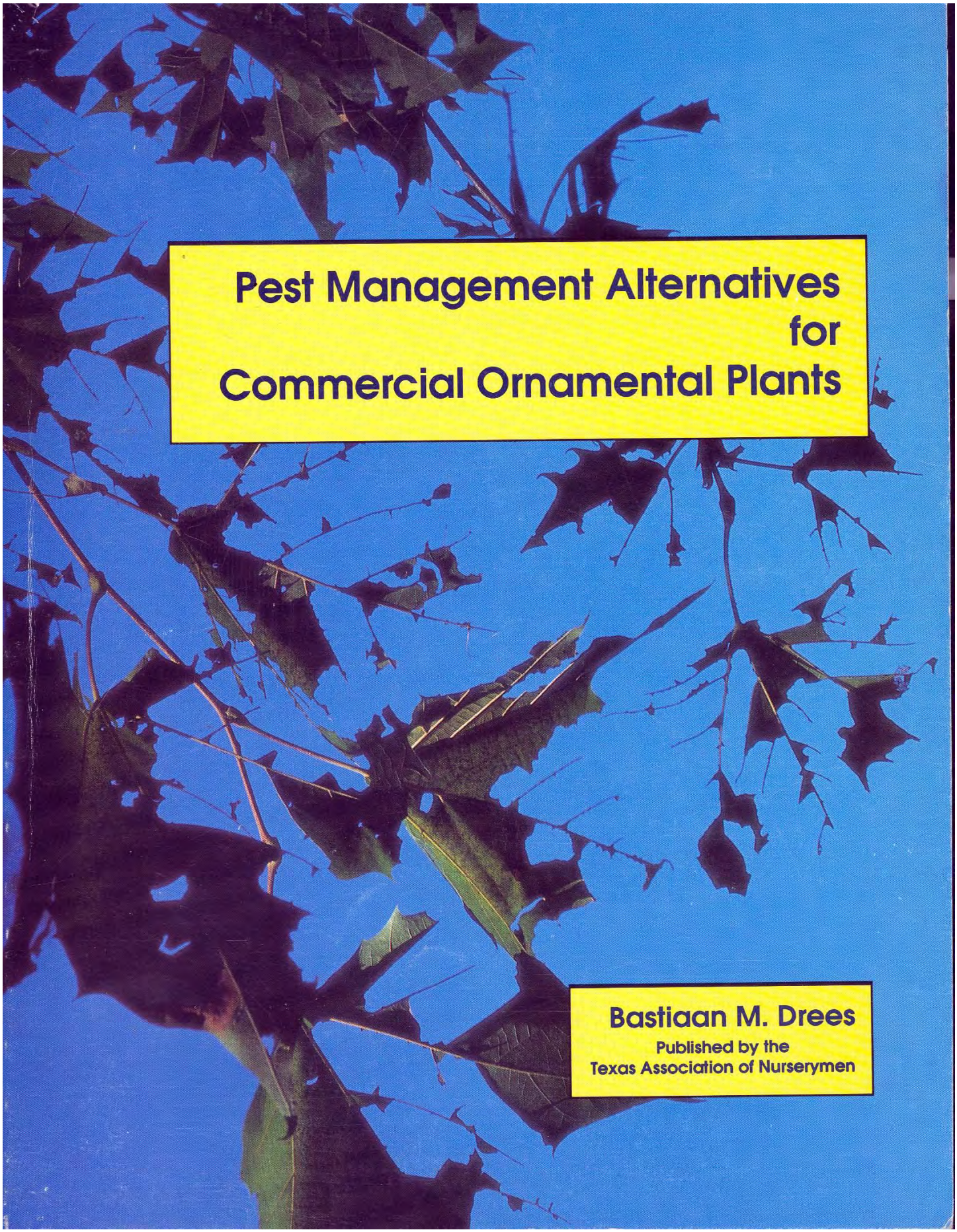


Pest Management Alternatives for Commercial Ornamental Plants

Bastiaan M. Drees

Published by the
Texas Association of Nurserymen

Pest Management Alternatives for Commercial Ornamental Plants

Bastiaan M. Drees
Extension Entomologist
and Associate Professor
Texas A&M University System

Texas Agricultural Extension Service
&
Texas Agricultural Experiment Station
The Texas A&M University System
College Station, Texas

Published by the
Texas Association of Nurserymen

Published by Texas Association of Nurserymen
7730 South IH-35
Austin, Texas 78745-6698
(512) 280-5182

Contents

Introduction

The information in this manual is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Texas Agricultural Extension Service or the Texas Association of Nurserymen is implied.

Suggested pesticides must be registered and labeled for use by the Environmental Protection Agency and the Texas Department of Agriculture. The status of pesticide label clearances is subject to change and may have changed since this publication was printed.

The user is always responsible for the effects of pesticide residues on crops, as well as problems that could arise from drift or movement of the pesticide from the user's property to that of others. Always read and follow carefully the instructions on the product label.

Acknowledgments

The author appreciates review comments from C. L. Cole, R.L. Crocker, J.A. Jackman, M. E. Merchant, and R.E. Richter. Pesticide information was reviewed by F.W. Plapp, Jr. and citations of plant names by D.C. Wilkerson. P.J. Hamman wrote the section on LD_{50} values; the *Pesticide Compatibility with Adjuvants* section was modified from C.T. Allen, *Pesticide Adjuvants*; and the Phytotoxicity chapter written, in part, by B.S. Sparks. The section *Commercially Available Natural Enemies*, was modified from Henn and Weinzieri (1990). Editorial comments by J. Winn are also much appreciated.

Products listed in these tables are merely examples containing active ingredients listed by common name of the pesticide. Other products containing similar ingredients were not omitted or neglected for any particular reason other than economy of space and availability of current product label. Please provide the author with any suitable additions or corrections.

How to Use this Book

To determine treatment for a pest:

1. Identify the pest.
2. Refer to the chart on the following pages to find which tables contain information about that pest. **Note:** Pests are listed in more than one table. To find the maximum alternative treatment approaches and products, read all applicable tables.
3. Use the table appropriate to your site and application method to determine treatment.
4. Consult the footnotes for phytotoxicity warnings and safety precautions.

Tables in this book are organized as follows:

Arthropods are listed within the tables in the following order:

CHEWING INSECTS

ANTS
- carpenter ants
- fire ants

BEETLES
- cucumber beetles
- bark beetles
- blister beetles
- borer beetles
- flea beetles
- June/May beetles
- leaf beetles
- pine chafer
- rose chafer
- weevils
- white grubs

BUTTERFLIES,MOTHS & CATERPILLARS
- armyworms
- azalea caterpillar
- bagworms
- borers
- budworms
- cankerworms
- cutworms
- diamondback moths
- elm spanworms
- green fruitworm
- greenstriped mapleworm
- hornworms
- inchworms
- io moth
- iris borer
- leafrollers
- loopers
- Nantucket pine tip moth
- maple leafcutter moths
- oakworms
- oak skeletonizer
- oleander caterpillar
- omnivorous leaftier
- orange tortix
- palmerworm
- puss caterpillar
- redhumped caterpillar
- saddle back caterpillar
- saddled prominent
- skelentonizers
- stripped oakworms
- tent caterpillars
- tortricids
- tussock moth
- walnut caterpillar
- webworms
- yellownecked caterpillar

FLIES
- fungus gnat
- gall midges

WASPS
- gall wasps
- sawflies including rose slugs

MISC. CHEWING PESTS
- crickets, grasshoppers, katydids
- earwigs
- leafminers
- springtails
- termites

SUCKING INSECTS
- adelgids
- aphids
- boxelder bugs
- fleahoppers
- hackberry nipple gall
- hemlock chermes
- lacebugs
- leafhopppers
- mealybugs
- plant bugs
- psyllids
- scale insects
- spittlebugs
- stink bugs
- thornbugs
- treehoppers
- whiteflies

RASPING INSECTS
- thrips

NON-INSECT ARTHROPODS
- mites
- pillbugs and sowbugs

SNAILS & SLUGS

Guide to Tables

Arthropod name	Table I	Table II	Table III	Table IV	Table V	Table VI	Table VII	Table VIII	Table IX
adelgids	•				•				
ants	•	•	•				•	•	•
aphids	•	•	•	•	•	•	•	•	
armyworms	•	•	•				•	•	
azalea caterpillar	•	•	•						
bactra moth larvae	•								
bagworms	•					•			
bark beetles	•								
beetles	•	•	•	•	•	•	•	•	
blister beetles	•								
borer beetles	•								
borers	•				•	•			
boxelder bugs	•						•		
budworms	•					•			
butterflies	•	•	•	•	•	•	•	•	
cankerworms	•	•				•			
carpenter ants	•								•
casebearer						•			
caterpillars	•	•	•	•	•	•	•	•	
centipedes							•		
corn earworm		•	•						
cotton bollworm		•	•						
crickets		•					•	•	•
cucumber beetles	•								
cutworms	•	•	•		•		•		
diamondback moths		•	•						
earwigs							•		•
eastern tent caterpillar						•			
elm leaf beetles								•	
elm spanworms	•								
fire ants	•							•	
flea beetles	•								
fleahoppers		•							
flies	•	•	•	•			•	•	•
fungus fly	•							•	
fungus gnat	•		•	•			•	•	
gall midges	•								
gall wasps	•					•			
grasshoppers	•	•					•		
green fruitworm		•	•						

(continued)

