
Section A: General Pesticide Information

The pesticide information contained in this section is intended as an overview. For more specific information regarding pesticide use, contact your local Extension office, State Pesticide Coordinator or State Lead Agency (see Appendix for contact information). All people who apply pesticides, even if only general use materials, should purchase and read their state's Pesticide Core Manual. Pesticide regulations change constantly; always check with your State Lead Agency for the most current information.

TOXICITY AND LABELS

Pesticides are poisons, both in name (*icide=to kill*) and in fact. They can enter a person's body through the skin (dermal poisoning), be swallowed (oral poisoning), or be inhaled (respiratory poison). A pesticide's toxicity is usually expressed in parts per million (ppm) or milligrams per kilogram (mg/kg) of body weight. A pesticide's "LD50" represents the dosage that kills 50 percent of the test animals, usually rats. A higher LD50 number signifies a less toxic product.

Reading the label is a quick way to learn how toxic a pesticide is. Highly toxic pesticides, which should be handled with extreme care, display a skull and crossbones symbol in addition to the signal words "DANGER-POISON." Moderately toxic pesticides are labeled "WARNING" and slightly toxic products are labeled "CAUTION." All labels bear the words "KEEP OUT OF REACH OF CHILDREN."

Read the label before purchasing or using a pesticide. Follow all label directions and safety precautions. Do not apply more pesticide than the label prescribes. Overdosage is wasteful, expensive, and illegal! Several registered products may contain the same active ingredient. Be sure the product you choose has the application site and/or crop listed on its label. If it does not list a target pest for a given crop, contact your local Cooperative Extension professional.

The "current policy is that it is not unlawful to use a pesticide in a greenhouse unless such use is prohibited on the label or the label allows use in a greenhouse only under certain circumstances (such as for home greenhouses only). In other words, if there is no reference to greenhouse use on the pesticide label then it is not unlawful to use the product (in

accordance with label instructions) in a greenhouse as long as there are specific directions for the crop being treated. However, State Cooperative Extension Specialists may adopt more stringent policies when making recommendations to growers."

While there is no formal written policy on this topic from EPA, one of this section's authors spoke with the Office of Pesticide Programs who stated that this is indeed EPA policy at the time of this writing (August 2008). If the label has multiple sections, and one of those sections is for greenhouse application, then the label must be followed explicitly for greenhouses with no exceptions. For example, if the greenhouse section of the label states that this pesticide could be used at a particular rate for roses and carnations then no other "crops" other than roses and carnations could be sprayed in the greenhouse with that product, even though another section of the label might state a rate for those other crops. That is the rate for outdoor applications on that crop and it could NOT be used for those crops in the greenhouse, since those crops were not included in the greenhouse section of the label.

In spite of the EPA policy, growers using a pesticide on a labeled crop inside a greenhouse where the label neither specifically allows nor prohibits greenhouse use do so with the possibility of increased risks to worker, customers and plants. Also, growers must be aware when fumigating or using a smoke generator for an entire greenhouse, that every crop in the greenhouse must be listed on the product label. As a result we advise against applying a product in the greenhouse unless the label specifically allows its use.

STORAGE

Pesticide storage areas should be clean, cool, dry, well lit and well ventilated. Control switches should be outside the storage area so that you must turn switches on before entering. The floor should be sealed with a non-absorbent material. If the pesticide storage facility is a separate, specifically designed building, site it where it is not upwind of a sensitive area, and not in an area that could be prone to flooding or other natural disaster. If the pesticide storage area is in an existing structure such as a headhouse, be sure the pesticides are kept in a properly designed area or cabinet that is properly

posted and locked at all times. If your operation is small enough that you actually store pesticides in the basement of your home (which is not recommended), keep the pesticides in a specially designed pesticide storage cabinet. In any case, be sure to contact your State Lead Agency for proper siting instructions and regulations. Clearly mark the storage area "POISON STORAGE-KEEP OUT" on all exterior sides with water-repellent ink that is readable at 20 feet. Attach "NO SMOKING" signs to the facility. Keep the storage area locked at all times.

