

Using Pesticides in Greenhouses



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Using Pesticides in Greenhouses

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The objective of using pesticides in greenhouses is to suppress pest populations below damaging levels without endangering the lives of greenhouse workers or customers, and without harming plants. Therefore, 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 associated with pesticide applications, and 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 leaves; however, some pesticides are available in granular formulations that are incorporated into the growing medium or topdressed on the growing medium surface. In addition, some liquid formulations can be mixed with water and then applied as a drench to the soil or growing medium.

Spray Application

When a pesticide is applied, the material is dispersed into small droplets. The smaller the droplets, the greater the number of droplets per area, and the greater the likelihood of contacting the target pest (Table 1). Smaller droplets (10 to 50 microns) are more likely to contact flying insects (note: 1 micron equals 0.000004 inch). Droplets that are 30 to 50 microns are more likely to come into contact with insects and mites on leaves, while larger droplets (250 to 500 microns) are better for contacting insects in the growing

medium. The type of spray equipment used determines the droplet size.

Spray Application Equipment

Several different types of sprayers are available commercially for use in greenhouses. Each has benefits and limitations. There is no one best choice; however, certain sprayers may be more effective for pest management/plant protection programs depending on the greenhouse facility.

Table 1. Relationship Between Droplet Size and 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
1,000	0.13

Direct versus Fixed-Position Sprayers

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

Table 2. Advantages and Disadvantages of Different Spray Application Methods

Spray Application Method	Advantages	Disadvantages
Direct	<ul style="list-style-type: none"> • Can be targeted to a specific area (spot application). • Easier to use, but still difficult to cover leaf undersides thoroughly. 	<ul style="list-style-type: none"> • Labor-intensive. • Greater pesticide exposure to the applicator. • Requires a trained applicator.
Fixed Position	<ul style="list-style-type: none"> • Less labor involved. • Less exposure to pesticide. 	<ul style="list-style-type: none"> • Cannot target a specific area. • Entire greenhouse is treated. • Difficult to cover leaf undersides thoroughly, especially when plants are large. • Relies on horizontal airflow fans for distribution.

High-Volume Versus Low-Volume Sprayers

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

small volume of pesticide. The same amount of active ingredient is applied; however, the chemical is broken into smaller droplets. Low-volume sprayers also include ultra-low-volume (ULV) sprayers, which produce even smaller droplet sizes. Several LV application methods are described in Table 3, and comparisons to other spray application methods are presented in Table 4.

Table 3. Methods of Low-Volume Pesticide Application

<p>Ready-to-Use Aerosols The chemical is in a pressurized canister that produces a fog when released.</p> <p>Thermal Pulse-Jet Foggers The pesticide is injected into a hot stream of air that vaporizes the pesticide into small droplets. A carrier is mixed with the pesticide to improve uniformity of droplet size. High temperatures and low humidity result in rapid settling of the pesticide, resulting in the pesticide collecting on the upper leaf surface.</p> <p>Cold Foggers/High-Pressure Hydraulic High-pressure pumps and atomizing nozzles are used to produce mist-sized droplets. A spray stream is formed that may reach 10 to 12 feet.</p> <p>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.</p> <p>Electrostatic Applicators 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.</p>

Table 4. Different Spray Application Methods and Equipment

Spray Volume	Application Method	Application Type	Droplet Diameter (microns)	Advantages	Disadvantages
High	Hydraulic	Direct	100 to 400	<ul style="list-style-type: none"> • Can be used with many pesticide formulations and for “spot” applications. • Relatively inexpensive. 	<ul style="list-style-type: none"> • Larger droplet sizes may result in poor coverage. • Labor-intensive. • May cause excessive runoff on plant leaves.
Low	Cold Fogger/High-Pressure Hydraulic	Direct	30	<ul style="list-style-type: none"> • Can use for “spot” applications. 	<ul style="list-style-type: none"> • Difficult to get thorough coverage of leaf undersides, especially when plants are large.
Low	Air-Assisted Electrostatic	Direct or Fixed Position	40	<ul style="list-style-type: none"> • Less spray drift than other Low-Volume application methods. • Can obtain thorough coverage of both sides of leaves. 	<ul style="list-style-type: none"> • Charged particles are attracted to other charged surfaces.
Low	Thermal Pulse-Jet Fogger	Fixed Position	0.5 to 50	<ul style="list-style-type: none"> • Very effective with volatile pesticides. • Can treat large areas quickly. • Can be used to spray below porous benches to improve lower leaf coverage. 	<ul style="list-style-type: none"> • Cannot perform “spot” applications. • Difficult to cover leaf undersides.
Low	Mechanical Aerosol Generator	Fixed Position	0.5 to 15	<ul style="list-style-type: none"> • No human applicator needed. 	<ul style="list-style-type: none"> • Difficult to cover leaf undersides.
Low	Ready-to-Use Aerosols	Fixed Position	15	<ul style="list-style-type: none"> • Minimum labor required. • Convenient for small greenhouses. 	<ul style="list-style-type: none"> • Distribution depends on air movement. • Difficult to cover leaf undersides.