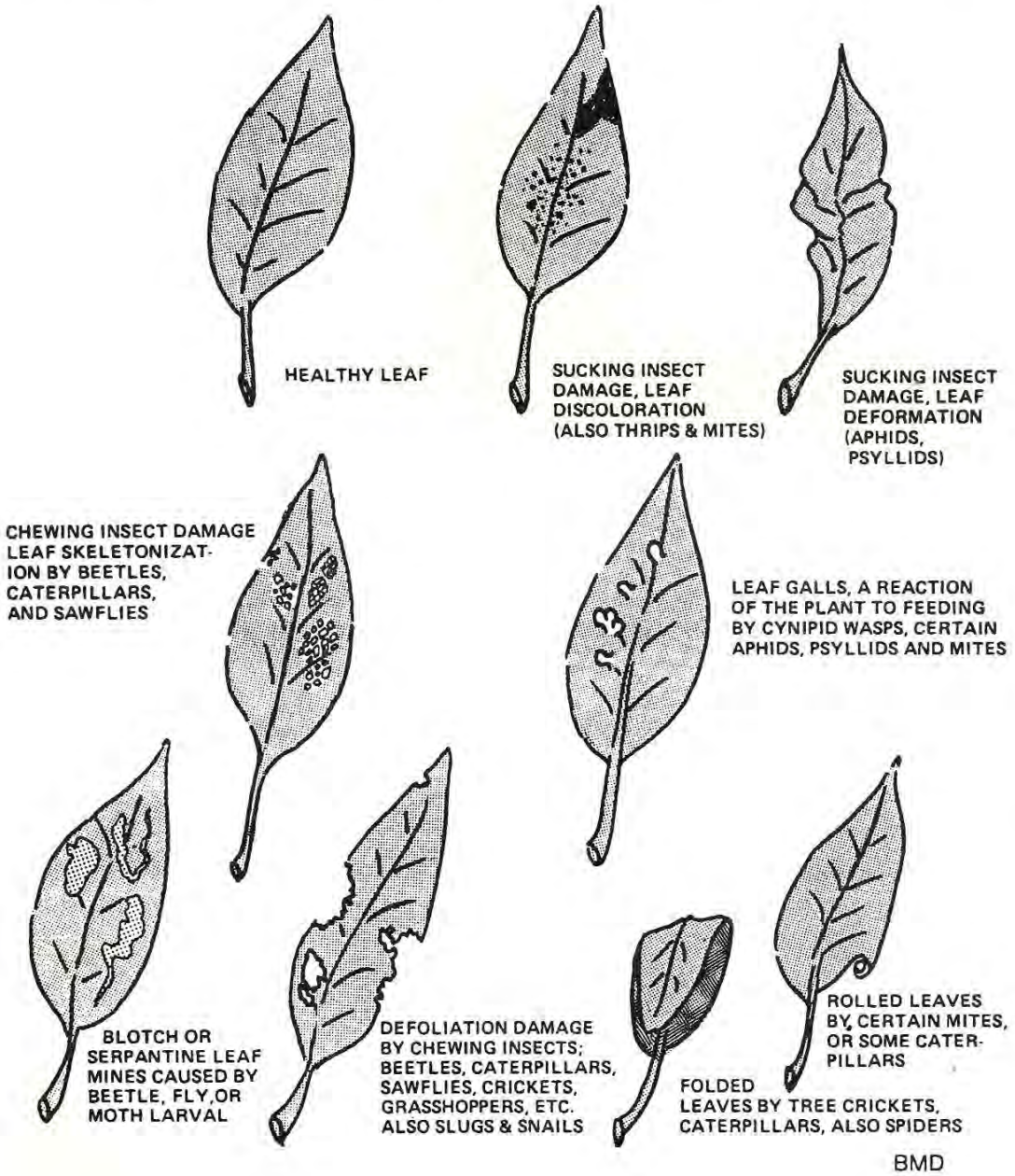
Arthropod name	Table I	Table II	Table III	Table IV	Table V	Table VI	Table VII	Table VIII	Table IX
greenstriped mapleworm	•								
hackberry nipple gall	•								
hemlock chermes	•								
holly bud moths	•								
hornworms	•	•							
inchworms	•	•							
io moth	•								
iris borer		•							
June/May beetles (white grubs)	•						•		
katydids									
lacebugs	•	•	•	•	•	•	•	•	
leaf beetles	•								
leaf folder						•			
leafhoppers	•	•	•	•		•	•	•	
leafminers	•	•	•	•		•	•	•	
leafroller	•	•	•	•	•		•		
loopers	•	•	•				•		
maple leafcutter	•								
mapleworm						•			
mealybugs	•	•	•	•	•		•	•	
millipedes									•
mimosa webworm								•	
mites	•	•	•	•	•	•	•	•	
mole crickets			•					•	
moths	•	•	•	•	•	•	•	•	
Nantucket pine tip moth	•					•		•	
oak skeletonizer	•								
oakworms	•								
oleander caterpillar	•								
oleander moth		•							
omnivorous leaftier	•	•							
orange tortrix	•								
palmerworm	•								
pillbugs	•	•							•
pine chafer	•								
plant bugs	•	•	•	•	•		•		
poplar tentmaker	•								
psyllids	•	•	•		•	•			
puss caterpillar	•								
redhumped caterpillar	•								

(continued)

Guide to Tables

Arthropod name	Table I	Table II	Table III	Table IV	Table V	Table VI	Table VII	Table VIII	Table IX
rose chafer	•		•						
saddleback caterpillar	•							•	
saddled prominent	•								
sawflies	•	•				•	•		
scale insects	•	•	•	•	•	•	•	•	
skelentonizers	•								
slugs	•	•	•				•		•
snails	•	•	•				•		•
sowbugs	•	•	•				•		•
spittlebugs	•	•	•			•	•		
spring elm caterpillars	•								
springtails	•	•	•	•					•
stink bugs		•	•				•		
stripped oakworm	•								
tent caterpillar	•								
termites	•								
thornbugs	•								
thrips	•	•	•	•		•	•	•	
tobacco budworm		•							
tortricids		•	•						
treehoppers	•								
tussock moth	•								
walnut caterpillar	•								
wasps	•	•				•	•		
webworms	•	•				•	•		
weevils	•			•				•	
white grubs (June/May beetles)	•							•	
whiteflies	•	•	•	•	•	•	•	•	
yellownecked caterpillar	•								

A PICTORIAL KEY TO INSECT-RELATED LEAF DAMAGE



BMD

Proper Pest Identification

Pest identification should be as accurate as possible. Management programs improve significantly with specific knowledge of the pest, its life cycle and behavior. Careful monitoring of species can enable you to detect subtle changes in a complex of pest species. (*Example*: The displacement of leafminer species by the chrysanthemum leafminer, *Liriomyza trifolii*, can result in significant problems in leafminer control). Generalized identifications can lead to control problems. (*Example*: Fungus gnats and shore flies are both problems in the greenhouse. Identification is important because their developing stages occur in different habitats. Fungus gnats breed in pots and water-saturated soils underneath benches, while shore flies breed in algal mats along the sides of benches, on the walls, and in other areas. Infestations are controlled only by treating the proper habitat.).

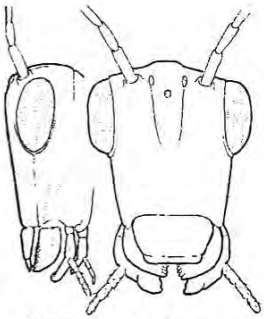
Legally, pest identification must be as specific as the identification on the label of the pesticide to be used. Thus, if "oakworms" are damaging an oak tree, a product for controlling "caterpillars" could be used unless the label lists only "tent caterpillars." Sometimes the actual common or scientific name of the pest is mentioned on the label, such as "forest tent caterpillar," signifying that the product should be used only for this specific pest. In other instances a more general name may be listed, such as "budworm," which requires some interpretation as to whether "spruce budworm" or "tobacco budworm" was intended.

The Federal Fungicide, Insecticide and Rodenticide Act (FIFRA) regulates the use of pesticides in the United States and specifies that they may be used only in accordance with the product label. Provision 2ee of FIFRA, however, allows the use of a product on *any* pest if the *site* for usage is listed on the product label. For ornamental plants, the site refers not only to the plant group or species, but also to the growing situation (greenhouse, interiorscape, nursery, etc.).

Damage Recognition

Arthropod pests produce characteristic plant damage related to the way they feed. These feeding symptoms are often easier to detect than the hidden pests themselves.

Chewing Insects



Grasshoppers - chewing mouthparts

Caterpillars, sawflies, grasshoppers, and beetle larvae and adults all have chewing mouthparts that can remove plant tissue. These pests chew holes in leaves, skeletonize leaves, or defoliate plants. They may also tunnel in petioles and stems or consume them entirely. Recently damaged plant parts will have freshly damaged edges. Later the edges turn brown and die. Other evidence of chewing insects includes silk, found at some caterpillar feeding sites, or fecal material (excrement) in the vicinity of the damage.

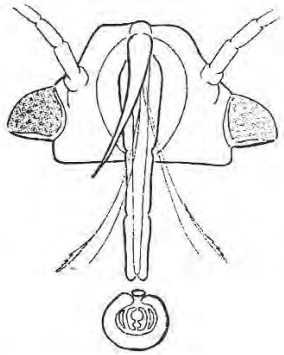
When damage is found, always look for the arthropods responsible before applying pesticide. Beetles and grasshoppers often leave the area after feeding. Caterpillars, which are best controlled with insecticides before they are half-grown, may finish feeding and pupate before they are detected.

fungus gnat

Fungus gnats. Immature stages of fungus gnats are small larvae (1/8 to 3/16 inch long) with black heads supporting jaws or mandibles that are usually used to chew up decaying organic matter and fungi. However, they also chew their way through young plant roots. Adult fungus gnats are small (1/16 to 1/8 inch long) black flies that are a nuisance in the greenhouse because they swarm above the benches, but they do not feed on or damage plants.

Leafminer flies. Leafminers, the immature stages or maggots of small flies, produce blister-like trails or blotches in leaves. The 1/8-inch yellow maggots have chewing mouthparts which tease apart the tissue between the outer layers of leaves. They feed inside leaves for several days before emerging to pupate on the ground. This resting stage lasts about two weeks. Adult leafminers look like tiny house flies (less that 1/8 inch long) marked with yellow and black patterns. Like house flies, they have lapping mouthparts. Female leafminer flies damage plants during egg laying by producing small, circular indentations, called stipples, on upper leaf surfaces.

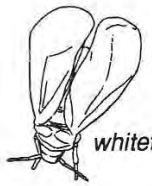
Sucking Insects



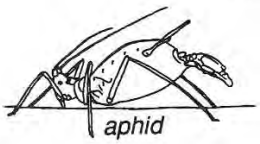
Stinkbug - sucking mouthparts

Aphids, whiteflies, mealybugs and scales (all usually less that 1/4 inch long), as well as the larger plant bugs and stink bugs, are sucking insects. Aphids can be identified by the two "exhaust pipes," called cornicles, on the ends of their abdomens, and they may or may not have wings. Whitefly immatures look like scale insects on the undersurfaces of leaves, but adults can fly when disturbed. Mealybugs are covered with white, waxy ornamentations and crawl along the surface. Scale insects attack leaves and stems, and look like variously shaped domes attached to the plant.

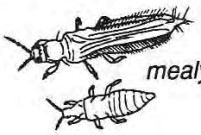
All of these sucking insects feed by puncturing plant parts with their long, straw-like mouthparts and removing sap, causing plant stress and sometimes making plants appear wilted. Some of these pests inject a toxic salivary secretion into plant tissues as they feed, which causes extensive yellowish or reddish areas or dead areas. Damaged or dead leaf spots sometimes fall off the plant, leaving holes that might be mistaken for chewing insect damage. Sucking insects also cause plant deformities similar to thrips damage on growing plant parts. Some mealybug species feed below the soil on roots.



whitefly

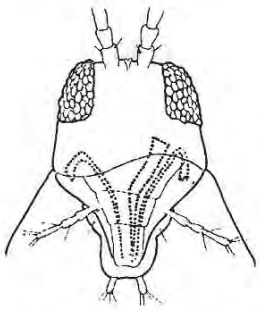


aphid



mealybug

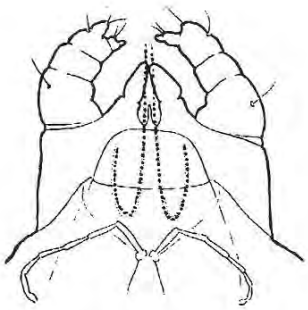
Aphids, whiteflies, mealybugs and scale insects remove more sugar-rich fluids from plants than they need, and eliminate this sticky material, called honeydew, around feeding sites. A fungus called sooty mold grows on leaves covered with honeydew. This black mold decreases the aesthetic value of plants and stresses them further by blocking the sunlight needed for photosynthesis. Some sucking insects can transmit plant diseases. Preventing diseases by attempting to control potential vectors is extremely difficult.



Thrips - rasping mouthparts

Rasping Insects

Thrips. Thrips are tiny (1/32 to 1/16 inch long), slender bodied insects. Adults have hairy wings; immature thrips do not. The resting stage, during which nymphs turn into adults, occurs in the soil. With their sword-like mouthparts, adult and nymphal thrips feed by slicing or rasping open plant cells on the surfaces of leaves, buds, flowers or fruits. They then suck the contents out of the ruptured cells. On mature plant parts, their feeding causes tiny silver streaks which are rows of empty, dead cells. If plant parts are still growing when attacked by thrips, the damaged surface cells stop growing and undamaged cells continue to develop around them. This causes deformed plant parts. Often, thrips are no longer present when these deformities begin to show. Thrips will also feed on pollen, and some thrips species prey on other insect and mite pests. Anticipate massive thrips migrations into production areas when nearby alternate hosts, such as weeds and wildflowers, begin to mature and die.



Mites - piercing-sucking mouthparts

Piercing-sucking arthropods

Mites. Spider mites, the tiny (1/32 inch long) eight-legged relatives of insects, produce damage similar to that of thrips. However, they use their mouthparts to first pierce plant cells and then to suck out the contents. Spider mite damage gives a stippled appearance to leaf surfaces, causing leaves to appear bronzed. Infestations always begin on the undersurfaces of leaves. Breeding infestations often can be identified by the whitish cast skins of developing mites. Mites also produce silken webbing around infested plant parts. Outbreaks often occur during drought stress or after the use of broad-spectrum insecticides that allow mites to survive while eliminating their natural enemies. Repeated applications of a miticide should be made after spider mites are first detected, since the egg stage is usually unaffected.