Unsafe pesticide storage can lead to serious accidents. Do not leave pesticides where children, customers or animals can accidentally come in contact with them. Store pesticides dry in their original containers and away from hot (90°F or more) or cold (40°F or less) areas. Mark the purchase date on each container. Pesticide shelf lives vary; biologicals in particular have quite short shelf lives. Make note of expiration dates on product labels and abide by them. If any pesticide is placed in anything other than its original container, that secondary container must be labeled with the product name, concentration of the active ingredient, signal word and warning statements, along with a copy of the pesticide label. Keep an inventory of stored pesticides in a secure place in case of emergency at the storage facility.

Read each label for specific storage recommendations. Keep combustible materials away from steam pipes and heat sources. Note flammability precautions on labels and store accordingly. Store highly toxic pesticides together, and store herbicides separately from all other pesticides. Some herbicides, such as 2,4-D, can volatilize and be absorbed by other pesticides. Properly dispose of all torn and/or leaking containers of old or unused products and those that are missing their labels. Contact your State Lead Agency (see Appendix) or local Cooperative Extension office for information about proper disposal of pesticides. Keep absorbent materials (clay, kitty litter, activated charcoal, vermiculite, sawdust or super-absorbent polyacrylimide gel products) on the premises to soak up spills. Dispose of contaminated materials properly.

Post the following outside the pesticide storage area:

- A list of Poison Control Centers with addresses and phone numbers (see back cover of this publication);

- Chemtrec's toll-free telephone number, 1-800-424-9300; and
- A list of the stored chemicals. Also, give a copy of this list and any known special hazards, along with the name of a contact person, to emergency personnel (fire and police departments), so that they can take appropriate action in case of an emergency at the pesticide storage facility.

Keep the following on file in your office:

- A copy of the booklet, *Recognition and Management of Pesticide Poisonings* (<http://www.epa.gov/oppead1/safety/healthcare/handbook/handbook.htm>), or a similar booklet handy (see Appendix);
- A copy of labels and Material Safety Data Sheets (MSDS). Read these before you use a pesticide; and
- Any other Right-to-Know requirements in your state.

Shelf Life

Although pesticides may have long storage lives under optimum conditions, it is advisable not to buy more than will be used in one or two growing seasons. Exposure of liquid, wettable powder and granular formulations to humidity, air, light, and/or temperatures below 40°F and above 90°F (some pesticides may be affected at temperatures lower than 90°F) may decrease the efficacy of the chemical preparations.

Read each label for shelf life statements. Most pesticides are designed to last for two years or longer when stored properly. Always check for expiration dates, especially on biological pesticides. Wettable powders stored at cool temperatures and low humidity may be stable for at least two years if kept dry. Bags should be tightly sealed during storage, for example with spring-loaded clothes pins. Liquid formulations generally do not last as long as powders, but may also last two years if kept sealed and away from extreme temperatures. One of the best ways to determine the usability of a product is to record the physical state of the pesticide when new, and examine it before each use to note changes which may indicate shelf-life problems (see Table A-1 on next page).

Table A-1: Deterioration of stored pesticides

Formulation	General signs of deterioration
Emulsifiable concentrates	Milky coloration does not occur with the addition of water. Sludge is present. Separation of components in the container.
Oil sprays	Milky coloration does not occur with the addition of water.
Wettable powders	Lumping occurs when mixed. Powder does not suspend in water.
Dry flowables	Excessive lumping.
Granulars	Excessive lumping.
Aerosols	Aerosol nozzle becomes obstructed.

