covered

Table 1. Major pests of anthuriums in Hawaii.

Common name	Scientific name
Citrus red mite	*Panonychus citri* (McGregor)
Anthurium thrips	*Chaetanaphothrips orchidii* (Moulton)
Banana rust thrips	*Chaetanaphothrips signipennis* (Bagnall)
Burrowing nematode	*Radopholus similis* (Cobb) Thorne

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Efficacy trials

Citrus red mite

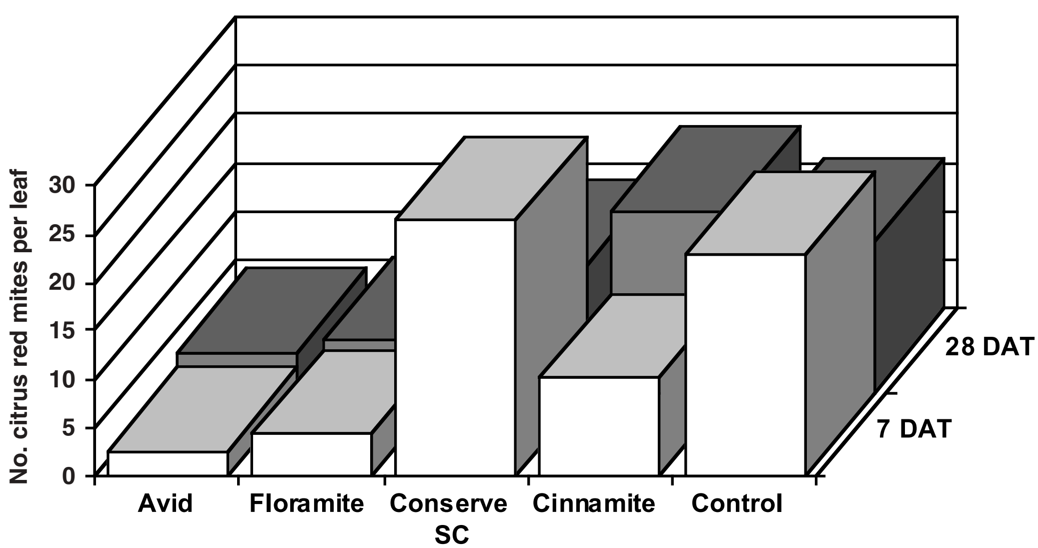
- Avid and Floramite gave good initial and residual control of citrus red mite (CRM) up to 28 days after treatment (DAT) with lower mite counts per leaf than Conserve and untreated controls (Fig. 1).
- Conserve exhibited poor control of citrus red mite throughout entire trial.
- Cinnamite treatment showed an initial drop in mite counts, but their numbers climbed back up by 14 DAT to be the same as on untreated plants.

Treatment	Rate (amount / 100 gallons)
Untreated check	- - -
Conserve SC	20 fl oz
Cinnamite*	85 fl oz
Floramite	4 oz
Avid 0.15 EC	4 fl oz

*Cinnamite has been discontinued.

Location: Pahoa, HI; **Time of year:** September to October 1999; **Treatment applications:** Once in September using a 20 gal compressed CO_2 backpack sprayer with a #3 disk, 45 core hollow cone nozzle, 0.23 gpm at 40 psi**.** Each treatment was replicated three times. **Cultivar:** ‘Rainbow Obake’. **Plot description:** 5 ft x 16–20 ft plots grown in cinder under 80% shade cloth. **Evaluation:** Upper and lower surfaces of 8 random mature leaves (1 per plant per plot) were examined with a dissecting microscope for the number of live mites. There were no differences in pre-treatment mite counts between treatments. **Reference:** Yogi, J.T., C.M. Jacobsen and A.H. Hara. 2000. Efficacy of Cinnamite, Conserve, Avid and Floramite against citrus red mite on anthuriums, 1999. Arthropod Management Tests 25:345–346.

Figure 1. Efficacy of Avid, Floramite, Conserve SC, and Cinnamite against citrus red mite on anthuriums.



Citrus red mite

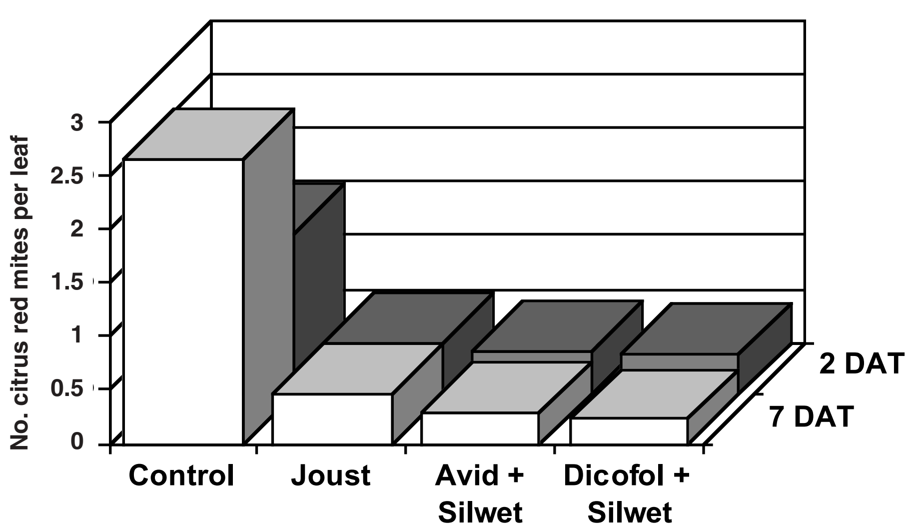
- For all treatments, there was a significant reduction in citrus red mite (CRM) numbers from 2 days after treatment (DAT) up to 7 DAT (Fig. 2).
- After 7 DAT, CRM numbers were beginning to increase slightly in all treatments, which may be an indication of loss of residual miticidal activity.
- CRM populations on untreated check plots remained high throughout the test period.
- **Phytotoxicity:** In a phytotoxicity trial conducted concurrently with this efficacy trial, Dicofol and Joust caused phytotoxic reactions in 'NPR' and 'Marian Seefurth'. In addition, Dicofol affected 'Kalapana' and 'Midori'.

Treatment	Rate (amount / 100 gallons)
Untreated check	- - -
Joust*	4 fl oz
Avid 0.15 EC +	4 fl oz
Silwet surfactant	2 fl oz
Dicofol 4 EC +*	4 fl oz
Silwet surfactant	2 fl oz

*Joust and Dicofol have been discontinued.

Location: Pahoa, HI; **Time of year:** October 1998; **Treatment applications:** One in October using a 20 gal compressed CO_2 backpack sprayer with a 22x hollow cone nozzle, 0.033 gpm at 40 psi. Each treatment was replicated 3 times. **Cultivar:** 'Mickey Mouse'. **Plot description:** 4 ft x 8 ft plots of 60–70 plants 10–18″ high grown in cinder under 80% shade cloth. **Evaluation:** Upper and lower surfaces of 8 random mature leaves (1 per plant per plot) were examined with a dissecting microscope for the number of live mites. There were no differences in pre-treatment mite counts between treatments. **Reference:** Yogi, J.T., A.H. Hara, C.M. Jacobsen, T.Y. Hata, R.Y. Niino-DuPonte, and R. Kaneko. 2000. Efficacy of Avid, Dicofol, and Joust against citrus red mite (CRM) on anthurium, 1998. Arthropod Management Tests 25: 345.

Figure 2. Efficacy of Joust, Avid, and Dicofol against citrus red mite on anthuriums.

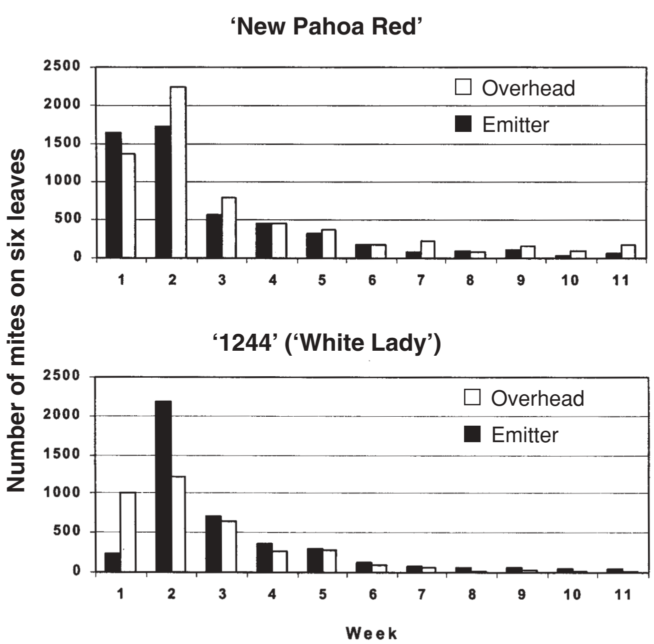


Citrus red mite

- Results from this trial indicate that irrigation methods did not influence CRM populations (Fig. 3).
- 'New Pahoa Red' had slightly more mites on the drip-irrigated plants than overhead irrigated plants.
- '1244' ('White Lady') had slightly higher numbers of CRM per leaf on overhead irrigated plants than drip-irrigated plants.
- Over the course of this trial, CRM populations in both treatments declined dramatically. Efforts are still being made to identify the factor(s) involved.