Granular Pesticide Application

Granular pesticide formulations are labeled for incorporating into and/or topdressing the growing medium. Granular formulations generally are 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 medium or transplanting into the growing medium may be exposed to the residues of a granular pesticide. Therefore, they need to receive the Environmental Protection Agency's (EPA) worker protection standard training for *pesticide handlers* or *pesticide workers*. Contact your county agricultural Extension agent for training information or visit psep.utk.edu.

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, high-volume (HV) sprayers apply a much higher volume of solution to the crop. For example, HV sprayers use 25 to 50 gallons per 10,000 square feet, while a low-volume (LV) sprayer uses only 0.25 to 2 gallons per 10,000 square feet. If the pesticide label indicates the amount of pesticide to be added to 100 gallons of water but not the area that the pesticide is to be applied, consult the LV sprayer manual to determine the actual amount of pesticide to apply.

Adjuvants

Adjuvants are materials incorporated into formulations or added to solutions to enhance the performance of pesticides against targeted pests. The two most common adjuvants used are surfactants and spreader stickers.

Surfactants are wetting agents that reduce the surface tension of water, thus increasing the spreadability of the pesticide over the leaf surface. Spreader stickers are adhesives that increase 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 pesticide formulations may already contain adjuvants. For example, emulsifiable concentrates contain some adjuvants already; therefore, adding additional adjuvants may increase the probability of causing phytotoxicity (burning and/or damage to sensitive plants).

Adjuvants should always be added with some caution, as phytotoxicity is possible. Start by adding 1 ounce per 100 gallons. Continue adding 1 ounce at a time until adequate coverage of leaves is achieved. Follow the manufacturer's recommendations and be careful if adding more than 8 fluid ounces of an adjuvant per 100 gallons of water because higher rates may harm sensitive plants. Always test the spray solution on a small number of plants (n=10) before applying to the entire crop. Perform the application when weather is warm and sunny, as this will reduce any possible phytotoxic effects to plants. Wait three to five days for evidence of phytotoxicity.

Tank Mixes

Mixing two pesticides together is referred to as tank mixing. Always check labels for possible issues associated with compatibility or incompatibility. When mixing two pesticides:

- Check for precipitates forming in the tank or for color changes, which likely indicate incompatibility.
- Spray the mixture on a small group of plants to check for possible phytotoxicity.
- Never allow the concentrated pesticides to come in contact with each other.

- Always dilute the individual pesticides prior to tank mixing.
- Add any adjuvants after the pesticides have been combined.
- Provide constant agitation to the solution.

When tank mixing, both the pesticide dosage and water required should be considered. The amount of chemical that is recommended on a given area is listed on the label. Many pesticide labels list a rate range such as 4 to 12 ounces per 100 gallons. Selection of the rate should be made based on the level of pest infestation, type and maturity of the crop, and past experience. If this is the first time that the pesticide is being used, a dosage in the middle of the rate range would be a good starting point.

Entomologists discourage the use of tank mixes because of the increased potential for phytotoxicity to the crop and the increased rate at which a pest population can develop resistance to a pesticide.

Water Quality

A water pH above 7.0 can reduce the effectiveness of some pesticides. This is called alkaline hydrolysis. High pH is a problem mostly when pesticide solutions are mixed and then not immediately applied. In general, pesticide solutions should be applied within a few hours after being mixed. Allowing a pesticide to sit overnight in high pH water can result in the pesticide breaking down, thus reducing effectiveness.

Application Technique

Fixed-position sprayers require that an airflow pattern be established prior to introducing the pesticide into the greenhouse. The airflow pattern is achieved by turning the sprayer fans on for 15 minutes before application. The fans are left on for 30 to 60 minutes after the application.