DISPOSAL

Proper disposal of pesticides is an important phase of pest control. An improperly disposed product can be hazardous to people and the environment. Rinse liquid pesticide containers three times when emptied: fill the containers about one-third full and swish the diluent around. Allow the containers to drain well between each rinse (30 or more seconds). The rinse material should be poured into a spray tank and applied to a registered site. Triple-rinsed containers are considered non-hazardous and should be disposed of according to state recommendations. Before throwing out powders or granular pesticide containers, be sure to remove all contents from the containers.

Plan ahead in preparing spray mixtures! Mix only the amount of pesticide you need to do the job. Clean equipment immediately after use. Be sure rinse water will not collect or contaminate groundwater or be accessible to children, pets or unauthorized individuals. Never leave hazardous equipment and material unattended because that may attract children. Many states have “attractive nuisance” laws, which may make you liable for damages. Never reuse an empty pesticide container. If an empty triple-rinsed container cannot be disposed of immediately, store it in a safe, locked area.

For current state regulations on pesticide disposal, consult your State Lead Agency (see Appendix) or local Cooperative Extension office.

SAFETY RECOMMENDATIONS & EQUIPMENT

This section provides general guidelines about safety equipment. Refer to the Worker Protection Standard on page A.11 for specifics.

To reduce the risk of exposure to pesticides, always wear proper safety equipment. Always consult the label for recommendations on the *minimum* amount and type of equipment that must be worn. In case of an accident, always keep at least a five-gallon container of clean, fresh water and a squeeze container of liquid dish detergent on any pesticide application job. These should be present so that a pesticide can be washed off the victim immediately. (See First Aid section in Appendix).

Gloves

Safety gloves should be made of a chemical-resistant material and be free of holes and tears. These can be purchased at safety supply houses. Read pesticide labels for specific recommendations. Gloves made of polyvinyl chloride (PVC) or rubber (butyl, nitrile, or natural rubber) must be at least 14 mils thick. Wear gloves tucked inside sleeves with the end of the glove folded into a half-inch cuff to prevent pesticides from running onto wrists and arms when arms are raised. Replace worn or damaged gloves; keep several pairs of gloves available. To prevent contamination of hands, wash gloves with detergent and water before removing them.

Cotton or leather gloves should not be used to apply pesticides because they become contaminated too easily.

Boots

Boots should also be made of a chemical-resistant material. Again, read pesticide labels for any

specifically recommended materials. Wear boots inside pant legs. Wash and dry the boots after each use.

Coveralls

Wear clean, dry coveralls made of Tyvek or similar material, as listed on the label. Coveralls should cover the entire body from the neck down, and should be worn when mixing and applying pesticides. Wash the coveralls after each use, separating them from other laundry. After pesticide-soiled clothing has been laundered, run the empty machine through another wash and rinse cycle. Destroy disposable coveralls after use according to directions. Research has shown that cotton coveralls contaminated with highly toxic pesticides may remain contaminated even after repeated washing. If any coveralls are contaminated with a concentrated pesticide, dispose of them immediately.

Head and Neck Coverings

Wear a waterproof, wide-brimmed chemical resistant cap when applying pesticides. Avoid hats with cotton or felt bands, because they may absorb chemicals. Wash head gear after each use. Follow these steps when laundering pesticide contaminated clothing:

1. Wear rubber gloves when handling clothing.
2. Pre-rinse clothing before laundering.
3. Use heavy-duty liquid detergent, and pre-treat heavily contaminated garments.
4. Wash separately from family laundry, ideally in a washing machine dedicated to pesticide contaminated clothing.
5. Wash only a few garments at one time.
6. Use hot water (140°F), full water level and normal wash cycle.
7. Rinse with two full warm rinses.
8. After laundering, clean the washer by running it with hot water and detergent only (no clothes).
9. Hang clothing to dry. Do not use dryer because of possible contamination.

Goggles or Face Shield

Eye protection is extremely important when working with hazardous chemicals. Wear a full face shield that attaches to a hard hat or eye goggles that are ventilated to prevent fogging. Wear eye protection when preparing and applying pesticide mixtures. Headbands of goggles should be made of non-absorptive material.