Location: Waiakea, HI; **Time of year:** October to December 1998; **Treatments:** Physical control of citrus red mite on anthurium plants was evaluated by comparing the effects of two irrigation practices, (1) emitter, or drip irrigation to roots, and (2) overhead sprinklers that completely wetted foliage, on CRM populations**. Cultivars:** 'New Pahoa Red' and '1244' ('White Lady'); **Evaluation:** Six leaves were randomly sampled for CRM counts.

Figure 3. Decline of citrus red mite population on anthurium plants through irrigation practices.



Anthurium thrips and banana rust thrips

Withdrawal of registering Dursban 2% Coated Granules against anthurium thrips and banana rust thrips pupae—*Sequence of events*

1998–1999. One application of Dursban 2G was found to significantly reduce the number of thrips per flower for 4 months. Greatest control was observed when granules were applied in combination with a foliar spray targeting nymphs and adults.

1999–2000. After 75 DAT, Dursban 2G was still significantly reducing the degree of thrips injury in anthurium flowers. A treatment that combined Mavrik as a foliar spray and Dursban 2G was more effective than Dursban 2G alone.

Dursban 2G was then under US Environmental Protection Agency and FQPA review and could possibly have its use reduced in the future. Registration for use on anthuriums and other ornamentals was put on hold pending the EPA findings.

2000–2001. On June 8, 2000, the US EPA and the manufacturer of Dursban 2G (Dow AgroSciences) announced eliminating the widely used pesticide for nearly all household and termite control purposes, and curtailing agricultural and ornamental nursery production uses by classifying chlorpyrifos as a Restricted Use Pesticide (RUP).

Therefore, the registration of Dursban 2G G on anthuriums has been withdrawn and will no longer be pursued. Alternative granular products that control thrips pupae in the soil need to be identified.

Anthurium thrips and banana rust thrips

- Malathion and Topcide, a pyrethroid, provided good control of thrips, and flowers had very little or no injury (Fig. 4).
- Plots treated with Avid had higher numbers of thrips and increased flower damage compared to the other treatments. It still needs to be confirmed whether Avid's lower efficacy was due to innate non-susceptibility of the thrips species to Avid or if insect resistance had developed.
- Anthurium thrips has been almost completely displaced by banana rust thrips on both opened and budding flowers.
- A *Dorcadothrips* sp. was also found during sampling, but more often on leaves and opened flowers, suggesting that it plays only a limited role in damaging flowers at bud stage.

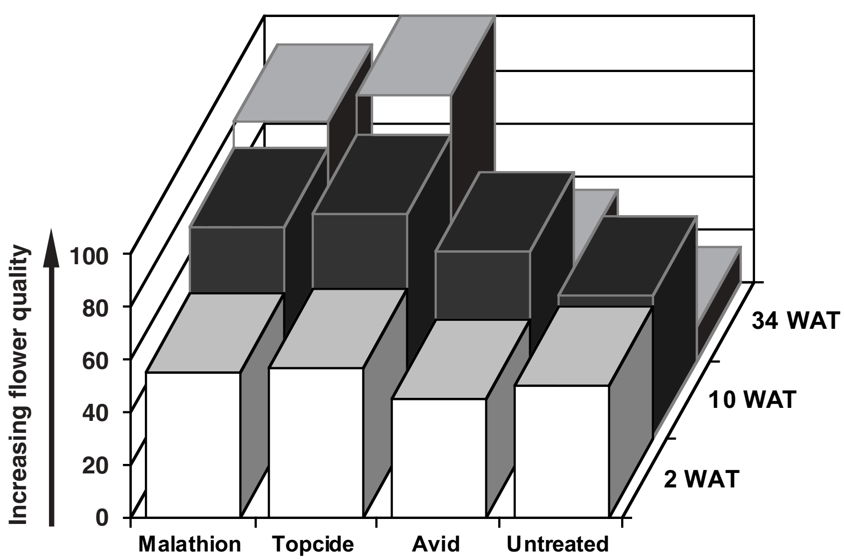
Treatment[1]	**Rate (amount / 100 gallons)**
Untreated check	- - -
Malathion	1.5 pt (24 fl oz)
Topcide*	2.4 oz
Avid	4.0 fl oz

[1]Silwet was added to each spray treatment at a rate of 2 fl oz/100 gal.

*Topcide is no longer available; it has been replaced with Scimitar GC supplemental label.

Location: Pahoa; **Time of year:** January to December 1999; **Treatment applications:** Treatments were applied at two-week intervals using a 2 gal compressed CO_2 sprayer fitted with a 22x hollow cone nozzle, .033 gpm at 40 psi. **Cultivar:** 'Kalapana'. **Plot description:** The four treatments were randomly assigned to one of four rows within four 50 ft established bed plots (volcanic cinder). Each treatment was replicated 4 times. **Evaluation:** Mature flowers were harvested every 2 weeks and were rated for quality based on a 100-point scale: 100 = perfect, <70 unmarketable due to thrips feeding damage, <4 severe thrips damage affecting extent of flower opening. Thrips were sampled and identified. (This research was done in collaboration with Dr. Robert Hollingsworth, USDA, Agricultural Research Service, Pacific Basin Agricultural Research Center.)

Figure 4. Anthurium flower quality after treatment with Malathion, Topcide, or Avid for anthurium thrips and banana rust thrips



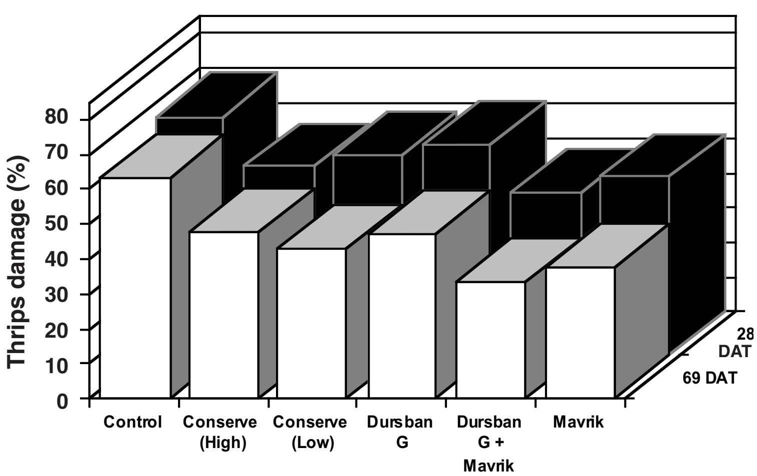
Anthurium thrips and banana rust thrips

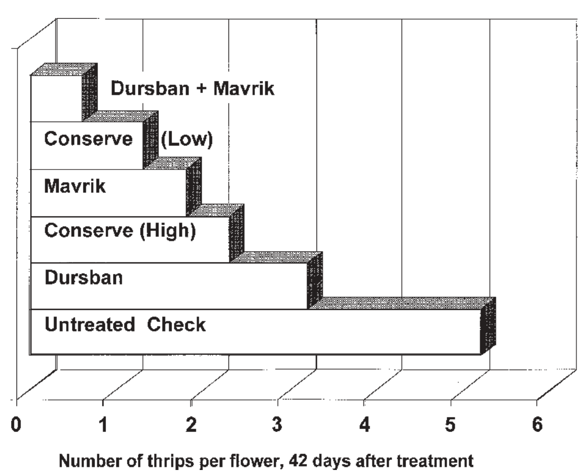
- Thrips damage began to decline for all treatments as compared to the untreated check approximately 39 DAT (Dursban G) and 28 days after the second application of the other treatments, but percent thrips damage was again as high as the untreated control 13 days later (Fig. 5).
- There appeared to be no residual effect after 84 and 95 DAT for Dursban G and other treatments, respectively.
- **Phytotoxicity:** Conserve has demonstrated to be nonphytotoxic to anthuriums and orchids (1997).

Treatment	Rate
Untreated control	- - -
Conserve (High)	11 oz per 100 gallons
Conserve (Low)	6 oz per 100 gallons
Dursban G	217 lb per acre
Dursban G +	217 lb per acre
Mavrik	6 oz per 100 gallons
Mavrik	6 oz per 100 gallons

Time of year: August 1998-January 1999; **Treatment applications:** Conserve and Mavrik treatments were applied twice (11 days apart) by foliar application. Dursban G was applied once on 25 Aug to the cinder media surface. **Cultivar:** 'Marian Seefurth' anthurium plants. **Evaluation:** Anthurium flowers were evaluated for number of thrips and thrips damage every 2 weeks.