There are other mite species that attack ornamental plants. Cyclamen, broad and eriophyid mites can produce various plant deformities, but they do not produce the silken webbing or the bronze stippling characteristic of spider mites. They are also even smaller and harder to detect than spider mites, and may only be seen with a hand lens or microscope.

Unidentified pests

Many of the tiny insect and mite species seen on ornamental plants are not pests. They are likely to be natural enemies (predators or parasites) of pests which I refer to as the "free help" in taking care of real pest problems. Other arthropods may be just casual invaders passing through the area and uninterested in plants other than as a place to rest. The effort invested in making correct pest identifications can save you money by helping to eliminate unnecessary pesticide applications.

If the cause of a plant health problem is undiagnosed, control measures are often futile. Plant deformities or irregular growth may be caused by insect pests that have already left or ones that are difficult to identify, as well as by disease, improper watering or fertilizing, toxic compounds and other problems. County Extension agents and specialists can help in identifying the causes of plant damage. Or, specimens can be submitted to the Texas Plant Disease Diagnostic Laboratory for identification (for a nominal fee). If you don't know, don't treat, get help!

Integrated Pest Management

In this age of environmental awareness, the concept of routine, preventive treatments for plant pests is no longer acceptable. Although preventive treatments are still necessary for the control of plant diseases, insecticides and miticides should be used only when specific pests appear, or where there is an historical basis for anticipating a pest. Every effort should be made to prevent the outbreak of insect/mite infestations through nonchemical means. When an insecticide or miticide can be justified, the least toxic, most effective, most pest-specific product(s) should be used.

The philosophy of integrated pest management (IPM) encourages the use of pest suppression tactics that are:

1. most effective,
2. least expensive,
3. least detrimental to the environment.

IPM tactics include monitoring pests and their damage and using cultural, biological, and chemical control techniques. Over-reliance on chemical control can cause pests to become resistant to the chemicals used, increase growers' costs unnecessarily and contaminate the environment.

Tips for Developing Your Own IPM Program

- **Determine your objectives**

  Design the IPM program for a specific production objective. In commercial ornamental production, the objective is usually to produce a product free of pests and pest damage. In the landscape, however, the objective may be to maintain healthy plants. This allows for some tolerance of minor pest damage.

- **Start with a clean production/maintenance area**

  Treat or thoroughly clean up the production/planting area before introducing new plants. This eliminates pest problems from the last planting and keeps pests on neighboring plants from moving to new plants. Empty greenhouses can be fumigated. Eliminate weeds and other alternate hosts to help prevent problems on the new crop.

- **Select pest-free, high quality plants**

  Carefully inspect plants being brought into the production area. It is wise to hold them in a quarantine area for a while, and discard, treat, or return those found to be infested. Knowing the susceptibility to pests of the plant species and cultivars to be grown will help you anticipate problems.

- **Detect pest problems early**

  Once plants are established, there are several scouting methods for detecting the onset of pest problems: regular visual inspections for pests and related damage, particularly susceptible "indicator" plants; beating portions of the plants on off-white paper to dislodge pests; and monitoring pheromone, yellow sticky and/or ultraviolet light traps.

- **Recognize damage and define the problem**

  Properly identify pests and try to quantify the damage produced before beginning any control measures. This is the only way to justify control measures and evaluate their success or failure.

- **Consider all management tactics**

  Evaluate the economic, toxicological (worker safety, phytotoxic potential and pesticide residue) and environmental effects of all control options. When pesticides are necessary, select the least toxic, most target-specific, most effective, and most affordable material possible.

Monitoring Pests

A fundamental component of an IPM program is basing management decisions on what is actually happening to the plants. The only way this data can be obtained is through regular scouting activities and documentation. It is just as important to monitor the populations of natural pest enemies as it is to determine the pest population densities. There are several methods of scouting.

1. **Inspections**

   Regular (weekly, semi-weekly) visual inspections of all plant parts (particularly the undersides of leaves) can document the percent of plants infested, the percent of infested leaves and/or the number of pests per plant. For early detection, pay particular attention to or maintain pest-susceptible "indicator plants." For example, schefflera plants are good trap crops for most pests in a foliage plant greenhouse or interiorscape. Trap crops such as cucumbers, planted among tomatoes, will attract whiteflies and spider mites before tomatoes. In interiorscapes and greenhouses, scout plants close to vents and doors first, and scout where temperatures are highest for early detection of spider mite infestations. Outdoors, events such as the hatching of tent caterpillar eggs and scale crawlers should be monitored by careful observation when these events are anticipated.

2. **Beat Sheets**

   The "beat sheet" technique can be used to detect even small numbers of thrips, mites and aphids. Shake each plant over a piece of off-white paper or cardboard to dislodge pests, then count the pests present.

3. Sticky Traps

Yellow sticky traps will attract the adults of thrips, leafminer, fungus gnats, shore flies, winged aphids and whiteflies. Traps are best suited for use in greenhouses, and are used to detect pests early and document changes in pest densities over time. For best results:

- use the same brand of sticky trap throughout the monitoring period so that an accurate picture of relative insect population densities can be documented;
- hang traps just above the plant canopy over the center of the crop, but also in doorways and near vents;
- change traps weekly and count pests per card or per area (i.e., pests per square inch) of card;
- in greenhouses, use one trap per 10,000 square feet and place them at least 150 feet apart (one trap per 4 acres outdoors). Blue sticky cards may be more attractive to thrips than yellow ones.

4. Light Traps

Light traps can be used to monitor moth and beetle flight periods. They are labor intensive to use, however, and collect many non-pest insects. This can make pest identification difficult.

5. Pheromone Traps

Pheromone traps are now available for a wide range of insects. They are useful in outdoor areas, such as Christmas tree plantings, to monitor flight periods of specific pests such as the Nantucket pine tip moth. Traps must be deployed and monitored in the same way as yellow sticky traps. Treatment decisions, however, are best made by monitoring the damaging (larval) stages of these pests on plants and using pheromone traps as supporting evidence of adult flight times.

Cultural Control

Good horticultural practices constitute the first line of defense against pest problems. Select pest resistant or tolerant varieties, cultivars or species whenever possible. Select proper sites for growing plants. Plants are healthier and better able to tolerate pests when they are protected from sun scalding and given good growing conditions. The use of slow-release fertilizers at optimum rates and proper watering practices can make plants less attractive to pests. Proper pruning and removal of clippings and other debris from the growing area will eliminate some of the sites that harbor pests. Weed control in and around production areas eliminates alternate host plants for pests.

Physical Methods

Pest infestations can be physically manipulated with light, humidity and temperature. In interior plantings, light quantity and quality affect plant health and influence pest populations and their damage. Relative to conventional lights, yellow "bug" lights used at night around plantings will not attract insects such as moths, crickets, and June beetles. Temperature and humidity are important, although not always controllable. In greenhouses and interiorscapes, these factors can sometimes be manipulated to reduce pest survival or improve the success of natural enemy releases. Devices which use sound for pest suppression have not been shown to be effective.

Mechanical Methods

Mechanical methods for pest suppression and exclusion can be helpful.

Screens can exclude plant pests from the greenhouse. Insect exclusion products such as Visqueen® are sold with instructions for proper use. When they are placed in front of fan vents, be careful not to reduce air flow. Proper maintenance of exclusion devices is essential.

Tree wraps may aggravate the damage caused by some pests such as insect borers. They also may provide harborage sites for other pests such as fire ants. There are devices which prevent damage to tree trunks from mowers.

High pressure water sprays. Devices which produce high pressure water sprays effectively dislodge spider mites and some aphids from host plants.

Trapping. Light traps, yellow sticky traps, and sticky-surfaced pheromone traps attract and kill certain insect pests. However, they will not provide absolute control. These devices are best used to monitor pest population densities over time and to detect infestations early. They can also be used to evaluate the impact of management practices.

Biological Control

The term "biological control" refers to the use of natural enemies to suppress pests. Biological control tactics include the conservation, augmentation and importation of natural enemies. Biological control is an environmentally safe method and is the basis for some integrated pest management programs.

Importation

Many pests are exotic and have no natural enemies in Texas. Reuniting pests with their natural enemies has often provided the most dramatic and sustainable method of suppressing them. The importation of such natural enemies is classical biological control. The parasite *Neodusmetia* successfully suppressed Rhodesgrass mealybug in Texas after being widely distributed by airplane. The search for exotic beneficial organisms which can control serious plant pests in Texas is a major mission of the biological control scientists within the Department of Entomology at Texas A&M University.

Conservation

Pesticides kill beneficial predators, parasites and pathogens as well as pests, and can cause outbreaks of secondary pests or rapid resurgence of pests that were initially suppressed. Using nonchemical control methods, or pesticides which kill only the target pest, protects natural enemies. Some easily seen predators are spiders, lacewings, lady beetles, ground beetles, rove beetles, syrphid flies, flower flies, hover flies, true bugs (including minute pirate bugs, big-eyed bugs, and damsel bugs), predatory mites, and even fire ants. However, many important natural enemies are rarely seen, such as parasitic wasps and flies (more than 8,500 species), nematodes and pathogenic bacteria and fungi.

Augmentation

Natural enemies can be released all at once or over time to suppress pests or keep their numbers low. Also, the environment can be enhanced to favor natural enemies. Although research has shown that releases of natural enemies can be very effective in greenhouses and interiorscapes, outdoor releases are affected by unpredictable environmental conditions. Furthermore, if a second pest is unaffected by the released organism, pesticides used to control the second pest often eliminate the natural enemy of the first pest. Specific recommendations for Texas are still being developed.

The application of microorganisms in a manner similar to conventional pesticides is a type of augmentation. These products are referred to as "microbial insecticides." Several products available contain varieties of the bacterium *Bacillus thuringiensis*, which controls certain caterpillars, beetles and flies but does not affect other arthropods. Microbial insecticides are relatively slow acting and are most effective if applied when pest numbers are low and pests are in early stages of development.

Commercially Available Natural Enemies

(extracted from Henn and Weinzieri, 1990)

Predators

Convergent Lady Beetle, *Hippodamia convergens*. The adult beetle is orange with six small, black spots on each side and a black area with white markings behind the head. The larva is soft-bodied, alligator-shaped, grey and orange in color with rows of raised black spots. Larvae and adults feed on aphids and other small, soft-bodied insects and mites. Adults also feed on nectar, pollen and honeydew. Development (egg to adult) takes two to three weeks, and adults live up to several months.

This species occurs throughout North America. In California, adult beetles overwinter in huge aggregations on mountainsides. These are harvested, stored at cool temperatures and shipped to customers in the spring and summer for release in gardens or crops. Unfortunately these releases have limited usefulness because the beetles fly away soon after release. They provide long-term, adequate aphid control only if they reproduce. Female beetles cannot produce eggs until they have fed on prey, and they lay eggs only where prey are abundant. Larvae provide better aphid control.

Suppliers recommend release rates ranging from one pint to one quart of beetles per home garden, and from one gallon of beetles per acre to one gallon per 15 acres for larger areas.

Mealybug Destroyer, *Cryptolaemus montrouzieri*. The adult of this Australian lady beetle is a small (3/16 inch), black beetle with orange on the wing tips and behind the head. The larva is covered with white, waxy material and resembles a mealybug. Adult and larval stages feed on aboveground mealybug species, but will also consume aphids and immature scale insects. This natural enemy won't reproduce without large numbers of mealybugs and optimum environmental conditions (72 to 77 degrees F. and 70 to 80 percent relative humidity). The mealybug destroyer may not control mealybug infestations during winter months. It is most effective when used for quick reduction of heavy mealybug infestations.

Suppliers recommend releasing one beetle per two square feet of planted area or two to five beetles per infested plant. Supplies are often limited because colonies are difficult to maintain.