Respirators (gas masks and cartridges)

Read each pesticide label to determine what type of respiratory protective gear you must wear. Respirators prevent you from inhaling fumes. Wear them during any pesticide exposure, and especially when mixing and pouring concentrates. Cartridge respirators, which cover the nose and mouth and have either one or two cartridges to filter pesticide fumes, vapors, etc., may be worn when applying pesticides labeled "CAUTION." They can also be worn when working with very low concentrations of more highly toxic pesticides. Change the cartridges after eight hours of use, or whenever pesticide odors are detected. Different chemical cartridges may be needed for different pesticides. Be sure that the cartridge is approved for the pesticide you intend to use.

If you wear glasses, have a beard or for some other reason do not like the way that nose/mouth respirators fit, check with your equipment dealer for a helmet-type respirator. This piece of equipment resembles a space helmet with a hose leading to a large cartridge filter that attaches to a belt worn around the waist. It provides the same protection as the previously mentioned cartridge respirators but may be more comfortable. Gas mask respirators cover the entire face, including the eyes. They have an attached canister with a greater capacity for absorbing toxic fumes, compared to cartridge respirators. Helmet-type respirators are usually worn when working with moderate to highly toxic pesticides, fumigants, or when heavily concentrated fumes are present.

All respirators should be approved by the National Institute for Occupational Safety and Health (NIOSH). Look for the NIOSH approval numbers beginning with the letters "TC."

Follow these precautions when using respirators:

1. *Read the label* on the pesticide container. Note safety equipment required.
2. *Read the label* on the respirator cartridge or gas mask canister. Be sure the chemical filter provides protection against the pesticide you intend to use.
3. Make sure all valves, mechanical filters, and chemical filters (cartridges or canisters) are properly positioned and sealed.
4. Fit the respirator on your face to ensure a tight but comfortable seal. Workers with eyeglasses or

beards may have to take extra care in fitting, or use a special respirator.

5. Ideally, you should conduct a respirator fit test every time you need to wear a respirator. However, since this isn't always practical, conduct the respirator fit test at least every time you change cartridges. Test for air leakage by placing your hand over the outside exhaust valve. Exhale to cause slight pressure inside the face piece. With the cartridges removed, do the same test for the intake valve. If air escapes, readjust the headbands until a tight seal is obtained or purchase a respirator test kit that includes an aromatic oil and follow the instructions.
6. Change filters whenever any leakage is detected by smell, taste or irritation to eyes, nose, or throat; or when breathing becomes difficult. If nausea, dizziness or signs of distress develop, seek fresh air immediately.
7. As a fundamental rule of safety, never use a cartridge for longer than eight hours.
8. After each use of the respirator, remove all mechanical and chemical filters, and wash the mask with soap and warm water. Rinse thoroughly with clean water to remove all traces of soap. Wipe with a clean cloth and allow to air-dry in a clean and well-ventilated area.
9. Store the clean respirator mask, cartridges, canisters, and mechanical filters in a clean, dry place, preferably in a tightly sealed plastic bag. Never store pesticide protective equipment (PPE) inside the pesticide storage facility.

Warning: If you have a respiratory impairment or have trouble breathing in a respirator, do not attempt to work where a respirator is required. If you absolutely must wear a respirator as part of your job, check with your physician before using the respirator.

Cholinesterase Testing

Cholinesterase is an enzyme necessary for the proper function of the nervous system in humans and several other animals. Carbamate pesticides (Sevin/carbaryl, fenoxycarb, etc.), organophosphates (malathion, acephate, etc.) and many other natural and synthetic chemicals interfere with the action of cholinesterase. If you apply these types of pesticides regularly, it is wise to have a cholinesterase activity test. This simple blood test, available at many hospitals, establishes your baseline level of the enzyme, so that you suspect you might have pesticide poisoning in the future, another blood test can be performed for

confirmation. The best time to establish your baseline is prior to your major pesticide application season, or at a time when you have not been exposed to these pesticides for at least 3-4 weeks. Discuss this with your physician before having a test done.