Figure 5. Efficacy of Conserve, Dursban G, and Mavrik against banana rust thrips on 'Marian Seefurth' anthurium flowers.





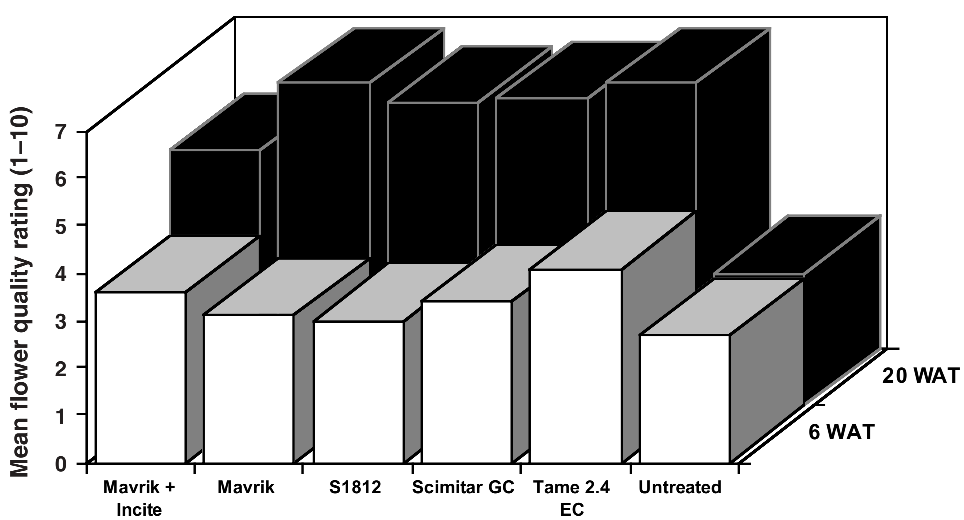
Anthurium thrips and banana rust thrips

- The pyrethroids Tame 2.4 EC, Scimitar GC, and Mavrik, and S-1812, a numbered compound from Valent, performed similarly; no differences in initial or residual efficacy were found (Fig. 6). Each treatment improved flower quality as compared with no treatment for at least 2 months.
- The addition of the synergist, Incite, to Mavrik did not increase flower quality as compared with Mavrik alone.
- Since it takes about 8 weeks for anthurium flowers to develop from flower bud to mature flower, improvements in flower quality were not observed until 8 weeks after the first of the two applications. From 10 through 16 weeks after treatment, all treatments displayed improved flower quality (ranged from 6.0 to 9.0) as compared with no treatment (ranged from 2.6 to 3.4).
- Over the course of the study, a much greater proportion of flowers from treated plants were of marketable quality (ranged from about 44 to 60% marketable) as compared with <2% marketability for the untreated check. In addition, most of the unmarketable flowers from treated plants were harvested during the first 8 weeks after treatment.

Treatment	Rate (fl oz / 100 gal)
Untreated check	- - -
Mavrik + Incite	4.0 + 8.0
Mavrik	4.0
S1812	6.0
Scimitar GC	1.5
Tame 2.4 EC	5.3

Location: Waiakea, HI; **Time of year:** January to July; **Treatment applications:** Tame, Scimitar, S-1812, and Mavirk with and without synergist Incite, were applied twice, 13 days apart**.** Each of the 5 treatements and an untreated check were replicated 4 times; each rep contained 30 plants. **Cultivar:** ‘Marian Seefurth’. **Plot description**: Established anthurium plants were grown in 7 x 7.5 x 14-inch bags on 5 benches in a shade house. **Evaluation:** Flowers (5 per rep) were harvested every 2 weeks and rated for quality (1 = poorest, 10 = highest) and thrips damage.

Figure 6. Anthurium flower quality after two foliar applications of certain pyrethroids with and without Incite (piperonyl butoxide) (ratings $\geq$ 7 represent marketable flowers).

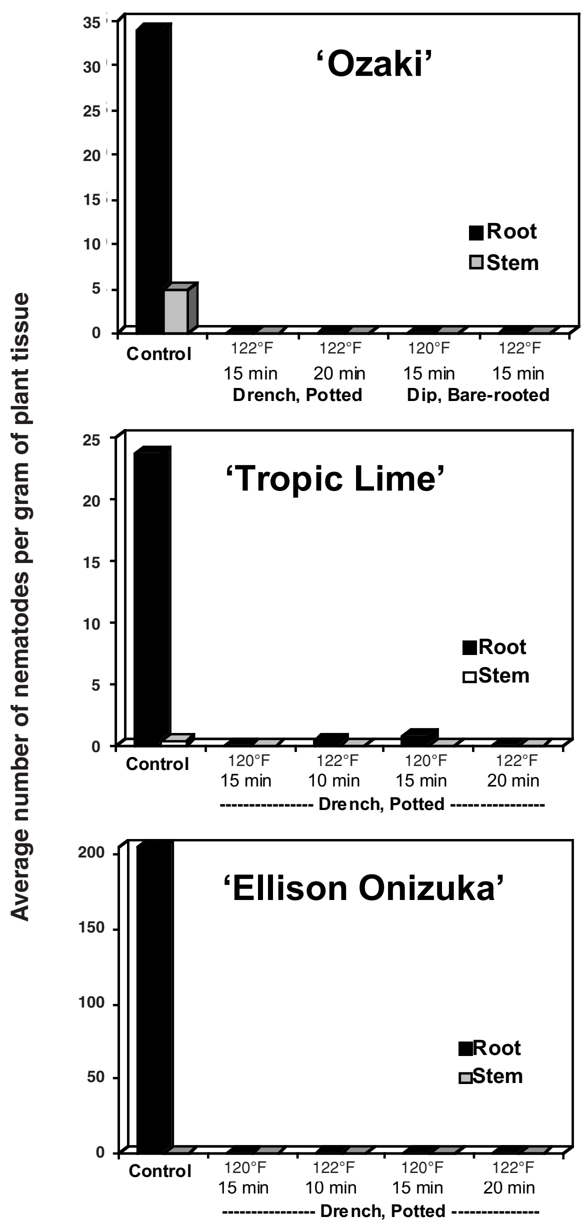


Burrowing nematode

- Drenching potted anthuriums at 120ºF (49ºC) for 15 min or at 122ºF (50ºC) for 15 to 20 min eliminated 95–100% of burrowing nematodes, *Radopholus similis*, infecting the roots and stems of plants (Fig. 7) to <1.0 g^{-1} in infested roots of potted anthuriums. Treatment duration of 5 to 20 min appeared to be equally effective. The random persistence of live nematodes in one or two plants irrespective of treatment temperature and duration combinations still poses a major challenge for quarantine purposes.
- Cooling hot water-drenched potted anthuriums with ambient temperature water reduced the potting media temperature faster (after 10 min) than air-cooling (> 10 min) and may reduce the potential for damage in heat-sensitive anthurium cultivars (Fig. 8).
- One week after hot water drench treatment, 100% efficacy was achieved in all cultivars tested and all plant partitions except for stem sections above the media line (Fig. 9). The exposed stem section did not likely reach target temperatures as it was not in direct contact with the hot water. By 4 weeks after treatment, burrowing nematodes were found in stems above and below the media line and the outer 4-cm-diameter of roots. In a follow-up experiment, when above-ground stems were removed immediately after hot water drenching, no *R. similis* survivors were detected at 1 or 4 weeks after treatment, indicating a possibility that nematodes that survive the treatment migrated within the stem.

