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Agricultural Extension Service
The University of Tennessee

PB 1595

Using Pesticides in Greenhouses

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Originally developed by James Faust, former Assistant Professor,
Elizabeth Will, former graduate student, Plant Sciences,
and Frank A. Hale, Associate Professor, Entomology and Plant Pathology

Using Pesticides in Greenhouses

Frank A. Hale, Associate Professor, Entomology and Plant Pathology,
Agricultural Extension Service, University of Tennessee,
Raymond A. Cloyd, Assistant Professor, Extension Entomologist, University of Illinois
Edward E. Burgess, Professor, Entomology and Plant Pathology,
Agricultural Extension Service, University of Tennessee

The objective of using pesticides in greenhouses is to reduce or manage pest populations without endangering the lives of greenhouse workers or customers, and without harming plants. To achieve this goal, it is essential to maximize pesticide exposure to the targeted pests and minimize human pesticide exposure. The first part of this publication will address issues related to pesticide applications, whereas the second part addresses human safety issues.

Pesticide Application

The focus of a pesticide application is to deliver the pesticide to the target pest (i.e., insect, mite and pathogen). Most pesticides are sprayed onto plant foliage; however, some pesticides are available in granular formulations that can be incorporated into the growing medium or topdressed on the growing medium surface.

Spray Application

When a pesticide is sprayed, the material is dispersed into small droplets. The smaller the droplets, the greater the number of droplets per area of greenhouse, and the greater the likelihood of hitting the target pest (Table 1). Smaller droplets (10 to 50 microns) are more likely to contact flying insects (note: one micron equals 0.000004 inch). Droplets that are 30 to 50 microns are most likely to come into contact with insects on foliage, while the larger droplets (250 to 500 microns) are most useful at contacting insects in the growing medium. The type of spray equipment used determines the droplet particle size.

Spray Application Equipment

Several different sprayers are commercially available to greenhouse operators. Each has its own benefits and limitations. There is no one best choice; however, certain sprayers may fit nicely into the pest management programs of different greenhouse facilities.

Table 1. Relationship between Particle Size and the Number of Droplets per Square Inch

Droplet diameter (microns)	Droplets per square inch
10	123,219
20	15,400
50	987
100	123
200	15
400	1.9
1000	0.13

Direct Spray versus Fixed-Position Sprayers

Direct sprayers are manually operated and can be aimed at targeted areas of the greenhouse, while fixed-position sprayers are placed into the greenhouse where they function without direct human supervision. The advantages and disadvantages of each type of application method are presented in Table 2.

Table 2. Comparison of the Advantages and Disadvantages of the Different Spray Application Methods

Spray Application Method	Advantages	Disadvantages
Direct	• Can be targeted to a specific area, i.e., spot application. • Easier, though still difficult to target undersides of leaves.	• Labor intensive. • Higher pesticide exposure to the applicator. • Requires a skilled applicator.
Fixed Position	• Lower labor requirement. • Lower pesticide exposure to the applicator.	• Can not be targeted to a specific area. • Everything in the greenhouse gets sprayed. • Difficult to spray undersides of leaves, especially when plants are large. • Relies on horizontal air-flow fans for pesticide distribution.

High-volume versus Low-volume Sprayers

High-volume (HV) sprayers use a large volume of water to carry the pesticide to the plant canopy. The hydraulic sprayer is most commonly used in greenhouses to apply pesticides. The equipment ranges from small hand pump sprayers to backpack sprayers to large power sprayers.

Low-volume (LV) sprayers use a smaller volume of pesticide. The same amount of active ingredient is applied; however, the chemical is broken into smaller droplets. This category also includes what is sometimes referred to as ultra-low-volume (ULV) sprayers. ULV sprayers produce even smaller droplet sizes. Several LV application methods are described in Table 3 and comparisons are made in Table 4.

Table 3. Methods of Low-volume Pesticide Application

Ready-to-Use-Aerosols
The chemical is in a pressurized canister that produces a chemical fog when opened.

Thermal Pulse-Jet Foggers
The pesticide is injected into a hot stream of air that vaporized the chemical into small fog particles. A carrier is mixed with the pesticide to improve the uniformity of droplet size. High temperatures and low humidity result in more rapid settling of the chemical, which results in more chemical falling on the upper side of the leaf.

Cold Foggers/High-pressure Hydraulic
High pressure pumps and atomizing nozzles are used to produce fog-sized particles. A spray stream is formed that may reach 10 to 12 feet.