Lacewing, *Chrysoperla carnea*. The common green lacewing is the most widely available lacewing species. *Chrysoperla rufilabris* is an eastern lacewing species that is better adapted for use in tree crops. Green lacewings occur naturally throughout North America. The adult has a delicate, light green body with large, clear, veined wings. Larvae are small, elongated and greyish brown with sickle-shaped mandibles. Eggs are deposited singly on silken stalks. Although *C. rufilabris* and most other lacewings are predaceous as adults, the adult *C. carnea* feeds only on nectar, pollen, and aphid honeydew, and females cannot produce eggs if these foods are unavailable. Adults fly at night and disperse soon after emerging whether or not ample food is present. Artificial foods may be a useful supplement to natural foods (nectar and honeydew) to attract and concentrate adult lacewings.

Lacewings can be purchased as eggs shipped in a mixture of rice hulls and frozen caterpillar eggs or larvae. Suppliers recommend releasing from one to five lacewing eggs per square foot for gardens, and from 50,000 to 200,000 lacewing eggs per acre in field crops and orchards. Releases are made singly or sequentially at two-week intervals, depending on the pest to be controlled. The costs of purchasing and releasing such high numbers of lacewing eggs may be prohibitive.

Preying Mantid. Several species occur naturally in most of the U.S. In the fall, females produce egg cases that may contain up to 200 eggs. Eggs hatch in the spring. Nymphs and adults are territorial and general predators, feeding on a wide variety of insects, including other mantids. They are not effective in controlling aphids, mites or most caterpillars. Mantids are nearly useless for pest control in gardens because of their feeding habits and high mortality rate. Egg cases of the Chinese praying mantid, *Tenodera aridifolia sinensis*, are most commonly available for purchase.

Predatory Mites. Spider mite predators in the genera *Phytoseiulus* and *Amblyseius* are quick breeding, fast moving, pear shaped predators with short life cycles (from seven to 17 days, depending on temperature and humidity). They are pale reddish and distinguished from twospotted spider mites by their lack of spots, their long legs, and rapid movement. Predatory mite eggs are elliptical and larger than the spherical eggs of spider mites. Adults feed on all stages of spider mites, whereas the nymphs feed on eggs, larvae and nymphs.

Phytoseiulus persimilis does best in a temperature range of 70 to 80 degrees F. and a relative humidity of 60 to 90 percent. The suppliers suggest releasing from two to 30 predatory mites per plant, depending on the stage and susceptibility of the crop. Some experimentation may be necessary to determine the best release rate and method for specific situations. U.S. insectaries often recommend releasing *P. persimilis* when one or fewer spider mites per leaf occur throughout the greenhouse. Where spider mite populations are larger, it is a good idea to apply an insecticidal soap or other nonresidual insecticide to reduce the infestation before predatory mites are released. Spot releases and uniform, area-wide releases both are occasionally advocated, depending on the distribution of the spider mite. In Europe, spider mites are sometimes released into the greenhouse at a low rate soon after planting, followed later by the release of predators. This practice allows the predatory mites to become established. In other cases, spider mites and predators are released together early in the season.

Phytoseiulus longipes tolerates temperatures up to 100 degrees F. when humidity is high, and tolerates lower relative humidities (down to 40 percent) at lower temperatures (70 degrees F.). *Amblyseius californicus* also tolerates high temperatures (up to 90 degrees F.), but consumes mites at a slower rate than *Phytoseiulus* species and survives better when spider mite numbers are low. Mixed releases of the two predators have been made in greenhouses where conditions and spider mite numbers are variable.

Thrips Predators. *Amblyseius cucumeris* and *A. mckenziei* (or *A. barkeri*) are mites that feed on the western flower thrips and onion thrips. They can also subsist for short periods on pollen, fungi, or spider mite eggs. These mites

require high humidity and are sensitive to insecticides. They do not produce eggs during the winter, which makes thrips control difficult at that time. Suppliers recommend releasing large numbers of these predators to control thrips. Rates vary from 10 to 50 predatory mites per week per plant, plus an extra 25 to 100 mites per infested leaf in the greenhouse, until there is one predatory mite for every two thrips. Very little research has been published about these types of releases, but literature from Europe indicates that lower release rates may be feasible. This is not an effective method of vector control for dealing with tomato spotted wilt virus.

Parasites

Greenhouse Whitefly Parasite, *Encarsia formosa*. This is a tiny parasitic wasp. Adults lay eggs during the third and fourth nymphal whitefly stages. Parasitized whitefly nymphs blacken within two to three weeks and die as the wasp larvae develop inside. Adults also feed on and kill early and late nymphal stages. *Encarsia* develops best in bright light, 70 to 80 degree F. temperatures and 50 to 70 percent relative humidity. Under these conditions it reproduces faster than whiteflies. Commercially available *Encarsia* are not effective parasites of the sweet potato whitefly, although adult wasps will feed on and kill the immature stages.

Most U.S. suppliers suggest making releases when fewer than one adult whitefly per upper leaf is found throughout the greenhouse. Releases should be made at two-week intervals to control immature whiteflies. Release rates range from one to five wasps per square foot or one to eight per plant, depending on plant species and the severity of the infestation. In European vegetable greenhouses, whiteflies are introduced at low levels before the natural enemy is released. Where this approach is not used, parasites must be released at the very first sign of whitefly infestation or on a preventive schedule.

Caterpillar Egg Parasites, *Trichogramma* spp. These wasps are extremely small, averaging about 1/36 inch in length as adults. Females lay their eggs in the eggs of moths and butterflies. A few species parasitize the eggs of other insects. *Trichogramma* larvae develop inside host eggs, killing the embryos. Instead of a caterpillar, one or more adult wasps emerge from the parasitized egg. There are many species and strains of *Trichogramma*. Some are general parasites but others parasitize only selected species.

Trichogramma wasps are usually released as mature pupae inside host eggs. Adults emerge within one to three days and live for about nine days. Releases are timed to correspond with the egg-laying period of the pest, as determined by monitoring. Single or sequential releases at rates of 50,000 to 300,000 wasps per acre per release have been made, but the results have been extremely variable. Two species available include: *T. pretiosum*, which parasitizes more than 200 species of caterpillar eggs (though not equally effective against all species); and *T. minutum*, which controls orchard and forest caterpillars. The size and host-finding ability of *Trichogramma* is influenced by the way the wasp is reared. In commercial operations they are reared in the small eggs of the Angoumois grain moth. The parasites produced this way are also small and may not do well at locating eggs of target pests in the field. Parasites reared locally on the eggs of the intended target pest are more likely to provide successful control.

Chemical Control

Treatment Decisions

In ornamental plant pest management, treatment decisions are often based on somewhat subjective criteria or "threshold levels." If the objective is to produce plants free of pests and pest damage, pesticides are often applied automatically. If such preventive treatments are based on the historic seasonal occurrence of damaging pest populations they can be justified. However, a more prudent approach is to begin treatments when a pest or pest damage is detected. If the objective is to maintain vigorous, healthy plants, higher pest numbers and damage levels may be tolerable before treatment begins.

Proper Pesticide Selection

In choosing a pesticide, the grower should select a product that is specific to the pest to be controlled in order to spare beneficial arthropods. Systemic insecticides are less likely to affect predators and parasites on plant surfaces. Insecticidal soaps may spare hard bodied predaceous or parasitic arthropods. Microbial insecticides such as *Bacillus thuringiensis* products (Dipel®, Thuricide®, M-1®, Gnatrol® and others) are target-specific for certain groups of insects. Specific miticides (Pentac®, Vendex®) generally spare other arthropods. Vendex® is less toxic to predaceous mites.

Care must also be taken when using pesticides other than insecticides and miticides. Certain fungicides such as Benlate® can affect insectivorous fungi and other non-target organisms. Broad-spectrum insecticides often are useful when more than one pest is present. But they may cause a rapid resurgence of the primary or secondary pest. Pyrethroid insecticides are harmful to parasitic wasps as well as the pests listed on their labels. They are most effective against chewing insects.

Interpreting Acute LD_{50} Values

Another important consideration in choosing a pesticide is its toxicity. The LD_{50} value of an insecticide is commonly used as a measure of its toxicity. The LD_{50} is defined as the single dose of a chemical which results in 50 percent mortality to a population within a specified time. It is expressed in milligrams of pesticide per kilogram of the test animal's body weight.

Example: LD_{50} = 50 mg/kg.

Sometimes this relative measure of toxicity is qualified by the species and sex of the test animal.

Example: LD_{50} male rat = 39 mg/kg.

LD_{50} values can be further qualified by route of absorption or the way in which the pesticide was administered to the test animal.

Example: Acute oral LD_{50} male rat = 39 mg/kg or acute dermal LD_{50} male rat = 98 mg/kg.

Generally, the lower the number the higher the acute toxicity. Acute oral (or dermal) LD_{50}s for an experimental animal are useful indications of the probable relative toxicities of compounds to man and other warm-blooded animals. However, they are not an absolute representation of how much pesticide would be required to kill a man (as compared to a rat), nor the only important measure of the potential toxic effects which might occur with exposure to a given compound. A number of pitfalls must be considered when interpreting acute LD_{50} values. These include the following:

- Individual variation (genetic, age, sex, nutrition, hypersensitivity).
- Difference in route of exposure (oral, dermal, inhalation).
- Formulated versus pure chemicals (effects of solvents, types of formulations, etc.).
- Impurities of technical material.
- Possible cumulative effects from multiple exposures to the same chemicals (chronic toxicity).
- Interactions with other chemicals in the individual's environment (drugs, environmental pollutants, etc.).
- Past or present disease status.

LD_{50} tells us nothing of the possible chronic effects of these compounds nor possibilities of sublethal toxicity. A high acute LD_{50} (low acute toxicity) does not mean that a compound can be used carelessly, or that it is safe as long as exposure levels are below that of acute toxicity. Since toxicity tests cannot accurately predict a chemical's effects on humans, the only way to reduce the hazard is to minimize exposure to any pesticide.

Resistance Management

Some species of ornamental plant pests, including the green peach aphid, the sweetpotato whitefly and the serpentine leafminer, have developed resistance/ tolerance to pesticides. When a pesticide loses effectiveness some growers try using higher concentrations or more frequent applications to obtain acceptable control. These measures encourage resistance, however. Resistance is most likely to develop during long-term exposure to a particular compound, particularly in organisms with short life cycles and high reproductive rates.

To prevent resistance, growers should use pesticides (particularly nerve toxins) only when needed to prevent economic losses, and should use the lowest acceptable doses of pesticides. Once resistance has become evident, growers should rotate pesticide classes (pesticides with different modes of action) between pest generations (*Example*: Use organophosphate or carbamate insecticides that are acetyl cholinesterase inhibitors through one generation, then rotate to either chlorinate aryl hydrocarbons or pyrethroid insecticides that destabilize nerve tissues or to avermectin insecticides that affect GABA neurotransmitter for the next generation). Insecticidal soaps, horticultural and petroleum oils, microbial insecticides and insect growth regulators are not nerve toxins. Resistance has been reported to both *Bacillus thuringiensis* and insect growth regulators.

Tank-mixing of insecticides is generally discouraged because it may cause pests to become resistant to all products in the mixture. However, there are times when tank mixtures can increase pesticide activity and lower the dose required. When a tank mix provides better control than the additive effect of each product applied separately, the mixture is said to be synergistic. The combination of acephate and a pyrethroid, for example, controls the sweetpotato whitefly better than either chemical used separately. This mixture is useful as a "rescue" treatment in crisis situations. However, routine use of this mixture, or any pesticide, can increase resistance.

In most cases, tolerant/ resistant arthropod strains are less fit than are susceptible strains. In the absence of the pesticide selection pressure, susceptibility will return to the population.