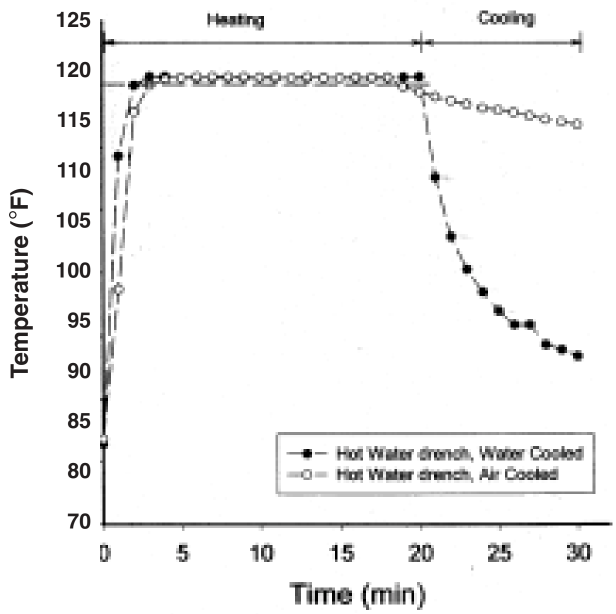
Location: Waiakea, HI; **Time of year:** July 1998 to February 1999; **Treatment applications:** Hot water drenching at 122ºF (50ºC) for 0, 5, 10, 15, or 20 min, or 120ºF (49ºC) for 15 min., with six to eight replicates per treatment, depending on availability; **Cultivars:** 'Ozaki', 'Tropic Lime', 'Ellison Onizuka'; **Plot description:** Plants were grown in 1.6-L plastic pots in a peat moss: volcanic cinder or sponge rock (50:50) media mix. Each pot was inoculated with 2,500 burrowing nematodes of mixed life stages suspended in 3 ml of water and poured at the base of the plant. Four months after inoculation, the media and roots in each pot were drenched with a continuous stream of hot water at the temperatures and durations described above. Immediately after heat treatment, plants were cooled for half the treatment time by running a constant flow of ambient temperature water through the pots. All plants were placed in a shade house on raised benches separate from the untreated controls and subjected to routine cultivation practices. **Evaluation:** Four months after hot water treatment, each anthurium plant was removed from its pot, separated into roots and shoots, and assayed for surviving nematodes. Burrowing nematodes were collected and counted with the aid of a dissecting microscope.

Figure 7. Effect of hot water drenching or bare root dipping at 120ºF (49ºC) or 122ºF (50ºC) on number of nematodes in three anthurium cultivars.



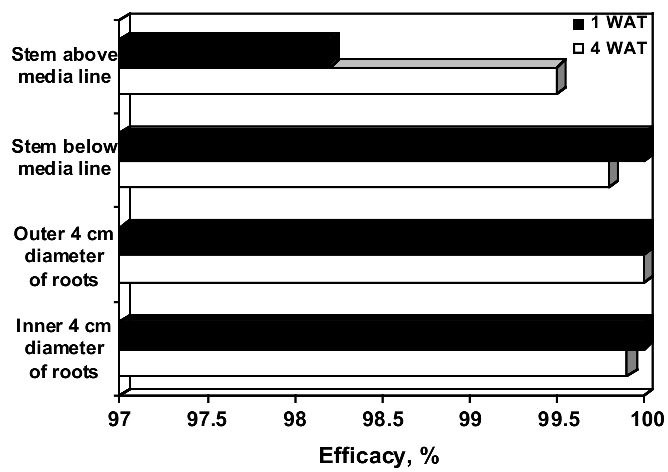
Treatments: Anthurium plants in 6-inch pots (50% peat:50% perlite media mix) were subjected to hot water drenching at 122ºF (50ºC) for 20 min followed with cooling either by ambient temperature water for half the treatment duration or by air. **Evaluation:** The temperature of each pot was monitored with five thermocouple probes to determine the temperature profile in the potting medium and root ball during heating and cooling. Temperatures were recorded at 1 min intervals for 20 min using a data logger (Model OM500, Omega Engineering, Stamford, CT). **Reference:** Tsang, M.C.C., A.H. Hara, and B. Sipes. 2002. Hot water treatments of potted palms to control the burrowing nematode, *Radopholus similis*. Crop Protection 22(4):589–593.

Figure 8. Temperature profile in potting media (50% peat / 50% perlite) during heat treatment of 122ºF (50ºC) for 20 minutes and cooling.



Location: Waiakea, HI; **Cultivars:** 'Misty Pink', 'Lady White', 'UH #1311', and 'Tropic Fire'; **Plot description:** Anthurium plants in 6-inch pots (50% peat:50% perlite media mix) were inoculated with 2,000 burrowing nematodes of mixed life stages suspended in 3 ml of water and poured at the base of the plant. Two months later, hot water treatments were applied with a recirculating hot water drenching system. Forty plants of each cultivar were tested; **Treatment:** Hot water drenching at 120ºF (49ºC) for 12 min. followed by cooling with ambient temperature water for 12 min; **Evaluation:** In order to identify the location within anthurium plants of any surviving burrowing nematodes after hot water drenching, samples from (1) outer 4 cm diameter of roots, (2) inner 4 cm diameter of roots, (3) stem below the media line, and (4) lower 5 cm of stem above the media line were taken 1 week and 4 weeks after heat treatment. Each section was assayed for burrowing nematodes. **Reference:** Arcinas, A.C., B.S. Sipes, A.H. Hara, and M.M.C. Tsang. 2004. Hot water drench treatments for the control of *Radopholus similis* in rhapis and fishtail palms. HortScience 39(3):578–579.

Figure 9. Efficacy of hot water drench at 120.2°F for 12 minutes on burrowing nematodes in potted anthuriums (cultivars combined).



Percent efficacy =

$$1 - \frac{(\text{Total number of live nematodes recovered}) \times 100}{\text{Mean number of live nematodes in control*}}$$

*control treated with ambient temperature water (77ºF) for 12 min.

Phototoxicity trials

Insecticides and acaricides

For more information on phytotoxicity of other insecticides and miticides on anthuriums see *Phytotoxicity of insecticides and acaricides to anthuriums* by Hata et. al. 1988, University of Hawaii, CTAHR, Research Extension Series 097.

Distance and Marathon

- Distance and Marathon were non-phytotoxic to all anthurium cultivars evaluated.

Location: Kurtistown and Panaewa, HI; **Time of year:** February to April 1997; **Treatment application** Distance and Marathon II were applied once to 12 to 16 plants per cultivar at 2x their label rate (18 fl oz, 3.4 fl oz per 100 gal, respectively). **Plot description:** Established anthurium plants grown in irrigated, poly-covered greenhouses in Kurtistown in pots or in growing beds, or in shadehouses at the Pana‘ewa nursery (only ‘Oishi Blush’ was protected from rainfall by a poly covering). Equal number of adjacent plants were left unsprayed as a means for comparison. **Evaluation:** Plants were evaluated for phytotoxic symptoms 4 times at weekly intervals starting at 1 week after treatment. Approximately 450 plants with 830 flowers within each treatment were observed.

Pinpoint and Pylon

- Phytotoxic symptoms for Pinpoint included bronzing of lower leaf and flower surfaces, curling and stunting of leaves and flowers, and appeared 2 weeks after application.
- All or most of the replicates for ‘Tropic Mist’, ‘Tropic Ice’, and ‘Ozaki’ were affected; only 2 of 12 replicates for ‘Alii’ were affected.
- All other cultivars evaluated exhibited no signs of phytotoxicity.
- Pylon was non-phytotoxic to all cultivars tested.

Location: Waiakea , HI; **Time of year**: May to June 1996 (Pinpoint), August to September 1996 (Pylon); **Treatment applications:** Pinpoint was applied once to 12 plants per cultivar at 3x its recommended rate (12 g per 12” diameter pot) then watered lightly after application. Pylon was applied twice (5 days apart) to 18 plants

Table 2. Phytotoxicity[1] of insecticides and miticides on anthurium cultivars.

Anthurium cultivar*	Pinpoint 15 G	Pylon[2]	Distance	Marathon II
Rate:	3x label	4x label	2x label	2x label
Amt. / 100 gal:	—[3]	20.5 fl oz	18 fl oz	3.4 fl oz
780			S	S
965	S			
1069	S			
1155			S	S
1244			S	S
1269			S	S
Alii	U	S		
Arcs	S	S	S	S
Blushing Bride			S	S
Ellison Onizuka[4]				
Gemini	S	S		
Jasmine			S	S
Kaumana		S		
Kalapana	S	S	S	S
Lady Anne			S	S
Lehua			S	S
Lady Jane			S	S
Lavender Lady			S	S
Leilani			S	S
Lola			S	S
Midori			S	S
Melody			S	S
Misty Pink		S		
Marian Seefurth[5]	S	S	S	S
Miura			S	S
Nicoya			S	S
North Star			S	S
Oishi Blush			S	S
Oshiro Red			S	S
Ozaki	U	S		
Pacora			S	S
Rainbow Obake[4]			S	S
Rising Sun			S	S
Rudolph		S		
Small Talk (Pink, Red, Salmon, Lavendar)			S	S
Tropic Ice	U	S	S	
Tropic Mist	U			

*Potted plant cultivars are in **bold print**; others are cut flower cultivars grown in beds.
[1]Relative safety: S = safe, L = low phytotoxicity, M = moderate phytotoxicity, U = unsafe.
[2]For greenhouse use only.
[3]Pinpoint 15 G at 3x label rate = 2-1/4 tsp per 12” diameter pot.
[4]Cinnamite was also found to be safe (S) on ‘Ellison Onizuka’ and ‘Rainbow Obake’.
[5]Spinosad was also found to be safe (S) on ‘Marian Seefurth’.

per cultivar at 4x its recommended rate (20.5 fl oz per 100 gal) to anthurium plants in 7.6-L plastic bags. Pylon was also applied twice (5 days apart) to plants ('Blushing Bride' only) in growing beds at 1, 2, and 4x recommended rates. There were three replicates of 24 plants per treatment. In both cases, Pylon was applied to just before runoff occurred (25 ml per sq ft) using a backpack sprayer fitted with a 8004 Teejet nozzle at 40 psi; **Plot description:** Established anthurium plants grown in irrigated, poly-covered greenhouses in pots, plastic grow bags, or in growing beds (volcanic cinder). Equal numbers of adjacent plants, serving as controls, were sprayed with water as a means for comparison. **Evaluation:** Plants were observed for phytotoxic symptoms at weekly intervals for 5 weeks starting at 1 week after treatment.