Directed sprays require a trained applicator to obtain uniform and thorough coverage. Low-

volume sprays are more highly concentrated than HV sprays; thus, the applicator must be moving continually, 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 calibrated correctly, which will result in the applicator applying the correct amount of active ingredient in the greenhouse.

Calibrating Equipment

Spray equipment must be calibrated so that the required volume of pesticide solution is applied. Proper pesticide application is a technique that comes with experience.

The amount of water needed to cover the growing area is dependent on the type of equipment used. With HV hydraulic sprayers, a rate of 25-50 gallons per 10,000 square feet is common. LV handheld sprayers use only ¼-2 gallons per 10,000 square feet.

Most pesticide labels state the amount to be diluted in 100 gallons of water and not the amount of spray concentrate that is to be applied to a given area. Other labels may list the amount of pesticide that should be applied per acre. Each sprayer's instruction manual contains charts or tables that help determine how much spray material to mix with water. Usually, this is based on a 10,000-square-foot area, so you may need to adjust the rate to fit the area to be sprayed.

Many pesticides are applied to the foliage and other plant parts. If this is the case, the label may state that to obtain effective control, apply the pesticide to the plant to provide thorough coverage. It is important to utilize the proper combination of sprayer type, spray nozzle and spray pressure to achieve an even deposition of the desired size droplets on the plant so that thorough coverage is achieved. The amount of pesticide spray solution applied will vary depending on the size of the plants that are sprayed.

To determine the amount of solution to be sprayed on a given area, fill the tank with water and start spraying until you maintain the desired coverage. At the time you begin to release the spray, use a watch to record the amount of time until you reach the desired coverage on the given area. Next, determine the amount of water that was applied over the area. To do this, you will need a container to catch water released from the sprayer for the same length of time that water was applied to the foliage. You may need to purchase a 100-milliliter graduated cylinder to measure the output. If so, remember that 29.57 milliliters equals 1 fluid ounce.

Determining your output allows you to determine the amount of pesticide to add to the tank.

The following exercise can be used to calibrate application equipment as well as train new applicators:

1. Mark off an area to be sprayed (e.g., 500 square feet).
2. Determine the appropriate pesticide application rate.
3. Use a sprayer and apply water for one minute into a 2-gallon measuring container. The volume of water collected in the container after one minute, measured in ounces, is the 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 area:
time (sec) = appropriate application rate (gal/10,000 sq. ft.)/sprayer rate (ounces per min.)*area (sq. ft.)*0.768.
6. Sometimes an applicator will spray areas at a faster rate than would be ideal. This can increase the potential for the product to drift or the site may not receive thorough coverage, therefore reducing the effectiveness of the application.

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 environmental conditions often shorten the shelf life, and volatile fumes from some pesticides may potentially affect plant growth.

When building a separate pesticide storage structure, locate it as far away as possible from water sources. Generally, it should be at least 150 feet from wells or 200 feet from other water sources. Building construction should include a 4-inch, watertight, concrete slab floor; watertight concrete block walls; steel construction roof; and two doors with 6-inch barriers to contain spills. Forced air ventilation should be provided as described below. The structure should be insulated.

Heating 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 overheating should be avoided. 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 an anti-siphon 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 service building or greenhouse, the room should be on an outside, windowless wall located away from heavily used rooms, such as offices or

break rooms. Walls should be concrete block or wood frame with a vapor barrier installed on the inside of the wall. Walls, floors, shelves and workbenches should be sealed with a chemical-resistant finish such as epoxy. Forced air ventilation also should be installed.

Ventilation

Forced air ventilation should either operate continuously or start automatically when interior lights are turned on. The ideal arrangement is a two-speed fan with a low-speed setting to run continuously and a high-speed setting that runs with a light switch. A ventilator should change the air every three minutes for high speed and every six minutes for 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 room volume by multiplying the length by width by height. Divide the resulting number by three for a high-speed fan or by six for a 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 would be adequate to ventilate the storage area.

Storage Procedures

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 maintained in a location other than the pesticide storage area.

Pesticides should be stored in their original containers with labels clearly visible and legible. You can use transparent tape or a coating of lacquer or polyurethane to protect the label. The purchase date should be clearly marked on each container.