Effect of pH

A pesticide label may caution you against mixing the product with an alkaline material such as lime or lime sulfur. Many pesticides, especially organophosphate insecticides, undergo a chemical reaction called alkaline hydrolysis when in contact with an alkaline material. This diminishes the product's effectiveness.

This process can also occur when water with a pH greater than 7 is used for mixing. You can quickly determine the pH of water with an inexpensive pH meter so that you can take steps to buffer the solution to a desired pH. For more information on the effects of pH on pesticides and growth regulators, visit www.umass.edu/umext/floriculture/fact_sheets/greenhouse_management/ph_pesticides.htm

Formulations and Application Equipment

Various pesticide formulations and application equipment are used in the greenhouse (see Table A-2 on page A.7). All pieces of application equipment have one thing in common: they must be kept clean. After each use, carefully clean the equipment and put it in a safe storage area.

LICENSING

"General use" pesticides are chemicals that can be purchased and used by the general public. "Restricted use pesticides" are chemicals that can be purchased and used only by certified and licensed pesticide applicators. Certification and license requirements vary from state to state:

Connecticut: Written exam must be passed. The core exam is a closed book exam, and commodity exams are open book. Twelve recertification credits are required in 5 years, or the exam must be retaken.

Maine: Written exam must be passed. Six recertification hours must be acquired in a 3-year period.

Massachusetts: Written exam must be passed. Twelve credit hours must be acquired in a 3-year period.

New Hampshire: Written exam must be passed.

Fifteen approved recertification credits must be acquired during the next 5 years.

Rhode Island: A 2-day training session must be completed, followed by a written exam. Four approved recertification credits must be acquired during the next 5 years.

Vermont: Written exam must be taken and passed.

Eight recertification credits must be acquired annually.

Contact your local State Lead Agency (see Appendix II) or local Cooperative Extension office for more information on your state's certification guidelines.

OSHA HAZARD COMMUNICATION STANDARD

The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard is often referred to as the "worker's right-to-know" law. This law requires employers to inform employees of any chemical hazards to which they may be exposed while performing their work. In most states, the Bureau of Labor Standards (or some comparable agency) is responsible for administering and enforcing these regulations.

These laws apply to agricultural producers and other pesticide users. Farmers who employ ten or fewer people during a year and do not have temporary labor camps are exempt from inspection. Other agricultural producers and businesses must comply with these regulations through the following means:

1. Develop a written policy on how they comply with the law;
2. Inventory all hazardous materials;
3. Obtain Material Safety Data Sheets (MSDS) for all hazardous materials or products (request that pesticide suppliers provide MSDS);
4. Provide warning labels for secondary containers that hold hazardous materials;
5. Report information on chemicals used and other information as requested, to the proper state agency; and
6. Provide documented *annual* training for each employee that includes the following information:
 - Explanation of your written hazard communication program, chemical inventory, MSDS and secondary warning

label system. Inform employees of these documents location and provide access to them;

- The physical and health hazards of the chemicals used;
- Areas or tasks where hazardous materials are present;
- Methods of detecting the presence or release of hazardous chemicals in work areas;
- Protective measures, including the use and limitations of personal protective equipment; and
- Emergency procedures.

The above practices are good to follow, regardless of the size of the operation. Check with your Cooperative Extension office for resource materials on the Hazard Communication Standard. Some states in the region have videotape training materials directed to agricultural chemical users. Many New England states have developed training materials specifically for greenhouse application.