Heat treatments

Some heat injury was observed on young shoots that were submerged during the drenching process, but there were minimal negative effects on the growth (measured by number of new leaves, and root and leaf + stem weights) of potted anthuriums which did not affect their overall market quality (Fig. 10).

Figure 10. Effect of hot water drenching or bare root dipping at 120°F (49°C) or 122°F (50°C) on anthurium plant quality (table continued on next page).

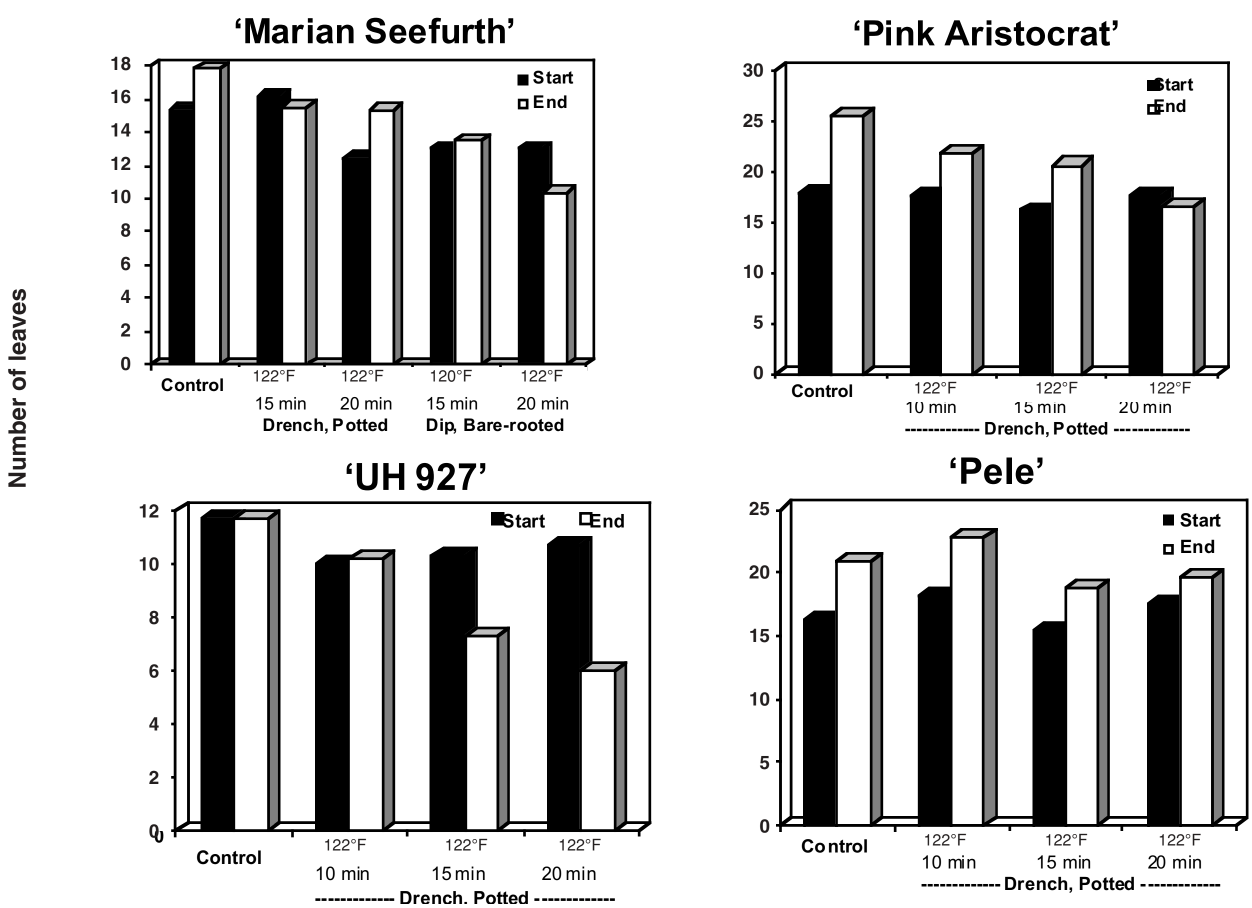
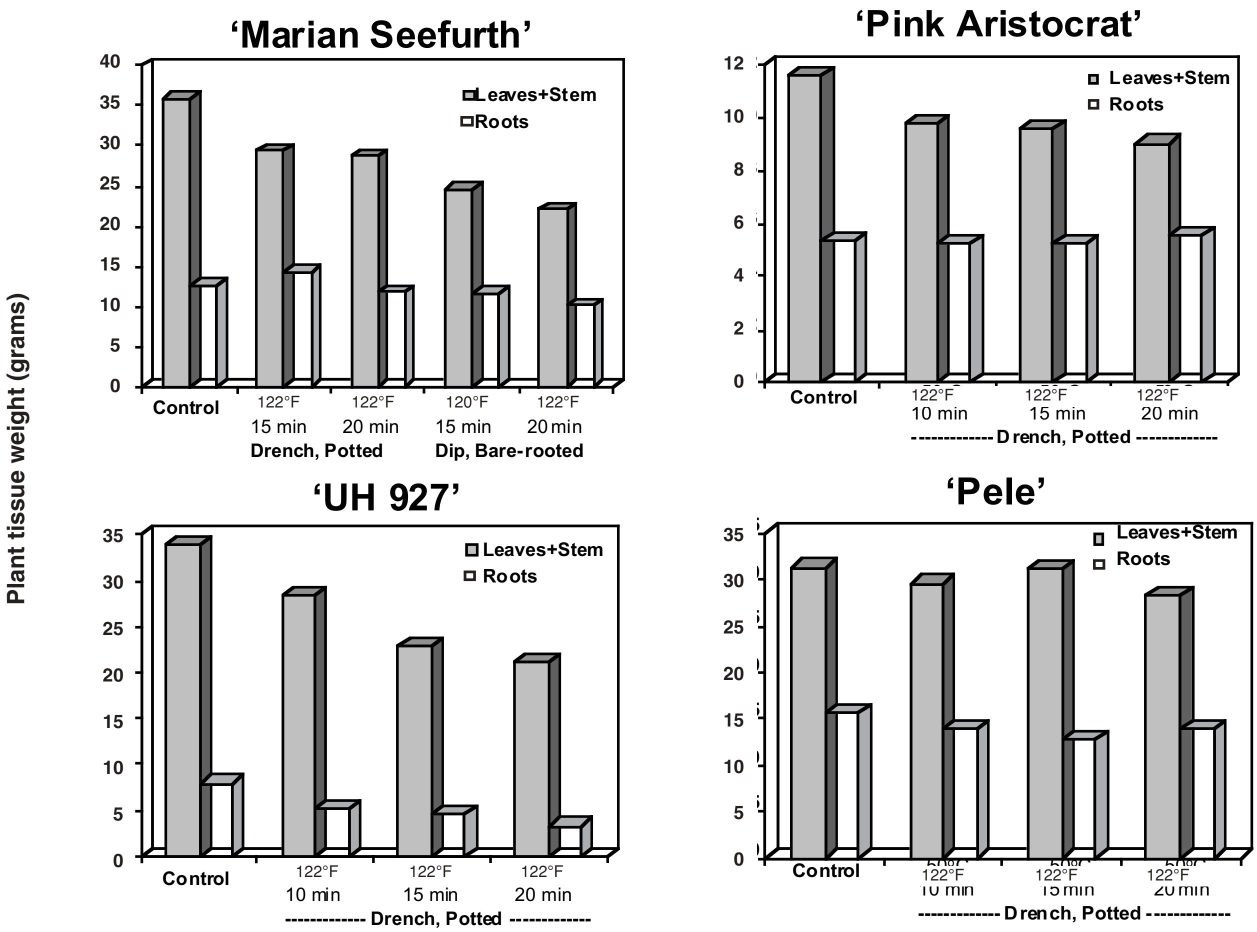


Figure 10 (continued). Effect of hot water drenching or bare root dipping at 120°F (49°C) or 122°F (50°C) on anthurium plant quality.