Mechanical Aerosol Generators
These are designed to be operated from a single position unattended inside the greenhouse. Air-atomizing nozzles are used to form small droplets.

Electrostatic Applicators
The spray droplets are electrostatically charged, which results in the droplets being attracted to both sides of the leaf surface. Handheld and unattended models are available.

Table 4. Comparisons among the Different Spray Application Methods and Equipment

Spray Volume	Application Method	Application Type	Droplet Diameter (microns)	Advantages	Disadvantages
High	Hydraulic	Direct	100 to 400	Can be used with many pesticide formulations. Can be used for " spot" treatment. Relatively low cost.	Large droplet size results in poor coverage and waste. Labor intensive. Spray to runoff is subjective.
Low	Cold Fogger/High-Pressure Hydraulic	Direct	30	Can make " spot applications."	Difficult to get coverage to leaf undersides, especially when plants are large.
Low	Air-assisted Electrostatic	Direct or Fixed Position	40	Less spray drift than other LV application methods. Good distribution to both sides of leaves.	Charged particles can be attracted to charged surfaces other than leaves.
Low	Thermal Pulse-Jet Fogger	Fixed Position	0.5 to 50	Very effective with " vapor-active" pesticides. Can treat large areas quickly. Can be sprayed from below porous benches to improve lower leaf coverage.	Can not perform " spot applications." Difficult to get distribution to leaf undersides.
Low	Mechanical Aerosol Generator	Fixed Position	0.5 to 15	No human applicator present.	Difficult to get distribution to leaf undersides.
Low	Ready-to-use Aerosols	Fixed Position	15	Low labor requirement. Convenient for small greenhouses.	Distribution depends on air movement. Difficult to get distribution to leaf undersides.

Granular Pesticide Application

Granular pesticide formulations are labeled for use by incorporating into and/or topdressing the growing medium. Granular formulations are generally used for pesticides that are translocated throughout the plant, such as systemics, or for pesticides that control pests in the growing medium, (i.e., fungus gnat larvae). If topdressed, the pesticide must be watered into the growing medium immediately after application. If incorporated into the growing medium, thorough mixing is essential. Workers mixing the growing medium or transplanting into the medium will be exposed to the granular pesticide. Therefore, they need to receive the Environmental Protection Agency's worker protection training for 'pesticide handlers' or 'pesticide workers.' Contact your county Agricultural Extension agent for training information.

Preparing Pesticides for Application

Dosage

The same amount of active ingredient must be applied to the greenhouse crop regardless of the type of sprayer; however, the HV sprayers apply a much larger volume of solution to the crop. For example, HV sprayers may use 25 to 50 gallons per 10,000 square feet, while a LV sprayer uses only 0.25 to 2 gallons per 10,000 square feet. If the pesticide label reports the amount of pesticide to be added to 100 gallons of water and not the area to which the pesticide is to be applied, one could consult the LV sprayer manual to determine the amount of pesticide to apply.

Adjuvants

Adjuvants are materials added to pesticide sprays to increase pesticide contact with the plant foliage. The two common types of adjuvants used by growers are surfactants and spreader stickers.

Surfactants are wetting agents that reduce surface tension and thus increase the spread of the pesticide over the leaf surface. Spreader stickers, such as latex, act as adhesives that increase the adhesion of the pesticide to the plant.

Before adding adjuvants, read the pesticide label. Compatibility or lack of compatibility may be indicated. In addition, some pesticides may already contain adjuvants. For example, emulsifiable concentrates already contain some adjuvants; therefore, adding additional adjuvants to these pesticides may increase the probability of causing phytotoxicity.

Adjuvants should always be added with some caution, since phytotoxicity is possible. Start by adding one ounce per 100 gallons. Continue adding one ounce at a time until adequate coverage of the foliage is achieved. Do not add more than 8 ounces per 100 gallons. Always test spray a few plants before applying the spray to the entire crop. Perform the test spray under warm, sunny conditions which will be adequate in promoting phytotoxicity. This test should determine if there are any potential problems.

Tank Mixes

When two pesticides are mixed together, this is referred to as "tank mixing." Always check labels for possible compatibilities or incompatibilities. When mixing two pesticides:

- Check for precipitates forming in the tank or for color changes. Either indicates incompatibility.
- Spray the mix on a small group of plants to check for possible phytotoxicity.
- Never allow the concentrated pesticides to come in contact each other.
- Always dilute the individual pesticides prior to tank mixing.
- Add any adjuvants after the pesticides have been combined.
- Provide constant agitation.