Tips for Purchasing Insecticides

1. Know the generic names of insecticides in brand name products.
2. Develop a label file with cross reference system to access pest/site information for the products you use.
3. Know the pH of the water where these pesticides are used.
4. Know applicable regulations (restricted vs. general use products, FIFRA section 2ee, etc.).
5. Store products in an organized fashion.
6. Keep records of the cost of the finished spray material (dollars per acre, per ant mound, per 100 gallons, etc.).
7. Purchase small quantities of products to avoid long term storage problems.
8. Keep products fresh, particularly fire ant baits.
9. Determine the proper application methods for products you buy, as well as the required equipment and adjuvants and the product's compatibility with other pesticides.
10. Understand the product's mode of action, rate of kill and other technological characteristics.

Storing and Using Pesticides

Shelf life

Use fresh products whenever possible. Buy only what is needed for the current year and mark the purchase date on the container. The shelf life of pesticide products is influenced by the formulation, the container type and the storage conditions (temperature, humidity). As a rule, an unopened container stored at moderate temperature will remain effective for two to five years. Under poor storage conditions, the formulation and/or the active ingredient can deteriorate, separate, or solidify. To prevent damage to equipment, mix a small amount of any suspect material in a jar first to see if it mixes properly. The only way to know if the active ingredients have been affected is to treat a pest infestation and monitor the results.

Look for the following symptoms which indicate that a pesticide may have deteriorated:

Emulsifiable concentrate (EC)	*No milky formation; insoluble sludge or layers in the mixture.*
Wettable Powder (WP)	*Product is lumping and some of the material won't go into suspension.*
Dust	*Excessive lumping.*
Granular	*Excessive lumping.*
Aerosols	*Obstruction in opening.*
Smoke	*Difficult to light, lumping.*

from Langhans, R. W. 1980, *Greenhouse Management*, Halcyon Press of Ithaca, Ithaca, New York, 239 pp.

Alkaline water

The pH of water used as a diluent can affect the life of the active ingredient in solution. Many insecticides will degrade rapidly in alkaline water (pH greater than 7). Some pesticides, such as malathion and Dylox®, are particularly sensitive and degenerate within a few hours after being diluted. High temperatures increase the rate of degradation in alkaline water. Many product labels suggest proper pH ranges for water.

To prevent degradation of ingredients in a mixture:

1. Mix the pesticide with water and spray immediately or within a few hours. Never allow pesticides to remain in solution overnight before spraying.

2. Use an acidifier to adjust the pH of the water to neutral (pH = 7) or slightly acidic. Although vinegar is frequently recommended for lowering pH, commercially available buffers are better suited for this purpose. (See *Pesticide Compatibility with Adjuvants.*)

Temperature effects

Temperature alone can affect pesticide effectiveness. Organophosphate insecticides work better at higher temperatures (except for DDVP which is best used at about 50 to 72 degrees F.). Synthetic pyrethrum derivatives (sumithrin and resmethrin) are less effective at high temperatures. Many product labels suggest temperature ranges for making applications.

Pesticide Compatibility with Adjuvants

Many pesticides require no additives (adjuvants). But if there are problems achieving an adequate pesticide application, an additive may be needed. There are many types of adjuvants including emulsifiers, defoamers, drift retardants, spreaders, stickers, wetting agents, anti-caking agents, cuticle cutters, penetrants, buffers, translocation aids, nutrient buffers, thickeners, emulsion inverters, UV screens, and evaporation inhibitors. Adjuvants can be sorted into two categories:

- The activators that improve the application and/or effectiveness of products (wetters, spreaders, stickers, emulsifiers, emulsifiable oils and plant penetrants or translocators).

- The special purpose adjuvant (drift retardants, defoamers, buffers, stabilizing agents, and feeding stimulants, among others).

Surfactants are "surface acting agents." Surfactants are either non-ionic, anionic (negatively charged), or cationic (positively charged). The pesticide's label will tell you whether the pesticide is compatible with the different kinds of surfactants. Surfactants work either as spreaders or stickers.

Spreaders break the surface tension of water and allow water-based sprays to spread out on a leaf rather than beading up. Soaps and detergents should not be used for this purpose. Soaps are alkaline and will break down many pesticides. Detergents containing sulfates and phosphates are highly reactive and may react with the spray mixture.

Stickers are used to stick solid pesticide particles to leaves, reduce pesticide volatilization, and waterproof the pesticide. Many stickers also act as spreaders (alkylarylpolyethylenates). Most products that won't wash off with rain or irrigation contain latex (rubber), polyethylenes (plastic), resins (rosins), polymenthenes (resin-like compounds), or other long-chain polymers.

Buffers neutralize alkaline water, which normally breaks down insecticides through "alkaline dehydrolysis." Phosphoric acid is the active ingredient in many buffering agents.

In Texas, it is legal to apply pesticides in any adjuvant as long as the percentage concentration of adjuvant in the spray is lower than the percentage concentration of water (carrier) in the tank. Tank mixes must contain at least 50 percent water carrier.

Consult the pesticide label before using an adjuvant. Many labels make specific reference to spreaders/stickers. If not, make a test application on a small number of plants to see if the mixture is beneficial. Determining whether pest control has been enhanced is more difficult. Be cautious. New, untested tank mixtures may cause phytotoxic reactions in plants. There are so many products available that there are many possible combinations of pesticides and adjuvants. Few have been tested, however, so the grower must determine the usefulness of these products.

Phytotoxicity

Certain insecticides or spray mixtures cause plant damage called phytotoxic reaction. Pesticide labels usually mention sensitive plant species and cultivars. However, most plant listings on product labels are not binding and allow for these products to be used on other ornamental plants. The sensitivity of unlisted plants to the product or tank mixture is unknown.

Sometimes phytotoxicity occurs unexpectedly. In one situation chlorotic (yellowed) and necrotic (dead) lesions appeared all over ficus leaves after bendiocarb (Turcam®, Dycarb®) was applied to the foliage at the recommended rate to control Cuban laurel thrips. It was found that this problem resulted from spray runoff getting into the media or soil, and that it could be prevented by not spraying to runoff.

Sensitive flowering periods and stressed plants

Plants usually are more sensitive to pesticides after they begin to bloom, and foliar sprays should be avoided or used with caution at that time. During bloom, the careful use of smokes or certain aerosol products may be preferable in the greenhouse. Plants under water and/or temperature stress are also more prone to phytotoxic reactions. Avoid spraying when the weather is extremely hot and sunny. Spray in the mornings when possible, preferably between 6 and 10 a.m. When air or plant tissue temperature is about 90 degrees or higher, damage will likely occur. On bright, sunny days, leaf tissue temperature may be 5 to 15 degrees higher than that of the surrounding air, thus increasing the possibility of injury. Also don't apply pesticides when the temperature is either very high or very low, or when the spray will not dry quickly. Under

cool, humid conditions plants will remain wet, which increases the possibility of injury and disease. This is one of the reasons greenhouse plants are more likely to be damaged.

Pesticide formulations and application methods

Wettable powders are usually safer for plants than emulsifiable concentrates since they do not contain emulsifiers and solvents. The disadvantage of wettable powders is the objectionable residue left on the foliage by some products. Almost all aerosol and fogging formulations will cause phytotoxicity if applied at less than the recommended distance between nozzle and plant. A distance of 18 to 20 inches usually is recommended.

Tank mixtures

Mixtures of insecticides, miticides, or fungicides may cause plant injury when the use of one of the materials alone would not. Pesticides should not be tank mixed unless this use appears on their labels, or unless the grower knows firsthand that the mix will not injure his crop.

Phytotoxicity testing

When using a product, tank mixture, or application method for the first time, test it on a small group of plants and observe them for several days. With foliar applications the new growth is most likely to show phytotoxic damage. With soil drenches damaged root tissue may show up as plant stunting or slow decline, with the older, not younger, leaves damaged.

Symptoms of phytotoxic reactions

Plants react to pesticides in a number of ways:

Burn
Appears on the tip or margins of the leaf as necrotic areas. The entire leaf surface may appear burned or the roots can be burned.

Chlorosis
Appears as spots or as tip, margin, or leaf yellowing.

Leaf distortion
Appears as curling, crinkling, or cupping of the leaf.

Stunting
The entire plant is reduced in size or certain parts (fruit, flowers, roots) are smaller while the rest of the plant appears normal.

Abnormal growth
Excessive growth on either certain parts (aerial roots, suckering) or the entire plant.

To avoid phytotoxicity, study the label and any brochures that are available concerning the particular pesticide to be used. Pay attention to dosage rates, application instructions, and phytotoxicity information. Do not overdose. Use a clean sprayer after each use. Do not use sprayers in which herbicides have been used.

Proper equipment selection and application

In this publication, pesticide tables are divided by both site (greenhouse, interiorscape, etc.) and application method (foliar sprays, soil/media treatments, aerosols and fumigants, etc.). Both application sites and methods help determine the most appropriate product to use. The size of the planting and the size and structure of plants to be treated are also important considerations. The best application equipment for a particular situation is that which provides thorough coverage within a reasonable amount of time and with reasonable effort.

High-volume foliar sprays

Most ornamental plant growers apply pesticides with high-volume hydraulic applicators. These devices provide good coverage, particularly if care is taken to direct the nozzle(s) properly. Most pesticides are applied to the point of runoff to both the under- and uppersurfaces of foliage. However, some products (*Bacillus thuringiensis*, insect growth regulators and others) are applied to wet foliage only, avoiding runoff.

Low-volume applications

Low-volume application methods use higher pesticide concentrations and are frequently used to apply insecticides of short residual life. Some pesticide labels offer specific rate recommendations for use with mist blower applicators. Low-volume applications need to be repeated frequently, and coverage on the lower leaf surface may be poor. Thermal fogging devices and controlled-droplet applicators require that special carriers (diluents) be used with pesticides. Contact the manufacturers for specific information.

Coverage

When making applications, every effort should be made to determine if target surfaces are being reached. For less toxic, contact materials such as horticultural oils, insecticidal soaps, microbial insecticides, and insect growth regulators, applying sprays directly to the pests or pest-infested surfaces is essential for good control. Coverage is relatively less important when using systemic pesticides. There are several dye products available that can be mixed with the sprayer contents to reveal areas where pesticides have been applied. Certain application devices may improve coverage. Electrostatic sprayers add a charge to the spray particles that makes them attracted to leaf surfaces and may increase coverage of the undersurfaces. The Pestifoamer® is a specialized applicator that adds a foaming agent to the pesticide just as it leaves the nozzle, resulting in a sudsy spray. This reportedly results in better coverage and less spray drift, and may require less insecticide.

Granular systemic insecticides

The use of granular systemic insecticides before pest infestations occur is often referred to as a "preventive" treatment. Although these applications are convenient, they may or may not be justifiable either economically or environmentally. Making such applications unnecessarily can be a costly mistake. But if early pest outbreaks have occurred frequently in past production cycles, this approach could be justifiable.

It has been claimed that systemic insecticides are less harmful to natural enemies, since these organisms do not contact or directly ingest the pesticide. However, the period of protection offered by granular systemics varies. After application, growers should continue to monitor for outbreaks of pests, and should determine the length of the product's activity.

Oxamyl® 10G (oxamyl) is one granular systemic product still registered for wide use on ornamental plant pests. This product can be used in greenhouses, nurseries, and interiorscape plantings for control of whiteflies, mealybugs, aphids, fungus gnats, leafminers, mites, scales, thrips, other insects and certain nematodes. It can be used in interiorscapes and container-grown plantings, and around patios and other recreation areas where spraying is undesirable. (See Table VIII.)

Oxamyl works best when absorbed by the roots so granules on plant foliage should be brushed or washed off for maximum effectiveness. Granules can be incorporated into media before planting, or broadcast on the media after planting and then watered in. For pre-plant application, granules can be incorporated with a rotary tiller to a depth of four to six inches immediately after being broadcast on the surface; or, granules can be added to media while it is tumbling in a soil mixer. After planting, granules can be applied to the soil surface and lightly incorporated mechanically and/or by watering.

Fumigation of empty greenhouses with methyl bromide

Methyl bromide products such as Brom-O-Gas® and Terr-O-Gas® 98 (Great Lakes Chemical Corp.), labeled for fumigation of empty greenhouses for pests such as mealybugs, scale insects and mites, have undergone some major revisions. Fumigant atmosphere is the key. If workers will be exposed to fumigant concentrations exceeding 5 ppm (20 mg/M^3), certain safety equipment and procedures must be used.