In addition, potted plants of the following anthurium cultivars were treated with a hot water drench with no observed heat damage:

Cultivar	Hot water drench temperature and duration
'Lady White'	120°F (49°C), 12 min
'Waimea'	120°F (49°C), 12 min
'Tropic Fire'	120°F (49°C), 12 min
'Misty Pink'	120°F (49°C), 12 min

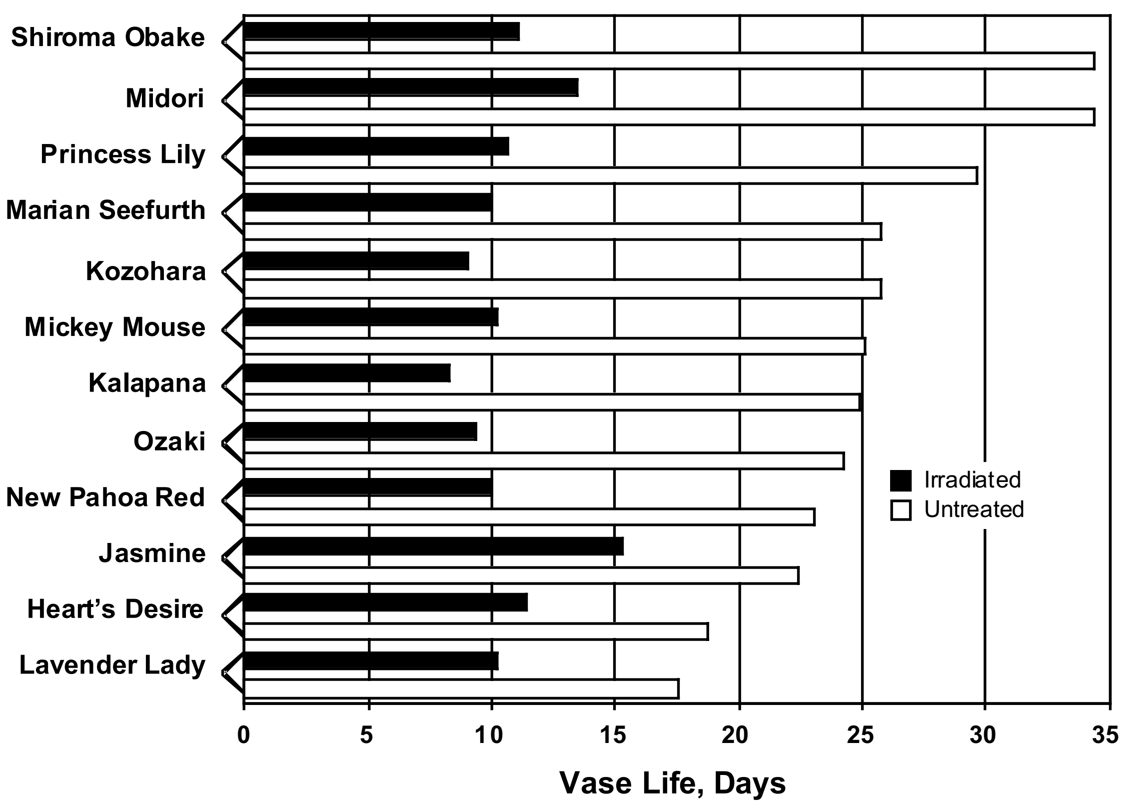
Location: Waiakea, HI; Time of year: June to October 1998; **Treatment applications:** Hot water drenching at 120°F (49°C) for 12 min followed by cooling with ambient temperature water for 6 min. Replicates consisted of 6 plants per cultivar per treatment; **Plot description:** Plants were grown in 1.6-L plastic pots in a peat moss: volcanic cinder or sponge rock (50:50) media mix. After treatment, all plants were placed in a shade house on raised benches and subjected to routine cultivation practices. **Evaluation:** Plants were observed every two weeks for signs of heat damage. Three months after hot water treatment, plants were removed from pots, separated into roots and shoots, and dried in a forced-air oven at 122°F (50°C) to determine dry matter. Numbers of leaves were counted prior to heat treatment and after 3 months at the end of the observation period.

Irradiation

- All tested cut anthurium cultivars were found to be intolerant of irradiation (electron beam) at 448 Grays, as indicated by shortened vase life (Fig. 11).
- Among the anthurium cultivars tested, irradiation damage symptoms varied from immediate browning of the delicate flowers on the spadex to premature yellowing or discoloring and wilting of the spathe.

Treatment: Ten stems of each anthurium cultivar were packed in shipping boxes and subjected to 448 Gy in Hawaii Pride's Surebeam electron beam/X-ray treatment. **Evaluation:** The flowers were held for 3 days in boxes, unpacked and placed in vases to observe quality and vase life.

Fig. 11. Average extent of vase life for irradiated (448 Gy) and untreated cut anthurium flowers of several cultivars



Chemical and non-chemical pest management strategies for anthuriums

General pest management methods

1. Monitoring pest populations or pest damage regularly is the key to a successful pest management program. Readily recognize pests and their damage. See Identifying Anthurium Flower Damage by Bushe et al. 1987, UH-CTAHR (HITAHR) Brief No. 073, for color photos of pests (also available at http://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-25.pdf.
2. Base spray applications on pest population levels and damage and not on a calendar schedule. See Reduced Pesticide Use in an IPM Program for Anthuriums by Hara et al. 1990 Journal of Economic Entomology 83:1531–1534.

General cultural control methods

1. Inspect all incoming plants and propagative material to ensure that they are free of pests. Designate a segregated holding area that can be used to monitor plants for any infestations that may develop within 1–2 weeks, then treat or discard infested plants.
2. Keep production area and surroundings, such as inside and outside of shade houses, free from weeds and other plants that may harbor pests.
3. Discard debris and old plant material from in and around shade houses promptly.
4. Seal pruned, infested or damaged plant parts in plastic bags and discard promptly to avoid spreading the pest.
5. Keep plants healthy and stress-free (optimal water, fertilizer, shade/sun conditions) to help them resist or recover from infestations.

General biological control methods

1. Encourage natural predators (lady beetles, lacebugs, spiders, pseudoscorpions, predatory mites) and parasitoids (wasps), of pests by avoiding over-spraying of broad spectrum carbamate, organophosphate, and pyrethroid pesticides.
2 Use pesticides that are not harmful to natural enemies including neem products, spinosyns, systemic insecticides applied as a drench and insect growth regulators.

General chemical control methods and resistance management

1. Read and follow the Pesticide Label! Following the label assures proper and legal use.
2. Spray pesticides only as needed. Do not tank-mix unless no single pesticide controls the pest.
3. When label permits, make 2 to 3 applications of an insecticide/miticide in sequence (10 to 14 days apart), then rotate to products with different modes of action (see Table 4 and the diagram on p. 21). Try to avoid applying the same insecticides/miticides to more than one generation of the pest.
4. For effective use of insecticides/miticides, proper timing of application is important by understanding the life cycle and the stages that are susceptible to the specific insecticides/miticides.

Table 3. Pest management strategies (non-chemical and chemical controls) for pests on anthuriums. Chemical controls are pesticides that are registered for use on ornamentals, which includes anthuriums. Pesticides with asterisk (*) indicate those that were tested in Hawaii or elsewhere and found effective against the pest.

Pest	Damage or problem	Non-chemical control	Chemical controls[1]
Aphids	Sooty mold caused by honeydew secretions; spotting cause by sucking mouthparts.	Highly parasitized by wasps and predated on by lady beetles and lacewings. Remove severely infested flowers and leaves.	Discus Marathon* Neem products Orthene* pyrethrins, pyrethroids oils, soaps* TriStar*
Thrips, anthurium and banana rust	White streaking of flower spathe; damage inflicted early in bud stage. Thrips may be present on mature, open flowers. Banana rust thrips may be more prevalent than anthurium thrips; gross characteristics of damage may be indistinguishable between species.	Remove severely infested buds. Thrips pupate in media below plant; apply control measures to media and emerging bud area.	Avid Conserve* Discus Malathion* Marathon pyrethroids* TriStar
Whitefly, anthurium	Waxy secretions in leaf sheath area; quarantine problem.	Remove severely infested plants.	Discus Distance* Marathon* Orthene* Talus Tristar
Beetle, black twig borer	Tiny hole in petiole associated with deafh of petiole & leaf distant to hole.	Strict sanitation; fallen petioles contain live beetles. Dispose of all infested petioles prior to insecticide application.	Discus Dursban/DuraGuard* Marathon pyrethroids
Mite, false spider and citrus red	Bronzing of upper and lowerr surfaces of leaf and flower spathe. Citrus red mite cause bronzing primarily on the upper leaf surface.	Monitor plants for mite damage on upper and lower surfaces of flower spathe. Initiate control measures if damage is detected. If unsprayed, fast-moving brown predatory mites & lady beetles may be present especially at high pest population	Avid* Floramite* Hexygon* Ovation Sanmite Tetrasan
Nematode, burrowing	Stunting of plants due to root damage and rot.	A 3–6 month bare, weed-free fallow period with well-decomposed plant parts will eliminate nematodes. Plant only nematode-free stocks. Hot water treatment at 120°F for 15 min will disinfest stems. Tests show that hot air at 122°F, 60% r.h. for 15 min may also disinfest stem.	Avid Ditera

[1]**CHEMICAL CONTROL RECOMMENDATIONS CHANGES FREQUENTLY DUE TO REGISTRATION ISSUES. READ THE LABEL BEFORE APPLYING THE PESTICIDE.** The user is responsible for the proper use, application, storage, and disposal of pesticides

Table 4. Suggested and tested insecticides, miticides, and nematicides for anthuriums. Read the pesticide label before use; labels are available at http://www.cdms.net/manuf/default.asp. See p. 21 for diagram of mode of action.