Store herbicides separately from insecticides and fungicides. Regularly inspect all containers for leaks or damage. When a pesticide container is damaged, follow one of four procedures:

1. Use the pesticide immediately at a site and use the recommended label rate.
2. Transfer any remaining pesticide into another pesticide container that originally held the same pesticide with the label intact.
3. Transfer the contents to a sturdy container that can be closed tightly. Then, transfer the label to the new container.
4. Place the entire damaged container and contents into a larger container.

Never store personal protective equipment (PPE) 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 in preserving the shelf life of many pesticides; however, any responses will vary depending on formulation 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 should 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; generally, emulsifiable concentrate (EC or E) and ultra-low-volume (ULV) formulations are flammable due to the addition of petroleum inert components.

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 F. Generally, dry pesticide formulations can be stored for longer periods of time than liquids if the containers are re-sealed tightly and protected from wetness. Always be aware of changes in the storage conditions and odors from pesticides as 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 required and apply to crops based on label recommendations. 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. Apply the rinsate to the labeled crop. Never burn pesticide containers, dump pesticide concentrates on the ground, or bury them. Do not flush pesticides down toilets or pour into drains.

Human Safety

It is important to minimize human exposure to pesticides. The Environmental Protection Agency (EPA) has developed a list of regulations, called the Worker Protection Standards, or WPS, that greenhouse managers must follow to protect employees properly. Because these standards are generalized, it is essential to use common sense in order to prevent pesticide exposure to workers. For more

information concerning WPS visit the following website:

[epa.gov/pesticide-worker-safety/safety-information-related-worker-protection-standard](https://www.epa.gov/pesticide-worker-safety/safety-information-related-worker-protection-standard).

Pesticide Toxicity (LD₅₀)

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

The three major exposure routes of pesticides into the human body are oral, dermal and inhalation. Oral exposure occurs primarily when hands are not washed after handling pesticides, which can lead to ingesting contaminated foods or drinks. Dermal exposure accounts for a majority of pesticide poisonings and can occur whenever a pesticide is mixed, applied or handled. Both dry and liquid pesticide formulations may be absorbed through the skin. Inhalation exposure occurs by breathing in pesticide vapors, dust or spray particles. The best way to avoid pesticide exposure is to wear the appropriate personal protective equipment (PPE).

Many pesticide classes have similar modes of action. For example, organophosphates and carbamates interfere with activity of the nervous system, leading to paralysis. The effects of the mode of action are the same for insects and humans.

Some older pesticides have been reformulated (i.e., microencapsulation) to minimize toxicity to humans. Many new pesticides are selective in the target pests on which they are active, thus reducing their toxicity to non-target organisms such as fish, birds, humans and other mammals. These include: insect growth regulators,

microbial insecticides, neonicotinoids, insecticidal soaps and horticultural oils.

The EPA requires pesticide manufacturers to provide data on the toxicity of the pesticide 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.

An LD₅₀ (the lowest dose of a toxicant that kills 50 percent of the exposed organism in a test) designates the acute toxicity of a pesticide. The estimated toxicity to humans is extrapolated on a weight basis and is expressed in milligrams of toxicant (mg) per kilogram (kg) of body weight. The lower the LD₅₀, the more toxic the pesticide is to humans.

The EPA requires labels to provide information on pesticide toxicity. A label must carry one of the three signal words (DANGER, WARNING or CAUTION) representing the general categories of pesticide toxicity. Pesticides with the signal word DANGER may have the skull and crossbones symbol and the word POISON (in red) on the label. These pesticides are considered highly toxic and may kill you when you have been exposed to low doses. Other labels that include the signal word DANGER also are highly toxic and may cause irreversible eye damage.

These three signal words represent pesticide toxicity. They are based on oral, dermal and inhalation routes of exposure plus eye and skin irritation. A listing of the different routes of pesticide exposure and associated toxicity categories (signal words) with the accompanying LD₅₀ values are presented in Table 5.