In empty greenhouses, Brom-O-Gas® and Terr-O-Gas® are to be applied at a rate of three pounds per 1,000 cubic feet of greenhouse volume (Table 1). For every 10-degree drop in temperature below 60 degrees F., dosage should be increased by 1/2 pounds per 1,000 cubic feet or an approved procedure should be used to heat the fumigant. Fumigation is not recommended at temperatures below 50 degrees F. Exposure time should be four hours.

Table 1. Brom-O-Gas® and Terr-O-Gas® 98 (methyl bromide) Soil Fumigant Used in Commercial Ornamental Production

Treatment Site	Rate (lb/a)	Exposure (hours)
Nursery soils: turf, ornamentals, floral crops, forest tree seedlings	180-435	24-48
Greenhouse soils: non-food crops	180-435	24-48
Seed or transplant beds (non-food):	180-435	24-48
Potting mix:	1 lb./cu. yd	24-48

(extracted from *Directions for use of the products*, Great Lakes Chemical Corp., 3/86)

New labels indicate that these products are restricted use pesticides and must be applied by individuals trained in their proper use. When methyl bromide products are used for fumigation of enclosed spaces such as greenhouses, two trained persons must be present at all times when worker exposure exceeds 5 ppm, or during most of the hazardous phases of operation.

Respiratory protection is required when the concentration of methyl bromide in the treated area exceeds 5 ppm. At these times all persons in the fumigation area must wear a NIOSH/MSHA approved, self-contained, breathing apparatus (SCBA) or combination air supplied/SCBA respirator. No protective respiratory equipment is required when the concentration of methyl bromide is below 5 ppm as measured by a pump and appropriate detector tubes (for example, Draeger, Kitagawa, MSA and Sensidyne).

The applicator must place a placard or sign in English and Spanish at all entrances to the fumigated area. Signs should include the following:

1. The signal word DANGER/PELIGRO and the skull and crossbone symbol;
2. The statement, "Area under fumigation, DO NOT ENTER/NO ENTRE";
3. The date of fumigation;
4. Name of fumigant used; and
5. Name, address and telephone number of the applicator.

Any person who transfers a treated commodity to another site without aeration must ensure that the new site is placarded until the commodity is aerated below the threshold concentration. Only the certified applicator may remove placards, and only when the methyl bromide concentration is below 5 ppm.

Before fumigating a greenhouse, check with appropriate municipal and county authorities to be completely familiar with local regulations. Ordinances may require watchmen, padlocks, or warning posters during and after fumigation and/or notification of the nearest fire station.

Before fumigating, notify anyone who would normally be in the area. Then follow these steps:

1. Remove food or feed commodities before fumigation.
2. Use only methyl bromide products containing 0.25, 0.5 and 1 percent chloropicrin, and 100 percent methyl bromide.
3. Seal the building by closing all external openings, including roof ventilators, chimneys, drain pipes, tunnels, etc.
4. Seal all floor and roof cracks, and around the eaves.
5. Take special care to seal partitions or adjacent storage or work areas in the building.

6. If possible, clear adjoining buildings sharing a common wall. If they cannot be cleared, check frequently with an approved detector to ensure the safety of the occupants.

7. Use an appropriate application method. In case of spill or leak, evacuate immediately. Use a NIOSH/MSHA approved, self contained breathing apparatus (SCBA) or combination air/ supplied/SCBA respirator when entering a treated area to correct a problem. Move leaking or damaged cylinders outdoors or to an isolated location, observing strict safety precautions. Work upwind if possible. Allow the spill to evaporate. Do not permit anyone to enter the spill area without appropriate respiratory protection, until the concentration of methyl bromide is determined to be less than 5 ppm.

Rate Calculations

Conversion Equations

Liquid

1 level tablespoonful = 3 level teaspoonsful
1 fluid ounce = 2 tablespoonsful = 29.57 milliliters
1 cup = 8 fluid ounces
1 pint = 2 cups = 16 fluid ounces
1 quart = 2 pints = 32 fluid ounces
1 gallon = 4 quarts = 128 fluid ounces

Weight

1 ounce = 28.3 grams
1 pound = 16 ounces = 454 grams
1 ton = 2,000 pounds

Dilution Tables

Wettable Powders

Number of ounces of wettable powder to use in small sprayers when amount per 100 gallons is known.

100 gals.	10 gals.	5 gals.	2 gals.	1 gal.
0.5 lb.	0.8 oz.	0.5 oz.	0.2 oz.	0.1 oz.
1.0 lb.	1.6 oz.	0.8 oz.	0.3 oz.	0.2 oz.
2.0 lb.	3.2 oz.	1.6 oz.	0.6 oz.	0.3 oz.
3.0 lb.	4.8 oz.	2.4 oz.	1.0 oz.	0.5 oz.
4.0 lb.	6.4 oz.	3.2 oz.	1.3 oz.	0.6 oz.
5.0 lb.	8.0 oz.	4.0 oz.	1.6 os.	0.8 oz.

Dilution Tables (continued)

Emulsifiable Concentrates

Number of fluid ounces of emulsifiable concentrate (EC) to use in small sprayer when amount per 100 gallons is known.

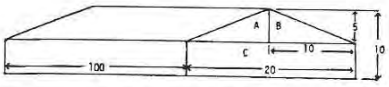
100 gals.	10 gals.	5 gals.	2 gals.	1 gal.
1 pt.	1.6 fl. oz.	0.8 fl. oz.	0.3 fl. oz.	0.2 fl. oz.
1 qt.	3.2 fl. oz.	1.6 fl. oz.	0.7 fl. oz.	0.3 fl. oz.
2 qts.	6.4 fl. oz.	3.2 fl. oz.	1.3 fl. oz.	0.6 fl. oz.
1 gal.	12.8 fl. oz.	6.4 fl. oz.	2.6 fl. oz.	1.3 fl. oz.

Mist Blower

Quantity of emulsifiable concentrate (EC) needed to make a 25X concentrate.

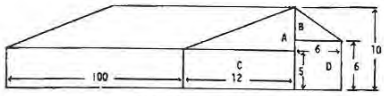
If amount per 100 gals for a high volume spray is:	Use this amount in a mist blower:			
	25 gals	*10 gals*	*2 gals*	*1 gal.*
1 pt.	6.25 pts	2.50 pts.	8 fl. oz.	4 fl. oz.
1 qt.	6.25 qts.	5.00 pts.	1 pt.	8 fl. oz.
2 qts.	3.13 gals.	5.00 qts.	1 qt.	1 pt.
1 gal.	6.25 gals.	2.50 gals.	2 qts.	1 qt.

Greenhouse Volume Calculations



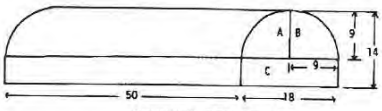
EVEN SPAN STRUCTURE

Even Span Structure
Area A and B = .5 (5 x 10) = 25
Area C = 20 x 5 = 100
Total Area = A + B + C = 100 + 25 + 25 = 150
Volume = Length x Total Area = 100 x 150 = 15,000 cu. ft.



3/4 SPAN HOUSE

3/4 Span House
Area A = .5 (12 x 5) = 30
Area B = .5 (4 x 6) = 12 Area C = 12 x 5 = 60
Area D = 6 x 6 = 36
Total Area = A + B + C + D = 30 +12 + 60 + 36 = 138 sq. ft.
Volume = Length x Total Area = 100 x 138 = 13,800 cu. ft.



ROUNDUP STRUCTURE

Roundup Structure
Area A + B = .5 (r^2) = 127
Area C = 5 x 18 = 90 sq. ft.
Total Area = A + B + C = 127 + 90 = 217
Volume = Length x Total Area = 50 x 217 = 10,850 cu. ft.

Using Chemicals Safely

When used as recommended on their labels, pesticides are safe and effective. However, all pesticides are poisonous and, if misused, they may be hazardous to man and animals and may also contribute to the pollution of the environment. Before using any pesticide, read the label in its entirety. Note any special precautions, such as the necessity of wearing special protective clothing when applying the chemical. Follow all safety precautions set forth on the label.

An ounce of prevention is worth a pound of cure.

- Risk equals toxicity multiplied by exposure. By simply reducing exposure, you reduce risk.
- Become familiar with the use of a pesticide before using it. Know its toxicity and the necessary precautions for its safe use.
- Keep all safety equipment such as face masks, respirators and protective clothing clean, on hand and in good working order.
- Mix pesticides in a well-ventilated area or outdoors. Avoid contact with skin, and do not breathe vapors.
- Much of the potential exposure to pesticides comes through your skin and hands. Wear rubber gloves when handling. Rinse the gloves before you take them off. Then wash your hands thoroughly. "Rubber Glove Zone" decals, booklets and videotapes are available from: NACA 1155 15th St., N.W., Washington, DC 20005.
- Do not re-enter treated areas unprotected until the re-entry interval specified on the product label has passed. Post "Do Not Enter" signs.
- Cleanup is an important part of the application operation.
- Do not save used pesticide containers. Dispose of old containers properly.
- Handle clothing contaminated with pesticide with rubber gloves. Garments saturated with full strength liquid concentrate should be discarded. Launder clothing immediately after each day's use. Keep contaminated clothing separate from other garments. Pre-rinse contaminated clothing. Wash it separately in hot water. Use the full or normal water level and small loads. Use the recommended amount of heavy-duty liquid detergent with oil-removing abilities. Line dry the garments. Run an "empty load" after washing contaminated clothing and clean the washing machine thoroughly. Use disposable protective clothing and equipment whenever possible when handling pesticides.

Summary of pesticide regulations. The Hazard Communication Standard (HCS) and the Superfund Amendment and Reauthorization Act (SARA), Title III, state that all employers who manufacture, use or store hazardous chemicals which legally require a Material Safety Data Sheet (MSDS) must now keep the MSDS on file. MSDS sheets must be available to anyone who requests them. Employers are responsible for developing or making available an employee training program. Contact the Texas Department of Agriculture or

Department of Health to find out about right-to-know compliance, Threshold Planning Quantity (TPQ) and Reportable Quantity (RQ). Start keeping an inventory of the chemicals in stock and how much is used per year.

Worker protection standards for agricultural pesticides require that handlers (workers who mix, load, transfer, transport, apply or dispose of pesticides; act as flaggers; or clean, adjust or repair contaminated parts of mixing, loading or application equipment) must wear all Personal Protection Equipment (PPE) specified on the product label, have access to a complete product label and be provided with specific decontamination facilities.

Avoiding groundwater contamination. Many of the agricultural chemicals identified in contaminated groundwater have been herbicides. Growers must take precautions to minimize the leaching of chemicals. Precision application to the root zone and controlled irrigation for as long as possible after treatment should reduce leaching.

Pesticides must be stored away from water supplies and wells. If available, use returnable, recyclable containers. Install a back siphon or back-flow device on the water line to keep fertilizer or pesticide from siphoning back down the pipe used to bring water from the aquifer. In addition, do everything possible to eliminate runoff which can carry fertilizers and pesticides into groundwater.

Selected References

References for Pest Identification

Baker, J. R. (ED) 1980. *Insects and related pests of shrubs, some important shrubs, some important, common, and potential pests in the Southeastern United States.* North Carolina Experiment Station, Dept. of Agric. Information, North Carolina State University, Raleigh, North Carolina 27607.

Baker, J. R. (ED) 1982. *Insect and related pests of flowers and foliage plants, some important, common and potential pests of North Carolina.* North Carolina Experiment Station, Dept. of Aric. Communications, North Carolina State University, Raleigh, North Carolina 27650.

Baker, J., 1986. *Insects found on yellow sticky cards.* N.Ca. Flower Growers Bulletin 30(1):10-13.