Trade Name **EPA Reg. No.** **Site use*** **Manufacturer**	**Common Name**	**Chemical Class and Plant Movement**	**Mode of Action** *(see diagram)* **and Mode of Entry**	**Target Pests on Label**
Avid EC** 100-896 GH,SH, O Syngenta	abamectin	Glycoside or macrocyclic lactone Translaminar	Nerve (A4) Contact, Ingestion	aphids, leafminer, mites, thrips (not anthurium or banana rust thrips), whiteflies
Cinnamite DISCONTINUED	cinnamal-dehyde			
Conserve SC 62719-291 SH, O Dow AgroSciences	spinosad	spinosyns Translaminar	Nerve (A2) Contact, Ingestion	caterpillars, thrips, leafminers, spider mites
Decathlon WP 3125-430-59807 GH, I, O, N Olympic	cyfluthrin	pyrethroid	Nerve (A3) Contact	aphids, caterpillars, beetles, grasshoppers, fungus gnats, lace bugs, leafhoppers, spittlebugs, thrips, weevils whiteflies
Dicofol 4 EC DISCONTINUED	dicofol			
Dimethoate 400 DISCONTINUED	dimethoate			
Discus 432-1392-59807 O, N Olympic	cyfluthrin & imidacloprid	pyrethroid & chloronicotinyl Systemic	Nerve (A3) & (A2)	ants, aphids, beetles, caterpillars, fungus gnats, grasshoppers, lace bugs, leafhoppers, leafminers, mealybugs, scales (immature), spittlebugs, thrips, whiteflies
Distance 59639-96 GH, I, SH,O Valent	pyriproxyfen	insect growth regulator Translaminar	Juvenile hormone mimic (E) Contact	scale insects, whiteflies fungus gnats (not adults)
DiTera WDG 73049-55 O Valent	*Myrothecium verrucaria*	fungus	Nematicide Contact	nematodes: burrowing, reniform
Dursban*** **50 WP** 62719-72 GH,SH, O Dow AgroSciences **TNP** 34704-66-65783 N, O Verdicon	chlorpyrifos	organophosphate	Nerve (A1) Contact	Broad spectrum, including ants, aphids, scale insects, beetles, borers, caterpillars, fungus gnats, foliar mealbugs, mealybugs, root mealybugs, weevils
Dursban G 34704-66-65783 *NOT REGISTERED FOR ANTHURIUMS* Verdicon	chlorpyrifos	organophosphate	Nerve (A1) Contact	ants, armyworms, cutworms, fleas, grasshoppers, millipedes, sowbugs
Floramite 400-481 GH, I, SH, O, N Uniroyal	bifenazate	carbazate	Nerve (A4) Contact	spider mites
Hexygon[+] 10163-251 GH, I, SH, O, N Gowan	hexythiazox	carboxamide	Ovicide Contact	spider mites
Incite 34704-454-36208 Loveland	piperonyl butoxide	a synergist	Interferes with mixed function oxidase Contact	

Trade Name **EPA Reg. No.** **Site Use*** **Manufacturer**	**Common Name**	**Chemical Class and Plant Movement**	**Mode of Action** *(see diagram)* **and Mode of Entry**	**Target Pests on Label**
Joust DISCONTINUED	morestan			
Malathion EC See label	malathion	organophosphate	Nerve (A1) Contact, Ingestion	Broad spectrum, including thrips
Marathon II 3125-492-59807 GH, I, O, N Olympic	imidacloprid	chloronicotinyl Systemic	Nerve (A2) Contact	aphids, beetles, lacebugs, leafhoppers, leafminers, mealybugs, thrips, whiteflies
Mavrik Aquaflow 2724-478 GH, O Wellmark	fluvalinate	pyrethroid	Nerve (A3) Contact	aphids, beetles, caterpillars, thrips, mealybugs, mites, whiteflies,
Neem, Neem oil products	azadirachtin	botanical Systemic	IGR (E) Contact	Broad spectrum: aphids, mites, whiteflies
Orthene 59639-91 GH, O Valent	acephate	organophosphate Systemic	Nerve (A1) Contact	aphids, beetles, mealybugs, scale (crawlers), thrips, whiteflies
Ovation SC+ 66222-53-58185 GH, SH, O, N Scotts	clofentezine	tetrazine	Energy production (D), Ovicide Contact	spider mites (eggs, early stages)
Oils, horticultural	paraffinic oil		Physical damage (B)	aphids
Pinpoint 15 G **DISCONTINUED**				
Precise 4 G 73614-1 GH, SH, O Pursell Technologies	acephate	organophosphate Systemic	Nerve (A1) Contact	aphids, lacebugs, mealybugs, ants
Pylon 241-374-59807 GH Olympic	chlorfenapyr	pyrrole Translaminar	Energy production (D) Contact	spider, broad, cyclamen, citrus bud and rust mites; caterpillars, foliar nemtodes, fungus gnats
S-1812 (Experimental) *NOT REGISTERED* Valent				caterpillars, thrips
Sanmite 7969-106 GH, O BASF Corporation	pyridaben	pyridazinone	Energy production (D) Contact	mites, spider mites
Scimitar GC 10182-400 Suppl. GH, SH, O, N Syngenta	lambda-cyhalothrin	pyrethroid	Nerve (A3) Contact	aphids, beetles, caterpillars, soft scales, leafminers (adult), scales (crawlers), thrips, mealybugs, whiteflies, spider mites
Silwet L-77 Loveland		silicone surfactant	Wetting/Spreading Contact	
Soaps	potassium salts of fatty acids		Physical damage (B)	aphids
Talstar F*** 279-3155 GH, O FMC Corporation	bifenthrin	pyrethroid	Nerve (A3) Contact	ants, aphids, beetles, caterpillars, fungus gnats, leafhoppers, leafminers, mites, spider mites, mealybugs, scales, spittlebugs, thrips, whiteflies

Table 4 (continued).

Trade Name EPA Reg. No. Site Use* Manufacturer	Common Name	Chemical Class and Plant Movement	Mode of Action *(see diagram)* and Mode of Entry	Target Pests on Label
Talus 71711-15-67690 GH, O SePro	buprofezin	thiadiazine	IGR (E), ovicide, suppress oviposition of adults	nymphs of: leafhoppers, mealybugs, scale, whiteflies,
Tame EC 59639-77 I, SH, O, N Valent	fenpropathrin	pyrethroid	Nerve (A3) Contact	aphids, beetles, lacebugs, leafhoppers, mealybugs, mites, spider mites, scales, thrips, whiteflies
TetraSan 5 WDG 59639-108 GH, SH Valent	etoxazole	2,4-diphenyl-oxazoline derivative Translaminar	mite growth regulator (E), ovicide	spider mites
Topcide DISCONTINUED	lambda-cyhalothrin	See Scimitar GC		
TriStar 70 WSP 8033-22-1001 GH, SH, O, N Cleary	acetamiprid	chloronicotine Translaminar	Nerve (A2) Systemic	aphids, mealybugs, leafhoppers, thrips, whiteflies

* Labeled for site use: GH=greenhouse, SH=shadehouse, I=indoor, O=outdoor/landscape, N=nursery

** Formulations: EC=emulsifiable concentrate; F=flowable; ME=microencapsulated; SC=suspension concentrate; WDG=water dispersible granule; WP=wettable powder; WSP=water-soluble powder