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

ROUTES OF PESTICIDE EXPOSURE	TOXICITY CATEGORIES			
	I Danger, Poison (in red) Skull and Crossbones Symbol	II Warning	III Caution	IV Caution
Oral LD ₅₀	<50 mg/kg	50 to 500 mg/kg	500 to 5,000 mg/kg	>5,000 mg/kg
Inhalation LD ₅₀	<0.2 mg/liter	0.2 to 2 mg/liter	2 to 20 mg/liter	>20 mg/liter
Dermal LD ₅₀	<200 mg/kg	200 to 2,000 mg/kg	2,000 to 20,000 mg/kg	>20,000 mg/kg
Eye Irritation	Corrosive; corneal opacity that is not reversible within 7 days	Corneal opacity irritation that is reversible within 7 days; with irritation persisting for 7 days or more	No corneal opacity irritation is reversible within 7 days	No eye irritation
Skin Irritation	Corrosive	Severe irritation after 72 hours	Moderate irritation after 72 hours	Mild or slight irritation after 72 hours

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

Worker Protection Standards

Personal Protective Equipment (PPE)

Employers must ensure that pesticide handlers:

- Are provided with the proper PPE required by the pesticide label for the specific task.
- Wear PPE during the entire handling task.

Employers must:

- Inspect all PPE each day before use.
- Provide handlers with clean sites away from pesticide storage and pesticide use areas to store personal clothing, wear PPE at the start of any exposure period, and remove 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 take home any PPE.
- Clean and maintain PPE.
- Replace respirator filters, cartridges or canisters accordingly.
- Properly dispose of PPE.
- Provide proper safety instructions to employees who clean PPE.

A checklist of requirements for agricultural employers of workers and handlers may be found on the following website:

<http://pesticideresources.org//wps/hosted/wps-ag-employer-checklists.pdf>

Personal Protective Equipment (PPE) Definitions

Chemical resistant — No measurable amount of chemical can penetrate the material during use.

Waterproof — No measurable amount of water (or water-based solution) can penetrate 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 the head, hands and feet.

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

Chemical-resistant apron — A garment 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. However, if not specified, follow these general guidelines in selecting gloves:

1. Barrier-laminate — Broad-spectrum chemical resistance with limited dexterity.
2. Neoprene — Chemical resistant with limited dexterity.
3. Nitrile — Chemical resistant with flexible dexterity.
4. PVC (polyvinyl chloride) — Chemical resistant with flexible dexterity.
5. Rubber — Chemical resistant (depending on thickness) with flexible dexterity.

Chemical-resistant footwear — Chemical-resistant shoes, boots or shoe coverings worn over shoes or boots. Materials include PVC/urethane and 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 — Respiratory Protective Device (RPD) prevents the applicator from breathing pesticide dusts or vapors. Must be the type listed on the pesticide label and be appropriate for the pesticide product being used.

The label will contain the National Institute for Occupational Safety and Health/Mine Safety and Health Administration Testing Certification (NIOSH/MSHA “TC”) approval number. All NIOSH approval numbers begin with the letters TC.

NIOSH uses the following designations:

- 13F: self-contained breathing apparatus (SCBA)
- 19C: supplied air respirator (SAR)
- 14G: gas mask with canister
- 23C: air-purifying respirator (APR) with chemical cartridge or powered air purifying respirator (PAPR) with chemical cartridge and particulate filter
- 21C: powered air-purifying respirator with particulate filter
- 84A: respirator with particulate filter or combination chemical cartridge with particulate filter

More information is available on the following NIOSH fact sheet:

[cdc.gov/niosh/docs/2011-179/pdfs/2011-179.pdf](https://www.cdc.gov/niosh/docs/2011-179/pdfs/2011-179.pdf)

Air Purifying Respirator Types

1. Half mask, disposable, particulate (NIOSH prefix TC-21C). Use for dust or solid pesticide formulations.
2. Half mask, disposable, maintenance-free and dual cartridge (NIOSH prefix TC-23C). Use for pesticides and ammonia.
3. Half mask, reusable and dual cartridge (NIOSH prefix TC-23C). Use the appropriate cartridge based on the contaminant.
4. Full-face, reusable and (NIOSH prefix TC-84A). Protects 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 provides better 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.

More information concerning respiratory protection may be found in the *Worker Protection Standard (WPS) Respiratory Protection Guide* on the following website:

[pesticideresources.org/wps/hosted/PERC-WPS-Respirator-Guide-print.pdf](https://www.pesticideresources.org/wps/hosted/PERC-WPS-Respirator-Guide-print.pdf).

Filters/Cartridges

Chemical cartridges 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 retained on the carbon surface. Absorption capacity is limited so cartridges must be changed regularly.

Mechanical filters provide protection against particulate matter such as dusts, which are physically trapped in the fibrous filter material. Although mechanical filters increase in efficiency during use, they also may become more difficult to breathe through. Mechanical filters should be changed when breathing becomes difficult.