Benyus, J. M. 1983. *Christmas tree pest manual.* USDA, Forestry Service, North Carolina Experiment Station, Superintendent of Documents, U. S. Gov. Printing Office, Washington, D.C., 20402.

Gill, R. J. *Photo recognition key to the white flies and scale insect families of California. Scale and White fly key #1.* State of Calif. Dept. of Food and Agric. Environ. Monitoring and Pest Management, 1220 N. St., Sacramento, CA. 95814.

Gill, R. J. *Color-photo and host keys to California white flies. Scale and White Fly Key #2.* State of Calif. Dept. of Food and Agric. Environ. Monitoring and Pest Management, 1220 N. St., Sacramento, CA. 95814.

Gill, R. J. *Color-photo and host keys to the mealy bugs of California. Scale and White fly key #3.* State of Calif. Dept. of Food and Agric., Environ. Monitoring and Pest Management, 1220 N. St., Sacramento, CA. 95814.

Gill, R. J. *Color-photo and host keys to the soft scales of California. Scale and White fly Key #4.* State of Calif. Depart. of Food and Agric., Environ. Monitoring and Pest Management, 1220 N. St., Sacramento, CA. 95814.

Gill, R. J. *Color-photo and host keys to the armored scales of California. Scale and White fly Key #5.* State of Calif. Depart. of Food and Agric., Environ. Monitoring and Pest Management, 1220 N. St., Sacramento, CA. 95814.

Johnson, W. T. and H. H. Lyon. 1988. *Insects that feed on trees and shrubs.* Second edition. Cornell University Press, 124 Roberts Place, Ithaca, NY. 14850. 556 pp.

References for Biological Control

Henn, T., and R. Weinzieri. 1990. *Beneficial insects and mites.* Circular 1290. University of Illinois, College of Agriculture, Cooperative Extension Service.

Steiner, M.Y. and D.P. Elliott. 1987. *Biological pest management for interiorscape plantings.* Alberta Public Affairs Bureau, Publication Services, 11510 Kingsway Ave., Edmonton, AB, Canada T5G 2Y5.

- For a listing of available biological control organisms in North America: California Department of Food and Agriculture, Biological Control Service Program, 3288 Meadowview Rd., Sacramento, CA 95832 and ask for a copy of 1985 *Suppliers of Beneficial Organisms in North America.*

- For a report on advances in biological control technology in the greenhouse: Bulletin Secretary, University of California Cooperative Extension, 4205 Wilson Way, Stockton, CA 95205 and request *Biological control of two-spotted spider mite in California greenhouses* and *Biological control of greenhouse whitefly in California greenhouses*.

References for Pest Control Recommendations

Hamman, P. J. 1984. *House and Landscape Pests*, B-1373. Texas Agricultural Extension Service. Dept. of Agric. Communications, Reed McDonald Building, Texas A&M University, College Station, Texas 77843.

Lindquist, R. K. 1987. *Insect and mite control chart-1&2*, Ohio Florist's Assn. Bull. #651. Sponsored by the Florist's Insurance Companies, 500 St. Louis St., Edwardsville, IL 62025.

Miller, R. L. and D. G. Nielsen. 1985. *Insect and mite control on woody ornamentals.* Bull. 504. Cooperative Extension Service, Ohio State University, Extension Publications Office, 2120 Fyffe Road, Columbus, OH. 43210.

Miller, R. L. and D. G. Nielsen. 1985. *Insect control on Christmas trees,* L-257., Cooperative Extension Service, Ohio State University, Extension Publications Office, 2120 Fyffe Rd, Columbus, OH. 43210.

Mother Earth News (ed.). 1989. *The Healthy Garden Handbook.* Simon and Shuster Inc., Simon & Shuster Bldg., Rockefellar Center, 1230 Avenue of the Americas, New York, New York, 10020. 192 pp.

Powell, C. C. and R. K. Lindquist. 1984. *Pest and disease control on indoor plants.* Bull. 11. Cooperative Extension Service Ohio State University, Extension Publications Office, 2120 Fyffe Road, Columbus, OH. 43210.

Short, D. E. 1983. Plant Protection Pointer: *Phytotoxicity of Insecticide and Miticides to foliage and woody ornamental plants.* Extension Entomology Report #57. Institute of food and Agric. Sciences, University of Florida, Gainesville, FL. 32611.

Thompson, W. T. 1983. *Tree, Turf and Ornamental Pesticide Guide.* Thomas Publications, P. O. Box 9335, Fresno, CA. 93791.

- The society of American Florists publishes a list of pesticide brand names. For information on obtaining this list write Valarie Kurylo, Society of American Florists, 1601 Duke St., Alexandria, VA 22314.

Pesticide Classes & General Product Information

Insecticidal Soaps and Oils

These materials trap and suffocate small, soft-bodied insects and impair the waxy layer on their exoskeleton, resulting in dessication.

A. Horticultural Oil - (unsulfonated residue of refined petroleum distillate) foliar spray, inseciticide/miticide
- SunSpray Ultra-Fine Spray Oil® (Safer Inc.). ***Caution***. For commercial use.

B. Insecticidal Soap - (potassium salts of fatty acids) foliar spray, insecticide/miticide
- Safer® Insecticidal Soap Concentrate (Safer, Inc.). ***Caution***. For commercial use. (See label for M-Pede™, Mycogen Corp., after August 1991)

C. Petroleum Oil - dormant/summer oil, insecticide/miticide/ovicide
- Volck® Oil Spray (Chevron Chemical Co., Ortho Consumer Products Div.). ***Caution***. Contains 97% petroleum oil.

Insect Growth Regulators

These materials affect developing insects only and do not kill adults.

A. Chitin synthesis inhibitors prevent the formation of the chitin, an important component of the exoskeleton, after a molt.

1. cyromazine - foliar spray, target-specific insecticide
- Citation® (Ciba-Geigy). ***Caution***. A wettable powder (75% a.i.). Special mixing instructions are provided.

2. diflubenzuron - foliar spray, target-specific insecticide
- Dimilin® 25 W (Uniroyal Chemical). ***Caution***. Restricted use.

B. Juvenile hormone mimics produce a hormone imbalance in developing insects that results in abnormal development and/or death.

1. fenoxycarb
- Logic® Fire Ant Bait (Ciba-Geigy). ***Caution***. Bait.
- PTR 2100 Preclude® (Whitmire Research Laboratories Inc.). ***Caution***. Total-release aerosol.

2. kinoprene - foliar spray, somewhat target-specific insecticide
- Enstar® 5E (Sandoz Crop Protection). ***Caution***. Contains 0.625 lb. a.i. per gal.

Microbial Insecticides (Bacterials)

These materials produce and/or contain toxins which disrupt the stomach lining of specific insects (biological, microbial, bacterial stomach poison).

A. *Bacillus thuringiensis* var. *kurstaki* - foliar spray
- Bactospien® Biological Insecticide. (Biochem Products) ***Caution***.
- Javelin® WA (Sandoz Crop Protection). ***Caution***.

B. *Bacillus thuringiensis* var. *israelensis* - soil-applied, target-specific insecticide
- Gnatrol® Biological Larvicide (Abbott Laboratories). ***Caution***.
- Vectobac® Biological Larvicide (Abbott Laboratories). ***Caution***.

C. *Bacillus thuringiensis* var. *san diego* - foliar spray for elm leaf beetles
- M-One® Insecticide (Mycogen Corp.). ***Caution***.

Botanicals

These plant-derived products have various modes of action.

A. pyrethrins - foliar spray, aerosols
- Pyrenone® Crop Spray Insecticide (Fairfield American Corp.). ***Caution***. Formulated as 6.0% pyrethrins with piperonyl butoxide (PBO).
- X·clude Encapsulated Natural Pyrethrum PT® 1600A (Whitmire Research Laboratories, Inc.). ***Caution***. Aerosol spray formulated with 0.3% pyrethrin, piperonyl butoxide (PBO) and N-octyl bicycloheptone dicarboximide.

B. nicotine - fumigant
- Nicotine Smoke Generator® (Plant Products Corp.). ***Danger***. Restricted use. For use only in greenhouses; for use on greenhouse ornamentals only. Contains 14.0% nicotine.

C. pyrethrins + rotenone - Aerosol
- i-Bomb® (Plant Marvel Laboratories, Inc.). ***Caution***.

Derivatives of Pyrethrins

These products destabilize nerve cell membranes and quickly kill arthropods contacted, but are quickly deactivated and have little residual activity.

A. resmethrin - foliar spray, insecticide/miticide
- Resmethrin EC 26 Insect Spray (B. B. Pratt, Miller Chemical & Fertilizer Corp.) ***Warning***. Contains 2 lbs. a.i. per gallon
- PT® 1200 Resmethrin (Whitmire Research Laboratories, Inc.). ***Warning***. Total release aerosol for use in garden centers, and greenhouses. 1-lb cans.

B. sumethrin - aerosol
- PT® 1400 Sumethrin (Whitmire Research Laboratories, Inc.). ***Warning***. Total release aerosol for use in floral shops, garden centers and greenhouses. 1-lb cans.

Pyrethroids

These products destabilize nerve cell membranes but are much more stable and can persist in the environment longer than pyrethrins and their derivatives.

A. bifenthrin - foliar spray, insecticide/miticide
- Talstar® 10 WP (FMC Corporation). ***Warning***. Label includes list of plants on which this product has been tested without phytotoxic response. SLN No. TX-910013 for use as media treatment for imported fire ants. SLN No. TX-9100011 for use on outdoor ornamentals.

B. cyfluthrin - foliar spray, insecticide
- Decathlon® Ornamental Insecticide (Olympic Chemical Company, Inc.). ***Caution***. Commercial use only. Wettable powder. Six level teaspoons Decathlon = 1.3 oz.
- Tempo® 2 Ornamental Insecticide (Mobay Corp.). ***Caution***. For use by lawn care and landscape applicators and commercial nurserymen. Contains 2 lbs. a.i. per gallon.

C. es-fenvalerate - foliar spray, stump spray, insecticide
- Asana® XL Insecticide (DuPont). ***Warning***. Restricted use. Contains 0.66 lbs. a.i. per gallon.

D. fenpropathrin - foliar spray, insecticide/miticide
- Tame® 2.4 EC Spray (Valent). ***Warning***. Contains 2.4 lbs a.i. per gal.

E. fluvalinate - foliar spray, insecticide/miticide
- Mavrik® Aquaflow® (Sandoz Crop Protection). ***Caution***. Commercial use. Contains 2 lbs. per gal. Sensitive individuals may temporarily experience an itching or burning sensation, with or without a rash, following exposure. Avoid hand or sleeve-to-face contact. Prior to exposure, or after washing, an application of certain vegetable oils may reduce these symptoms. Workers in frequent contact with treated foliage should wear light barrier gloves to reduce excess exposure.

F. permethrin - foliar spray, insecticide
- Pounce® 2.3 EC (FMC Corp.). ***Caution***. Restricted use. Contains 3.2 lbs. a.i./gal.
- Pounce® 25 WP (FMC Corp.). ***Warning***. Restricted use.

Chlorinated Aryl Hydrocarbons and DDT Relatives (Diphenyl Aliphatics)

These materials destabilize nerve cell membranes, preventing them from transmitting nervous impulses.

A. dicofol
- Kelthane®

B. dienochlor - foliar spray, target-specific miticide
- Pentac® Aquaflow® (Sandoz Crop Protection). ***Warning***. Contains 2 lbs. a.i. per gal.

C. endosulfan - foliar spray, insecticide/miticide
- Thiodan® 3 EC (FMC Corp.). ***Danger***.
- Thiodan® 50 WP (FMC Corp.). ***Danger***.

D. lindane - foliar and trunk spray

- Lindane Borer & Leaf Miner Spray (Ortho Chevron). ***Danger***. Contains 20% a.i. by weight. Causes irreversible eye damage and skin irritation. Wear protective clothing when handling this product, as specified on the product label. For homeowner ornamental tree use only.