Many entomologists discourage the use of tank mixes because of the increased rate at which a pest population can develop resistance to a pesticide. Also, there is increased potential for phytotoxicity to the crop.

Water Quality

High water pH, above 7.0, can reduce the effectiveness of some pesticides. This is referred to as alkaline hydrolysis. Most often high pH is a problem when pesticide solutions are mixed and then not immediately used. In general, pesticide solutions should be used within a few hours of being mixed. Allowing a pesticide to sit overnight in high pH water can cause the pesticide to break down, reducing its effectiveness.

Application Technique

Fixed-position sprayers require that an air flow pattern be established prior to introducing the pesticide into the greenhouse. The air flow pattern is achieved by turning the sprayer fans on for 15 minutes before application begins. The fans are also left on for 30 to 60 minutes after the spray is completed. Fixed-position sprayers usually have timers that determine the sequence.

Directed sprays require a skilled applicator to achieve uniform and thorough coverage. LV sprays are more highly concentrated than HV sprays; thus, the applicator must continually be moving, since any hesitation or stopping can result in a localized overdose of a pesticide. In order to apply the correct pesticide dosage, spray equipment must be correctly calibrated. This will result in the applicator applying the correct amount of active ingredient in the greenhouse.

Calibrating Equipment

To properly apply pesticides, the spray equipment must be accurately calibrated. This will result in applying the appropriate volume of pesticide. Proper pesticide application is a technique that must be learned. The following exercise can be used to calibrate spray equipment and to train new applicators.

1. Mark off an area to be practice-sprayed; for example, 500 square feet.
2. Determine the desired pesticide application rate.
3. Use the sprayer to apply water for one minute into a 2-gallon measuring container. The volume of water in the container after one minute measured in ounces provides the sprayer application rate in ounces per minute.
4. Practice spraying the marked-off area.
5. Perform the following calculation for the time required to properly spray the practice area:

$$\text{Time (sec)} = \frac{\text{Desired application rate (gal/10,000 sq. ft.)}}{\text{Sprayer rate (ounces per min.)}} * \text{Practice area (sq. ft.)} * 0.768$$

6. Compare the actual time to spray the practice area versus the proper time. Practice spraying the desired area size until the proper time can be achieve with water.

Pesticide Storage and Disposal

Storage Construction

Ideally, pesticides should be stored in a separate building away from the greenhouse facility. Due to the hazards associated with burning pesticides, firefighters may not approach or attempt entry into a burning building containing pesticides. Pesticides should not be stored in the greenhouse where the environment will shorten shelf life, and potential volatile fumes from some pesticides can affect plant growth.

When building a separate pesticide storage facility, locate the structure at least 150 feet from wells or other water supplies. Building construction should include a 4-inch, watertight, concrete slab floor; watertight concrete block walls; steel construction roof; and two doors with 6-inch thresholds to contain spills. Forced ventilation should be provided as described below. The building should be insulated. Heat and cooling should be provided if interior temperature extremes are possible. Extremes in hot or cold will shorten the shelf life of pesticides. Freezing or over heating should be prevented. Freezing temperatures can cause glass, metal, and plastic containers to break. Excessive heat can cause plastic containers to melt, some glass containers to explode, and some pesticides to volatilize and drift away from the storage site. The pesticide-mixing area should be separate from the storage area. Water supplies should have a antisiphon backflow device to prevent siphoning of waste water into the water supply. A stainless steel sink should be provided for mixing.

If pesticides are to be stored in an existing building (i.e., service building or greenhouse), the room should be on an outside, windowless wall located away from heavily used rooms, such as offices or breakrooms. The walls should be concrete block or wood frame with a vapor barrier on the inside of the wall. Walls, floors, shelves and work tops should be sealed with a chemical-resistant finish such as epoxy. Forced ventilation should also be provided.

Ventilation

Forced ventilation should either operate continuously or start automatically when interior lights are on. The ideal arrangement is a 2-speed fan with a low speed setting to run continuously and a high speed setting that is turned on with the light switch. The ventilator should change the air every three minutes on high speed and every six minutes on low speed. Use the following guidelines to determine the fan rating in cubic feet per minute (CFM) required to adequately ventilate the storage area.

Calculate the volume of the room by multiplying the length of the room by the width and by the height. Divide the resulting number by three for the high speed fan or by six for low speed fan. For example: a room 10 feet long, 5 feet wide and 8 feet high has a volume of 400 cubic feet. 400 divided by 3 = 133 cubic feet. So, a 150 cubic feet per minute (CFM) fan is adequate for ventilating the storage area.