All respirator manufacturers use the same color-coding system to reference cartridges designed for 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 associated with acid gas and organic vapors. More information on respiratory protection may be found on the following website: [osha.gov/Publications/osa3079.pdf](https://www.osha.gov/Publications/osa3079.pdf)

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 appropriate PPE required for early entry into greenhouses after a pesticide application. REIs for several insecticides and miticides used in greenhouses are presented in Table 6 below.

Five pesticide application situations:

1. *Fumigants*. Workers are prohibited from entering the entire greenhouse and adjacent areas not sealed off from the treated areas until criteria for ventilation have been completed.
2. *Low-volume (LV) smokers, misters, foggers and aerosols*. Workers are prohibited from entering the entire enclosed area until the criteria for ventilation and the REI have been completed.
3. *High-volume (HV) sprayers*. Applicators are required to wear a respirator. Workers are prohibited from entering the entire enclosed area until the criteria for ventilation have been completed. In addition, workers cannot enter the pesticide-treated area until fulfillment of the REI.
4. *Other spray applications*. Workers are prohibited from entering the pesticide-treated area and a 25-foot buffer surrounding the treated area until the application is completed. Furthermore, workers are prohibited from entering the pesticide-treated area until fulfillment of the REI.
5. *Other application methods*. Workers are prohibited from entering the pesticide-treated area until fulfillment of the REI.

Early Re-Entry

Workers can enter an area before the REI if:

- After at least four hours since the application, and inhalation exposure on the label and/or ventilation criteria have been fulfilled.
- Worker is wearing required PPE as indicated on the label.
- Worker performs minimal tasks up to eight hours in any 24-hour period, including watering.

Ventilation Criteria

(This usually concerns a fumigant, smoke, mist or fog application.)

Refer to the pesticide label for specific ventilation requirements. If there are none, provide one of the following:

- Two hours of mechanical ventilation with fans.
- Four hours of passive ventilation with vents open.
- Eleven hours of no ventilation followed by one hour of mechanical ventilation or two hours of passive ventilation.
- Twenty-four hours of no ventilation.

Table 6. Restricted Entry Intervals (REI) of Insecticides and Miticides Labelled for Use in Greenhouses

PESTICIDE	REI
Adept	12
Akari	12
Altus	4
Aria	12
Avid	12
Azatin	4
BotaniGard	4
Citation	4
Conserve	4
Decathlon	12
Dipel	4
Distance	12
DuraGuard	24
Duraplex	24
Endeavor	12
Enstar	4
Flagship	12
Floramite	4
Fulcrum	12
Gnatrol	4
Hachi-Hachi	12
Hexygon	12
Insecticidal Soap	4
Kontos	24
Mainspring	4
Marathon	12
Mavrik Aquaflow	12
M-Pede	12
Mesurool	24
Novato	12
Ornazin	12
Overture	12
Pedestal	12
Pylon	12
Rycar	12
Safari	12
Sanmite	12
Savate	12
Shuttle	12
Sirocco	12
SuffOil X	4
Sultan	12
Talstar	12
Tame	24
TetraSan	12
Triact	4
TriStar	12

Notification in Greenhouses

Signage must be posted in all treated areas as listed on the label. The two types of notification are verbal notification and written (signage) notification. If the pesticide label requires both types of notification, you must also notify workers verbally. Verbal warnings are not required for any worker who will not be in the greenhouse during a pesticide application or while a REI is in effect or to any worker who applied or supervised the application of a pesticide.

Post signs so they are visible from all points where workers enter the treated area, including doorways and aisles. Signs must be posted 24 hours or less before the scheduled application and be removed within three days after the end of the REI. Signs must be at least 14 inches wide and 16 inches high, and lettering must be at least 1 inch high. Smaller signs may be used if the treated area cannot accommodate 14-by-16-inch signs.

For all signs, the words “DANGER PELIGRO” and

“PESTICIDES PESTICIDAS” are located at the top of the sign and “KEEP OUT NO ENTRE” at the bottom. In addition, a circle containing an upraised hand and an individual with a stern face are located in the center of the sign. Signage may be obtained from various vendors such as [amazon.com](https://www.amazon.com) or [gemplers.com](https://www.gemplers.com).