E. methoxychlor - foliar spray

- Methoxychlor 4L Insecticide (Drexel). ***Caution***. Contains 4 lbs. a.i. per gal.

Avermectins

These products affect the GABA-dependent chloride ion channel and inhibit this nerve transmitter.

A. avermectin B_1 - foliar local systemic, insecticide/miticide

- Avid® 0.15 EC Miticide/Insecticide (MSD AgVet). The 2% concentrate contains 0.15 lb. a.i. per gal. ***Warning***. Commercial use only. Do not apply more than 16 fl. oz. or less than 8 fl. oz. per acre. Use in sufficient water to obtain uniform plant coverage.

Carbamates

These materials inhibit cholinesterase and prevent the termination of nerve impulse transmission.

A. bendiocarb - foliar spray, insecticide

- Dycarb® (Grace-Sierra Crop Protection Co.) ***Warning***. Contains 76% a.i. in wettable powder formulation.
- Ficam® W 76% Wettable Powder Insecticide (Nor-Am Chemical Co.). ***Warning***. For use only by pest control operators.
- Ficam® 2 1/2 G Insecticide (Nor-Am Chemical Co.). ***Caution***. For use only by pest control operators.

B. carbaryl - foliar sprays, granular, bait formulations, and soil treatments, insecticide/eriophiid miticide

- Sevin® SL (Rhone Poulenc). ***Caution***. For commercial use only. Contains 4 lbs a.i. per gallon.
- Sevin® 4-Oil (Rhone-Poulenc). ***Caution***. For commercial use only.
- Sevin® 80 S (Rhone-Poulenc). ***Warning***. For commercial use only.
- Sevin® 50 W (Rhone-Poulenc). ***Warning***. For commercial use only.

C. carbofuran - soil-applied systemic, insecticide/nematicide

- Furadan® 4 F (FMC Corp.). ***Danger***. Restricted use.
- Furadan® 10 G (FMC Corp.). ***Danger***. Restricted use.
- Furadan® 15 G (FMC Corp.). ***Danger***. Restricted use.

D. metaldehyde - bait molluscicide

- Bug-Geta® Deadline Slug & Snail Killer (Ortho Chevron). ***Warning***. Contains 4% active ingredients by weight.
- Bug-Geta® Slug & Snail Pellets (Ortho Chevron). ***Caution***. Conains 3.25% active ingredients by weight.

E. methiocarb - spray, aerosol and bait, insecticide/miticide/slugicide (molluscicide)

- Mesurol® 75% Wettable Powder Insecticide-Molluscicide (Mobay Corp.). ***Warning***. Restricted use.
- PT® 1700 Methiocarb (Whitmire Research Laboratories, Inc.). ***Danger***. Total release insecticide aerosol generator for use in commercial greenhouses. 1-lb. cans.
- Slug-Geta® Snail and Slug Bait (Ortho Chevron). ***Caution***. Contains 2 percent active ingredients by weight. For ornamental gardens.

F. methomyl - foliar spray, insecticide

- Lannate® Insecticide (E.I. DuPont de Nemours & Co., Inc.). ***Danger***. Restricted use. EPA SLN No. TX-910014 for use on commercially grown ornamentals in greenhouses and nurseries in Texas. Water soluble powder containing 90% a.i.
- Lannate® L Insecticide (E.I. DuPont de Nemours & Co., Inc.). ***Danger***. Restricted use. EPA SLN No. TX-910015 for use on commercially grown ornamentals in greenhouses and nurseries in Texas. Water soluble liquid containing 1.8 lbs a.i. per gal.

G. oxamyl - systemic foliar spray, soil/medium treatment, insecticide/miticide/nematicide

- Oxamyl 10% Granular (B G Pratt, Miller Chemical & Fertilizer Corp.). ***Warning***. For use by farm service persons.
- Vydate® L Insecticide/Nematicide Water Soluble Liquid (E.I. DuPont de Nemours & Co., Inc.). ***Danger***. Restricted use. Contains 2 lbs. a.i. per gal. Registered for use as foliar sprays for insect and mite pests and as a pre-plant soil-incorporation, soil mix, foliar drench and dip application (root, corm or bud) for control of certain nematodes. For use only in commercial green houses and nurseries.

Organophosphates

These products inhibit cholinesterase and prevent the termination of nerve impulse transmission.

A. Aliphatic derivatives of phosphoric acid

1. acephate - foliarly-applied, aerosol or trunk injected, systemic insecticide

- Orthene® Turf, Tree and Ornamental Spray (Valent™). ***Caution***. 75% wettable powder. One ounce = 4 tbsp. + 1 tsp.
- PT® 1300 Orthene® (Whitmire Research Laboratories, Inc.). ***Warning***. Total release insecticide aerosol generator for use in commercial greenhouses. 1-lb. cans.
- Acecap® 97 Systemic Tree Implants (Creative Sales, Inc.). ***Caution***.

2. dicrotophos - trunk injection, insecticide/miticide

- Inject-A-Cide® B (J.J. Mauget Co., Inc.). ***Danger***. Internal treatment by microinjection for systemic suppression of certain insects on ornamental trees. For use by commercial arborists, pest control operators, professional gardeners and other similarly trained personnel.

3. **dimethoate** - foliar spray, systemic insecticide
   - Dimethoate 2.67 EC (Drexel). ***Warning***. Contains 2.67 lbs. a.i. per gal.
4. **disulfoton** - granular soil treatment, systemic insecticide/miticide
   - Di-Syston® 15% Granular Systemic Insecticide (Mobay Corp.). ***Danger***. Restricted use.
5. **malathion** - foliar spray, insecticide/miticide
   - Malathion 5 EC (Drexel). ***Warning***. Contains 5 lbs. a.i. per gallon (57%).
6. **oxydemeton-methyl** - soil or trunk injection systemic insecticide/miticide
   - Metasystox-RS® (Mobay Corp.). ***Warning***. Contains 2 lbs. a.i. per gallon. Restricted use pesticide.
   - Inject-A-Cide® (J.J. Mauget Co., Inc.). ***Warning***. Internal treatment by microinjection for systemic suppression of certain insects on ornamental trees. For use by commercial arborists, pest control operators, professional gardeners and other similarly trained personnel.
7. **trichlorfon** - foliar spray, insecticide
   - Dylox® 80 Turf and Ornamental Insecticide (Mobay Corp.). ***Warning***. Commercial use only. 80% water soluble powder.

B. Carbon cyclic derivatives of phosphoric acid
1. **fenitrothion, sumithion** - foliar spray, insecticide
   - Pestroy® 4 EC Broad Spectrum Insecticide (PBI Gordon Corp.). ***Warning***. Contains 4 lbs. a.i. per gallon (also available in 8 lbs. per gallon formulation). For ground application only. See label for list of labeled plants. No mention of phytotoxicity.
2. **fenthion** - foliar spray, insecticide/miticide
   - Baytex® 4 Emulsifiable Insecticide (Mobay Corp.). ***Warning.*** For use only by pest control operators and commercial nurserymen. Contains 4 lbs. a.i. per gallon.
3. **isofenphos** - soil treatment, insecticide
   - Oftanol 2 Insecticide (Mobay Corp.). ***Warning***. For commercial applicator use only.

C. Heterocyclic derivatives of phosphoric acid
1. **azinphosmethyl** - foliarly-applied, insecticide
   - Guthion® 2S Emulsifiable Insecticide (Mobay Corp.). ***Danger***. Restricted use. Contains 2 lbs. a.i. per gal.
2. **chlorpyrifos** - foliar, dormant and trunk spray, soil treatment, insecticide/miticide
   - Dursban® 50 W Insecticides (also in water soluble 0.25-lb. packets)(DowElanco). ***Warning***. Commercial use only.
   - Dursban® 4 E (DowElanco). ***Warning***. Commercial use only. (released as DursbanR Turf Insecticide in 1991). Contains 4 lbs. a.i./gal.
   - Pageant® D F (dry flowable) (DowElanco). Warning. Commercial use only. Contains 50% a.i. by weight. Rates equivalent to Dursban 50 W.
3. **diazinon** - foliar spray, aerosol, soil treatment, insecticide/miticide
   - D•Z•N® Diazinon® 4 E (Ciba-Geigy). ***Warning***. 4 lbs. a.i./gal.

- D•Z•N® Diazinon® AG 500 (Ciba-Geigy). ***Warning***. 4 lbs. a.i./ gal. (Use same rates as for Diazinon 4E).
- D•Z•N® Diazinon 50 W (Ciba-Geigy). ***Warning***.
- PT® 1500R Knox•Out® Microencapsulated Diazinon (Whitmire Research Laboratories, Inc.). ***Caution***. Timed release insecticide greenhouse and foliage spray (hand-held aerosol applicator). 16-oz. cans.
- PT® 265 Knox•Out® 2 FM (Whitmire Research Laboratories, Inc.). ***Caution***. Contains 2 lbs. diazinon per gal.

Sulfonates, Sulfides, Sulfones, Sulfonamides, Sulfonites

A. propargite - foliar spray, miticide

- Ornamite® (Uniroyal Chemical). ***Danger***. Commercial use. 30% by weight of wettable powder. Also in 1/2-lb. water soluble bags. Not compatible with foliar spray oils. Leaf injury may occur. Do not combine with other chemicals or spray adjuvants. Not compatible with alkaline materials such as lime, lime sulfur or Bordeaux. The effectiveness of Ornamite will be reduced. Performance is best when temperatures average above 70 degrees F.

Miscellaneous Compounds

A. hexakis - foliar spray, miticide

- Vendex® 4 L (DuPont Agricultural Products). ***Danger***.
- Vendex® 50 WP (DuPont Agricultural Products). ***Danger***.
- Orthenex® Insect & Disease Control - Formula III (Ortho Chevron). ***Danger***. Contains acephate, triforine and hexakis.

B. hydramethylnon

- Amdro® Fire Ant Bait (American Cyanamid). ***Caution***.

C. oxythioquinox - foliar spray, insecticide/miticide

- Joust® Ornamental Miticide (Olympic Chemical Company). ***Caution.***
- Morestan® 25% Wettable Powder Miticide (Mobay Corp.). ***Caution.***

Fumigants

A. methyl bromide

- Brom-O-Gas® (Great Lakes Chemical Corp.). ***Danger***. Restricted use.
- Terr-O-Gas® 98 (Great Lakes Chemical Corp.). ***Danger***. Restricted use.

B. nicotine (botanical)

- Nicotine Smoke Generator (Plant Products Corp.). ***Danger***. Restricted use. For use in greenhouses only; for use on ornamentals only. Contains 14% nicotine.

C. sulfatepp

- Plantfume 103 Smoke Generator (Plant Products Corp.). ***Danger***. Restricted use. For use in greenhouses only; for use on ornamentals only. Contains 15% Dithio.

Tables

The tool you have needed to answer pest management questions

Pest Management Alternatives for Commercial Ornamental Plants

Includes:

- ***How to identify the pest***
- ***How to decide if you need a pesticide***
- ***What pesticide to use***
- ***When to switch pesticides***
- ***Listing by location and application method***
- ***Integrated Pest Management***

About the author: Dr. Drees is recognized as Texas' expert on Integrated Pest Management. He has been an extension entomology specialist for the Texas Agricultural Extension Service since 1980 and has statewide responsibility for extension programs relating to the management of arthropods on commercially produced ornamentals, rice, and soybeans. He also manages the red imported fire ant program, as well as the Africanized honey bee tracking service. He is area specialist for 16 upper gulf coast counties and presents educational programs to ornamental and commodity groups.

Dr. Drees holds a bachelors degree in biology and masters degree in entomology from West Virginia University, and a Ph. D. in entomology from Ohio State University. He received the American Registry of Professional Entomologists Outstanding Award in General Entomology in 1986. He is the author of the *Texas Ornamental Insect/Mite Management Guidelines*, the first publication produced by the extension service which addressed the needs and technology available to solve insect and mite problems of commercial producers.

Texas Association of Nurserymen
7730 South IH-35
Austin, Texas 78745-6698