Storage Operations

All storage facilities should be locked and access controlled on an as needed basis. Records should be maintained on all pesticide purchases, use and disposal, with duplicated copies kept somewhere other than the pesticide storage area. Pesticides should be stored in their original containers. Store pesticide containers with the label in plain sight. Labels should always be legible. You can use transparent tape or a coating of lacquer or polyurethane to protect the label. The purchase date should be clearly recorded on each container. Store herbicides separately from other pesticides such as insecticides and fungicides. Regularly inspect all containers for leaks or damage. When a pesticide is damaged follow one of four procedures.

1. Use the pesticide immediately at a site and rate allowed by the label.
2. Transfer the pesticide into another pesticide container that originally held the same pesticide and has the same label still intact.
3. Transfer the contents to a sturdy container that can be tightly closed. Transfer the label to the new container.
4. Place the entire damaged container and its contents into a suitable larger container.

Never store personal protective equipment or protective clothing inside a pesticide storage area.

Pesticide Shelf Life

All pesticides will break down over time. Although most pesticides will remain active for four to five years, it is recommended that products be stored for no longer than two to three years. Note that a pesticide may be two or more years old before it is purchased. Store pesticides in a dry, well-ventilated, cool area away from direct sunlight. This will maximize the shelf life of a pesticide.

Always read the pesticide label to determine particular storage requirements. Preventing exposure to extremes of hot or cold is important for many pesticides. Response may vary depending on formulations of the active ingredient. In general, high and low temperatures accelerate pesticide breakdown, resulting in decreased shelf life. Volatile alcohols and flammable solvents are common components of many pesticides. As a result, they must not be exposed to flames, sparks or hot surfaces. Some examples of flammable pesticides are Diazinon, Dibrom and Azatin. Flammability varies with formulation of the active ingredient. Low temperatures can result in separation of pesticide components and reduce effectiveness. For example, the insecticides Azatin, Decathlon and Mavrik should not be stored below 32 degrees F. Generally, dry pesticide formulations can be stored for longer periods of time than liquids if the containers are resealed tightly and protected from wetness. Always be aware of changes in the storage conditions and odors from pesticides. Improper storage can lead to pesticides not dispersing in water.

Disposal

The best way to minimize having to dispose of pesticides is to purchase only what is needed. In addition, mix only the amounts needed and apply them to crops for which they are labeled. Check the container label for disposal directions. Unless otherwise noted, empty pesticide containers should be triple or pressure rinsed. In addition, wash the outside of the container, and puncture or crush to avoid reuse. After following these procedures, dispose of pesticide containers in a sanitary landfill. The rinsate should be applied to the labeled crop. Never burn pesticide containers, dump pesticide concentrates on the ground, bury them or flush pesticides down toilets or drains.

Human Safety

The second objective of pesticide application is to minimize human exposure. The Environmental Protection Agency has developed a list of regulations, called the Worker Protection Standards, that the greenhouse managers must follow to properly protect greenhouse workers. Because these standards are generalized, managers must still use common sense to prevent pesticide exposure to workers.

Pesticide Toxicity (LD_{50})

The health risks from exposure to a pesticide are determined by the toxicity, the length of exposure time, and the route of entry into the human body. Toxicity is any adverse effect resulting from exposure to a pesticide. Acute toxicity is the immediate effect resulting from short-term exposure to a pesticide. Chronic toxicity, the long-term effect of repeated exposures to a pesticide at lower concentrations, may result in permanent damage to the human body.

The three major routes of pesticide entry into the human body are oral intake through the mouth, dermal or skin exposure, and inhalation. Oral exposure most often occurs through failure to wash hands after handling pesticides, which can lead to the contamination of food or drink. The dermal route accounts for a majority of pesticide exposures. It may occur whenever a pesticide is mixed, applied or handled. Both dry and wet pesticides may be absorbed through the skin. Inhalation exposure occurs from breathing pesticide vapors, dust or spray particles. It may occur when protective equipment is not worn or is improperly fitted.

Many pesticide classes have similar modes of action. For example, organophosphates and carbamates interfere with activity of the nervous system leading to paralysis. The basic mode of action is the same in insects, humans and beneficial organisms. Some of these pesticides are less toxic to humans than others because they are quickly broken down into harmless products in humans. Others, like Malathion, are inactive until enzymatically altered in the insect to the toxic form. Malathion is quickly broken down to relatively harmless products in mammals. Some older pesticides have been reformulated (i.e. microencapsulation) to minimize toxicity to humans. Many new generation pesticides have alternative modes of action, reducing their toxicity to mammals and beneficial insects when used properly in an integrated pest management program. These include insect growth regulators, microbial insecticides, soaps and oils.