Decontamination Sites

Decontamination sites provide a safe area for workers and handlers to use routinely or for emergencies. The following regulations are associated with 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 1 pint of eye flush water for each

pesticide handler. Eye flush water must be immediately accessible.

- Decontamination sites must be within one-quarter of a mile of all employees.
- Decontamination sites for workers cannot be located in areas that are being treated with pesticides or in which there is an REI. However, handler decontamination sites can be within areas being treated with pesticides or an area with an REI under the following conditions:
 1. Area where handler is performing tasks.
 2. Hand soap, single-use towels and clean changes of clothing are in closed containers.
 3. Tap water or water in a closed container is provided.

Information at Central Location

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

1. Worker Protection Standards (WPS) safety poster. Request the “WPS Quick Reference Poster” from Gempler’s (gemplers.com).
2. Emergency Medical Information, including name, address and phone number of nearest medical facility.
3. Pesticide Application List. The following pesticide application information needs to be maintained following the application:
 - Product name, Environmental Protection Agency (EPA) registration number and active ingredient.
 - Location and description of treated area.
 - Time, date of the pesticide application and REI.

4. For all workers or handlers, you must keep application records for two years as well as copies of labels and safety data sheets (SDS). For more information concerning Chemical Right to Know, contact the Tennessee Department of Labor at 615-741-2793 or 800-249-8510. Other offices and phone numbers are found on the following website:

tn.gov/content/tn/workforce/employees/safety-health/tosha-redirect/tosha-local-offices.html

5. Pesticide Label/Safety Data Sheets (SDS). The EPA requires that greenhouse managers ensure that pesticide labels are available to workers, while TOSHA/OSHA requires SDS be maintained at the Centralized Bulletin Board. SDS are available from pesticide manufacturers or suppliers.

Safety Data Sheets (SDS)

Safety data sheets are required for all businesses dealing with pesticides. The purpose of these sheets is to provide information associated with the hazardous materials used on the premises. Safety data sheets are available from pesticide companies/manufacturers or suppliers. Employees must have access to SDS, and if necessary, be shown how to read and understand them. The following information can be found on the SDS:

1. Pesticide 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. Personal 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 are individuals employed to work with greenhouse crops, such as harvesting, weeding and watering. Workers must be provided with pesticide safety information before entering any treated area. They must be properly trained on pesticide safety after employment and prior to entering any treated area. Contact your county Extension office regarding assistance in providing Worker Protection Standard (WPS training) or visit psep.utk.edu to download training materials.

Handlers are individuals who mix, load, apply or perform other tasks. Handlers also are individuals who come into direct contact with pesticides by means of cleaning pesticide application equipment or handling open pesticide containers. Handlers must be trained on pesticide safety prior to performing any handling tasks.

For more complete information, refer to the following three publications below, which are available from Gempler's (1-800-382-8473 or gemplers.com) or psep.utk.edu. These publications help in complying with WPS, including the training of employees.

1. WPS Reference Guide: Includes EPA's "How to Comply Manual" plus technical information on pesticide safety in English. (pesticideresources.org/wps/htc/htcmanual.pdf)
2. "Protect Yourself from Pesticides Guide for Agricultural Workers." Bilingual (English/Spanish). Also available in seven other foreign languages.
3. "Protect Yourself from Pesticides Guide for Pesticide Handlers." Available in both English and Spanish.

Important Information

1. Read the label of any pesticide before applying.
2. Do not rely on pesticides alone to manage pests; also implement cultural control methods.
3. Regulations and guidelines concerning the use of pesticides are subject to change without notice. Consult the pesticide label for use rates before applying. If recommendations in this publication conflict with the pesticide label, always follow the label instructions.
4. When a range of rates and application intervals are recommended, use the lowest rate and longer interval for minimal pest infestations and the highest rate and shorter interval for extensive infestations of pests.

Emergency Numbers

911 — Medical emergency, police/ sheriff and fire

1-800-222-1222 — Tennessee Poison Center

1-800-222-1222 — American Association of Poison Control Centers

1-800-424-9300 — CHEMTREC (Chemical Transportation Emergency Center) — You must be registered with CHEMTREC to use this number.

Disclaimer

This publication contains pesticide recommendations that are subject to change at any time. The recommendations in this publication are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. The label always takes precedence over the recommendations found in this publication. 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 that may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product. The author(s), the University of Tennessee Institute of Agriculture and University of Tennessee Extension assume no liability resulting from the use of these recommendations.



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