*** **Restricted Used Pestcide due to human and/or bird and fish toxicity.**

\+ Do not rotate Hexygon and Ovation SC

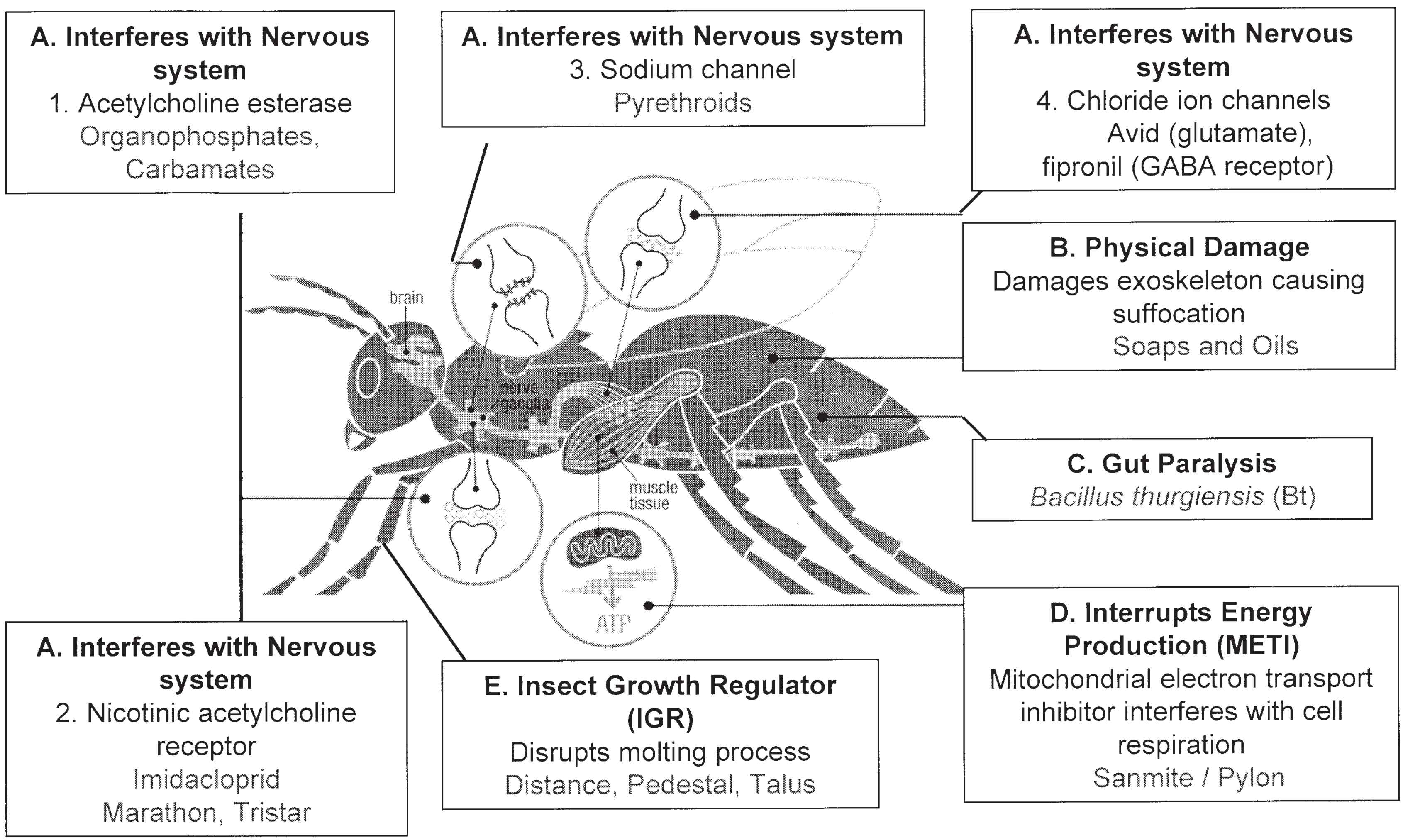
Precautionary statement

Consult a chemical sales representative, the Hawaii Department of Agriculture, or the University of Hawaii Cooperative Extension Service for correct formulation of pesticides, more information, or updated recommendations. The user is responsible by law to read and follow all current label directions for proper use, application, storage, and disposal of pesticides. The label is the law! To avoid injury to your crop by a pesticide always conduct a small scale test before making large scale application. Test should be conducted at the label rate and sprayed at least twice according to interval specified on the label. Allow 5 to 7 days for symptoms to appear. For systemic insecticides, allow 14 to 21 days for symptoms to appear.

Disclaimer

This publication contains pesticide recommendation that are subject to change at any time. These recommendations are provided only as a guide. Due to constantly changing labels and product registration, some of the recommendations given in this publication may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation MUST be disregarded. Brand names are used for product name recognition and their use is not intended to discriminate against similar products not mentioned or to be a recommendation of only those products mentioned. The authors, the College of Tropical Agriculture and Human Resources, University of Hawaii, and the United States Department of Agriculture assume no liability resulting from the use of these recommendations.

MODE OF ACTION OF INSECTICIDES



Adapted from: Sanmite, A resistance management weapon in the battle for mite and whitefly control. Scotts-Sierra Crop Protection Co., Marysville, OH

Glossary

Active ingredient (AI) Chemicals in a product responsible for the pesticidal effect.

Biological control The control of pests (pathogens, mites, insects, vertebrates, weeds) by employing natural enemies including predators, parasites and pathogens.

Biopesticide Biological pesticides are chemicals naturally derived from bacteria, virus, fungi, and protozoa and can be used as pest control agents. Biochemicals are chemicals that are either naturally occurring or synthesized to be identical to naturally-occurring substances.

Broad spectrum insecticide Nonselective insecticide having the same toxicity to a wide range of insect species.

Chemical class A group of pesticides with similar chemical structure or mode of action.

Contact poison An insecticide that kills an insect by entering the body through the integument (or exoskeleton).

Efficacy The degree of effectiveness of an insecticide against a particular pest.

Ingestion Refers to insecticides that enters an insect by being eaten.

Insect growth regulator (IGR) Chemical substance that disrupts the action of insect hormones controlling molting, maturity to adult and other growth functions. Some IGRs inhibit chitin synthesis, which is the main constituent of the shell of insects and contributes to strength and protection to the insect.

Integrated pest management (IPM) A programmatic approach to pest control that has as its foundation the use of biological control methods, plant breeding, and the judicious application of pesticides, especially selective pesticides.

Mode of action The means by which a pesticide affects the biological process of an organism and kills it.

Organophosphate An insecticide that is an organic derivative of phosphoric or similar acids; acts by interfering with an insect's nervous system.

Pesticide Any substance used for controlling, preventing, destroying, repelling, or mitigating any pests. Includes fungicide (fungi), herbicide (weeds), insecticide (insects), miticide (mites), molluscicide (slugs and snails), nematicide (nematodes).

Phytotoxicity Injury to plants caused by application of a chemical.

Pyrethrin A natural botanical insecticide, with active ingredients extracted from chrysanthemum flowers.

Pyrethroid An organic synthetic insecticide with a structure based on natural pyrethrins but with improved insecticidal properties.

Reduced-risk pesticide A pesticide that has a reduced level of risk to the environment, humans and other nontarget organisms.

Surfactant An ingredient that aids or enhances the surface-modifying properties of a pesticide formulation (stickers, spreaders, wetting agents) to improve its effectiveness.

Synergist A compound that enhances another chemical's effectiveness; certain synergist (e.g. piperonyl butoxide) is used in combination with pyrethrinds or pyrethroids to prevent insects from detoxifying the insecticide.

Systemic Insecticides or miticides that are absorbed by the roots and translocated throughout the plant (usually except flowers).

Translaminar Local, systemic movement of an insecticide from the upper surface of a leaf to underside of that leaf.

Wetting agent An additive that causes liquid spray mixtures to contact plant surfaces more thoroughly.

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Ware, G. W. 1989. The pesticide book, Thomson Publications, Fresno, CA.

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List of manufacturers

BASF Corporation
P.O. Box 13528
Research Triangle Park, NC 27709

Cleary Chemical Corporation
178 Ridge Road
Dayton, NJ 08810-1501

Dow AgroSciences LLC
9330 Zionsville Road
Indianapolis, IN 46268

FMC Corporation
1735 Market Street
Philadelphia, PA 19103

Gowan Company
P.O. Box 5569
Yuma, AZ 85366-5569

Loveland Industries, Inc.
P.O. Box 1289
Greeley, CO 80632-1289

Olympic Horticultural Products
P.O. Box 230
Mainland, PA 19451

Pursell Technologies
P.O. Box 1187
Sylacauga, AL 35150

Scotts-Sierra Crop Protection Company
14111 Scottslawn Road
Marysville, OH 43041

SePRO Corporation
11550 N. Meridian Street, Suite 600
Carmel, IN 46032

Syngenta Crop Protection, Inc.
P.O. Box 18300
Greensboro, NC 27419

Uniroyal Chemical Company, Inc.,Crompton Corp.
199 Benson Road
Middlebury, CT 06749

Valent USA Corporation
P.O. Box 8025
Walnut Creek, CA 94596-8025

Verdicon (formerly United Horticultural Supply)
9335 Elm Court
Denver, CO 80260

Wellmark International
12200 Denton Drive
Dallas, TX 75234