The United States Environmental Protection Agency (EPA) requires pesticide formulators to provide data on the toxicity of the active ingredient. This information is derived from tests conducted on animals that are physiologically similar to humans and amenable to laboratory studies, such as rats, mice, rabbits, guinea pigs and dogs. Acute toxicity is determined by intravenous, oral inhalation and dermal exposure. An LD_{50} (the lowest dose of a toxin that kills 50 percent of the exposed organism in a test) is established. The estimated toxicity to humans is extrapolated on a weight basis and expressed in milligrams of toxin per kilogram of body weight. The lower the LD_{50}, the more toxic the pesticide. Chronic toxicity of pesticides is less well understood and not often established.

The US EPA requires labeling that provides information on pesticide toxicity. A label must carry one of the signal words (DANGER, WARNING, CAUTION) that represent the three general categories of pesticide toxicity. Category I will have the skull and crossbones symbol and the word POISON (in red) in addition to the signal word DANGER. These three categories of pesticide toxicity are based on oral, inhalation and dermal LD_{50}; and eye and skin effects. Toxicity categories and what they mean are presented in Table 5.

Table 5. Toxicity Categories for the Major Routes of Pesticide Exposure

TOXICITY INDICATORS	TOXICITY CATEGORIES			
	I **Danger, Poison (in red)** **Skull and Cross-Bones Symbol**	**II** **Warning**	**III** **Caution**	**IV** **Caution**
Oral LD_{50}	Up to and including 50 mg/kg	From 50 to 500 mg/kg	From 500 to 5000 mg/kg	Greater than 5,000 mg/kg
Inhalation LD_{50}	Up to and including 0.2 mg/liter	From 0.2 to 2 mg/liter	From 2 to 20 mg/liter	Greater than 20 mg/liter
Dermal LD_{50}	Up to and including 200 mg/kg	From 200 to 2,000 mg/kg	From 2,000 to 20,000 mg/kg	Greater than 20,000 mg/kg
Eye Effects	Corrosive; corneal opacity not reversible within 7 days	Corneal opacity irritation reversible within 7 days; irritation persisting for 7 days or more	No corneal opacity; irritation reversible within 7 days	No irritation
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

Source: The Pesticide Book. G.W. Ware. 1994.

Worker Protection Standards

In 1992, EPA expanded the farmworker pesticide protection regulations, the Worker Protection Standard (WPS). The WPS covers pesticide use in the production of agricultural plants on farms, forests, nurseries and greenhouses. It requires a full range of pesticide protection and training for pesticide handlers and field workers.

Horticultural employers who use pesticides on their operation and who have one or more employees are subject to all of the provisions of the WPS. "Family" farmers and their immediate family members are exempt from many WPS provisions. However, they must observe the appropriate restricted-entry intervals (REIs) and must use the proper personal protective equipment (PPE) listed on pesticide labels.

FIFRA states that no pesticide may be used in a manner inconsistent with its label restrictions. This is particularly important for purposes of the WPS. Pesticide users must comply with all the WPS provisions listed on the pesticide label. Look in the "Agricultural Use Requirement" section on the label of those requirements.

Worker

Worker employers must make sure that workers and other persons do not enter specific areas within the greenhouse during and, in some instances, after certain greenhouse applications.

Handlers

During any pesticide application in a greenhouse or an adjacent structure that cannot be sealed, do not allow anyone other than an appropriately trained equipped handler, to be in the primary area, plus 25 feet in all directions.

Personal Protective Equipment (PPE)

PPE includes coveralls, respirators, protective eyewear (i.e., goggles), chemical-resistant suits, gloves, footwear, aprons and headgear. Following are guidelines for PPE use:

- Follow PPE requirements as stated on the pesticide label.
- Be certain that respirators fit correctly. To test for correct fit, place a odorous substance, such as banana oil, outside the respirator. If you can smell it, then the respirator does not fit properly. Individuals with beards can not legally wear facial respirators.
- Provide a pesticide-free area for storing personal clothing not in use.
- Do not allow PPE to be worn or taken home.
- Store and laundry PPE separately from other clothing.
- Regularly replace respirators and cartridges according to manufacturer's recommendations on the pesticide label.

Handler employers must make sure that pesticide handlers:

– Are provided with the PPE that the pesticide labeling requires for the task,
– Wear the PPE for the entire handling task, and
– Use the PPE correctly.

Handlers employers must:

– Inspect all PPE before each day
– Provide handlers with clean places away from pesticide storage and pesticide use areas to:
  • store personal clothing not in use,
  • put on PPE at the start of any exposure period,
  • take off PPE at the end of any exposure period.
– Take any necessary steps to prevent heat illness while PPE is being worn.
– Not allow any handler to wear home or take home PPE-contaminated with pesticides.
– Clean and maintain PPE.
– Replace respirator filters, cartridges or canisters at the proper time.
– Properly dispose of the PPE.
– Give proper safety instructions to persons who clean PPE.

PPE Definitions

Chemical resistant - no measurable amount of chemical can move through the material during use.

Waterproof - no measurable amount of water (or water-based solution) moves through the material during use.

Chemical-resistant suit - A loose-fitting, one- or two-piece, chemical-resistant garment that covers, at the minimum, the entire body except head, hands and feet.

Coverall - A loose-fitting, one- or two-piece garment that covers, at the minimum, the entire body except head, hands and feet. Made of fabric such as cotton or cotton-polyester blend. Not chemical-resistant.

Chemical-resistant apron - An apron made of chemical-resistant material that covers the front of the body from mid-chest to knees.

Gloves - Hand coverings or type listed on pesticide label. New pesticide labels may require certain types of gloves. If not specified, follow these general guidelines in selecting a glove:

1. Barrier-laminate - Broad-spectrum chemical resistance, limited dexterity

Table 6. Restricted Entry Intervals (REI) for pesticides labelled for greenhouse use

PESTICIDE	REI (hr)
Adept	12
Akari	12
Astro	24
Attain	12
Avid	12
Azatin	4
Botanigard	12
Cinnamite	4
Citation	4
Confirm	4
Conserve	4
Decathlon	12
Dibrom 8	24
Dipel	4
Distance	12
Dithio	4*
Duraguard	24
Duraplex	24
Endeavor	12
Enstar II	4
Floramite	4
Gnatrol	4
Hexygon	12
Insecticidal Soap	4
Kelthane	12
Marathon	12
Mavrik Aquaflow	12
M-Pede	12
Mesurol	12
Naturalis O	4
Nemasys	0
Nicotine	4*
Ornazin	12
Orthene TT&O	12
Orthene 1300	24
Ovation	12
Pedestal	12
Plantfume	4*
Precision	12
Preclude	12
Pylon	12
Pyrenone	12
Pyrethrum	12
Sanmite	12
Scimitar	24
Talstar	12
Tame	24
TetraSan	12
Thiodan	24
Triact	4
Ultra-Fine Oil	4
Vapona DDVP	4*
Vendex	48

* Minimum REI, if venting requirements met

2. Neoprene - Excellent chemical resistance, limited dexterity
3. Nitrile - Excellent chemical resistance, excellent dexterity
4. PVC (polyvinyl chlorine) - Good chemical resistance, good dexterity
5. Rubber - Fair-to-good chemical resistance (depending on thickness), good-to-excellent dexterity

Chemical-resistant footwear - Chemical-resistant shoes, chemical-resistant boots or chemical-resistant shoe coverings worn over shoes or boots. Materials include PVC/Urethane, TYVEK and latex.

Protective eyewear - Goggles, face shield or safety glasses with front, brow and temple protection.

Chemical resistant headgear - A chemical resistant hood or hat with a wide brim.

Respirator - A device that protects the respiratory system and prevents breathing pesticide dusts or vapors. Must be the type listed on the pesticide label and appropriate for the pesticide product being used and for the activity being performed. The label will contain the NIOSH/MSHA "TC" approved number.

Air purifying respirator types:

1. Half mask, particulate, disposable (NIOSH prefix TC-21C). Use for dust, pollen and mists, and certain pesticides applied in solid form.
2. Maintenance-free, dual cartridge half mask, disposable (NIOSH prefix TC-23C). Use for pesticides and ammonia.
3. Dual cartridge, half mask, reusable (NIOSH prefix TC-23C). Change cartridge to match contaminant.
4. Full-face, dual cartridge, reusable (NIOSH prefix TC-23C). Protects face, eyes and nose.
5. Power, air-purifying with helmet (NIOSH prefix TC-23C). Battery-powered fan pulls air through filters and circulates air through helmet.
6. Canister-type gas mask (NIOSH prefix TC-14G). Large canister gives greater protection than standard dual-cartridge respirators.
7. SCBA-Air supplied (NIOSH prefix TC-13F). Self-contained breathing apparatus. Breathable air supplied by cylinder on back of applicator.

Filters/Cartridges

Chemical cartridges are elements that are filled with specially treated activated carbon, which has a very high absorption capacity. Gases and vapors passing through chemical cartridges are attracted to and held to the surface of the carbon. Absorption capacity is limited so cartridges must be changed regularly.

Mechanical filters are elements that provide protection against particulate matter such as dusts or mists. Particulate matter is physically trapped in the fibrous filter material. Although mechanical filters increase in efficiency as they are used, they may also become more difficult to breathe through. They should be changed when breathing becomes uncomfortable. (Note: All respirator manufacturers use the same color-coding system for reference cartridges to specific applications. Pesticides are classified as organic vapors. Black is the color code for organic vapors and yellow is the color code for combined filters for acid gas and organic vapors.)

Restricted Entry Interval (REI)

The REI refers to the number of hours after a pesticide application that an individual may enter a treated area. Pesticide labels will indicate the REI and the PPE required for early re-entry. REI's for commonly used insecticides and miticides are presented in Table 6.

Five pesticide application scenarios:

1. Fumigants. Workers are prohibited from entering the entire greenhouse and adjacent areas not sealed off from the treated areas until the ventilation criteria are met.
2. LV Smokes, Mists, Fogs and Aerosols. Workers are prohibited from entering the entire enclosed area until the ventilation criteria and the REI criteria are met.
3. HV Sprays. Sprayers are required to wear a respirator. Workers are prohibited from entering the entire enclosed area until the ventilation criteria are met and they are prohibited from the pesticide treated area until the REI is over.
4. Other Spray Applications. Workers are prohibited from the pesticide-treated area plus a 25-foot buffer surrounding the treated area until the application is complete, and they are prohibited from the pesticide treated area until the REI is complete.
5. Other Application Methods. Workers are prohibited from the pesticide-treated area until the REI is complete.

Early Re-entry

Worker early re-entry during the REI is allowed if:

- At least four hours have passed since the application, inhalation exposure level listed on the label is reached, and the ventilation criteria have been met.
- The worker is wearing the required PPE indicated on the label.
- The worker performs "limited contact" tasks for up to eight hours in any 24-hour period. (Note: "Limited contact" activities include watering.)

Ventilation Criteria

See the pesticide label for specific ventilation requirements. If none, then provide one of the following:

- Two hours of mechanical ventilation with fans
- Four hours of passive ventilation with vents
- Eleven hours with no ventilation followed by one hour of mechanical ventilation or two hours of passive ventilation
- 24 hours with no ventilation

Notification in Greenhouses

All treated areas must be posted. If the pesticide labeling requires both types of notification, you must also notify workers orally.

Oral warnings need not be given to any worker or treated area posted, if workers will not be in the greenhouse during a pesticide application or while a restricted-entry interval is in effect; or, any worker who applied (or supervised the application of) the pesticide and is aware of all the information required to be given in the oral warning.

Post the signs so they can be seen from all points where workers usually enter the treated area, including doorways, aisles and other walking routes.

The signs must be posted 24 hours or less before the scheduled application and removed within three days after the end of the REI.

The signs must be least 14 inches by 16 inches, and the letters must be a least 1 inch high. You may use smaller signs if the treated area is too small to accommodate 14- by 16-inch signs. For example, when a single potted plant needs to be posted, a smaller sign would be appropriate.

The required words for the signs are "DANGER – PELIGRO" AND "PESTICIDES – PESTICIDAS" must be located at the top of the sign and "KEEP OUT – NO ENTRE" at the bottom. A circle containing an upraised hand on the left and a stern face on the right must be near the center of the sign.

Decontamination Sites

Decontamination sites provide a safe area for workers and handlers to use routinely or for emergencies. The following regulations are for the design and function of decontamination sites:

- Provide water for routine and emergency whole body washing and eye flushing.
- Provide clean coveralls, safe drinking water and one pint eye flush water for each pesticide handler. Eye flush water should be immediately accessible.
- Decontamination sites must be within 1/4 mile of all employees.
- Worker decontamination sites can not be in areas that are being treated with pesticides or in a REI area, whereas handler decontamination sites may be within areas being treated with pesticides or an area that has a REI in effect if:
    1. it is in an area where the handler is doing handling tasks.
    2. the soap, single-use towels, and clean changes of clothing are in closed containers.
    3. the water is running tap water or is in a closed container.

Information at a Central Location

Greenhouse owners are required to maintain a Centralized Bulletin Board that is accessible to all employees and contains the following information:

1. The Worker Protection Standards (WPS) safety poster (Request the "WPS Quick Reference Poster" from Gempler's. The phone number and Web site address are at the end of this publication.)
2. Emergency Medical Information: (Name, address and phone number of nearest medical facility).
3. Pesticide Application List. The following pesticide application information is to be maintained for 30 days following the application:
    - Product name, EPA registration number and active ingredient.
    - Location and description of treated area.
    - Time, date of the pesticide application and the REI.
4. TOSHA requires two posters be placed on the Centralized Bulletin Board: "State of Tennessee Public Employee Safety and Health Protection on the Job" and "State of Tennessee Hazardous

Chemical Right to Know." For more information contact the Tennessee Dept. of Labor, at 615-741-2793.

5. Pesticide Label/Material Safety Data Sheets (MSDS). EPA requires that greenhouse managers make pesticide labels available to workers, while TOSHA requires MSDS be maintained at the centralized bulletin board. MSDS are available through your pesticide suppliers.

Material Safety Data Sheets (MSDS)

MSDS are required for businesses dealing with hazardous pesticides. The purpose is to provide a means of communicating information concerning the hazardous materials used on the premises. MSDS are available from pesticide companies or their suppliers. Employees must have access to them, and if necessary, be shown how to read and understand them. The following information is found on the MSDS:

1. The pesticide's physical properties
2. Procedures for mixing and loading pesticides
3. Fire and explosive information
4. Health hazard information, including acute and chronic toxicity symptoms
5. Protective equipment (PPE) required
6. First aid treatment
7. Spill, leak and disposal information
8. Procedures for accidents
9. Storage and handling procedures

Worker and Handler Training

Workers - Defined as persons employed to work with greenhouse crops. For example, harvest, weed and water. Workers must be provided some pesticide safety information before entry into a treated area. They must be fully trained about pesticide safety within five days after employment. (Contact your county Agricultural Extension office concerning assistance in providing the WPS training.)

Handlers - Defined as persons who mix, load, apply or do other tasks that bring them into direct contact with pesticides, such as cleaning pesticide application equipment or handling open pesticide containers. Handlers must be trained about pesticide safety and handling prior to performing any handling tasks.

Keep in mind that this publication is only a summary of the WPS standards. For a more complete source of information, refer to the following three publications available through Gempler's. Every greenhouse manager should have a copy of these publications to explain responsibilities and comply with WPS, including the training of employees.

Gempler's
1-800-382-8473
www.gemplers.com

WPS Reference Guide. Includes complete addition of EPA's "How to Comply Manual" plus technical information on pesticide safety in English.

For Workers: "Protect Yourself from Pesticides Guide for Agricultural Workers." Bilingual (English/Spanish). Also available in seven other foreign language translations.

For Handlers: "Protect Yourself from Pesticides Guide for Pesticide Handlers." Available in both English and Spanish.

ATTENTION

1. Read the label of any pesticide before applying.
2. Do not rely on pesticides alone; employ all cultural methods of control.
3. Regulations and guidelines concerning use of pesticides are subject to change without notice. Consult the label of the product for usages and rates before applying. If recommendations in this manual conflict with the label, please follow the label instructions.
4. When a range of rates and application intervals are recommended, use the lower rate and longer interval for mild-moderate infestations and the higher rate and shorter interval for moderate-severe infestations.
5. Use of trade or brand names in this manual is for clarity and information. The Tennessee Agricultural Extension Service does not imply approval of the product to the exclusion of others which may be similar, suitable composition, nor does it guarantee or warrant the standard of the product.
6. Please ready the label before using a product.

Precautionary Statement

In order to protect people and the environment, pesticides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store, or dispose of a pesticide. According to laws regulating pesticides, they must be used only as directed by the label. Persons who do not obey the law will be subject to penalties.

Disclaimer Statement

Pesticides recommended in this publication were registered for the prescribed uses when printed. Pesticides registrations are continuously reviewed. Should registration of a recommended pesticide be canceled, it would no longer be recommended by the University of Tennessee.

Use of trade or brand names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others which may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product.

EMERGENCY NUMBERS

911 - Medical emergency, police-sheriff and fire

1-800-288-9999 - Poison Control Centers for Tennessee

1-800-424-9300 - CHEMTREC (Chemical Transportation Emergency Center)

1-800-262-8200 - CHEMTREC Information Line

Visit the Agricultural Extension Service Web site at
http://www.utextension.utk.edu/

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Agricultural Extension Service, Charles L. Norman, Dean