RECORDKEEPING

Many states and the National Farm Bill legally require applicators to keep records concerning each pesticide application. Such records are important for professional reasons as well, as they provide a history of pest management failures and successes. Keep the following records for a minimum of two years: applicator's name, equipment used, date of application, time of application, temperature of greenhouse, crop, target pest, pesticide formulation, adjuvants used, application rate and EPA registration number. Check with your local State Lead Agency (see Appendix) about which records must be kept in your state. Check with Cooperative Extension in your state to obtain record keeping logbooks, or visit www.ams.usda.gov/Science/sdpr.htm and choose "Pesticide Record Keeping" in the column on the right.

Table A–2: Commonly used pesticide formulations, their application equipment, and their advantages and disadvantages

Formulation	Equipment	Advantage	Disadvantage
Aerosol (A)	pressurized	relatively easy to use container	flammability; phytotoxicity; accurate dosage problems
Dry Flowable (DF)	portable power sprayers; compressed air sprayers	no dust to breathe	requires continuous agitation in the tank; may be abrasive to equipment and plants
Dust (D)	portable power dusters; hand dusters	can be evenly spread; more effective on some pests	may leave deposit undesirable at time of sale; may damage sensitive plants
Emulsifiable concentrate (EC)	portable power sprayers; compressed air sprayers; mist blowers	long lasting residues; less likely to be washed off	may be phytotoxic
Flowable (F)	same as DF	powder already suspended in liquid	same as DF
Fog (produced by vaporizing oil-based formulations of pesticides on a heated surface)	pulse foggers	relatively easy to use	flammability; phytotoxicity; accurate dosage problems
Fumigation (pesticide released as a gas; does not include soil fumigants)		broad spectrum control	extremely hazardous to humans and animals
Granular (G); bait (B)	hand-applied	usually safest formulation	slow; tedious hand application; calibration of existing equipment may be difficult
Smoke (generated by igniting a combustible pesticide formulation)		safer on plants than aerosols, fogs and mists	less residual activity than aerosols and fogs; hazardous to applicators
Water Soluble Packet (WSP)	same as DF	no contact with pesticide formulation	same as DF
Wettable powder (WP)	same as DF	uniform; long-lasting residues	same as DF

DELIVERY CALCULATIONS

It is essential that the recommended dosage of a pesticide be applied in all pest control treatments. If the dosage applied is insufficient, materials are wasted, time is lost, and most importantly, the desired control is not attained. This may lead to additional pesticide applications that may accelerate the build-up of pest resistance to the chemical and increase the hazards to humans and the environment. Dosages that are larger than recommended can be equally wasteful and injurious.

Keep records of not only dosage but also the total amount of material applied and environmental conditions such as light, temperature and relative

humidity. To ensure that the correct dosage is applied, you need the following information:

- Labeled dosage rates.
- The size of the area to be treated: greenhouse volume in cubic feet for fumigations (smoke, fog, mist, etc.) or square feet of planted area and type and height of plant material for sprays, dusts, aerosols and soil applications.
- The capacity in pounds, gallons, etc., of the equipment to be used or, as in the case of smoke generators, the volume in cubic feet treated by each unit.
- The extent and characteristics of the pest population.

Dosages for most liquid pesticides (such as liquids and emulsifiable concentrates) and solid pesticides (such as wettable powders and water soluble packets) used in the greenhouse are given on the labels in fluid ounces and ounces by weight, respectively, per 100 gallons of water. The resulting spray formulations are applied to plant material to the run-off point. Do not over-apply, as droplets on the surface of plants may coalesce, resulting in less protective residue. Aerosol labels indicate the length of time the nozzle should be directed at the plant material to deliver the necessary dosage. Smokes state the volume in cubic feet of greenhouse covered by one generator.

When using smoke generators, mist generators or foggers, first determine the pesticide rate and then calculate the greenhouse volume for the area requiring treatment. The accompanying diagrams show how to calculate the volume of several greenhouse types.

Before using sprays and aerosols, or making soil applications of pesticides, calculate the square feet of planted area. Calculate this by adding the bench space or production floor area to be treated. (Note: If plants are to be sprayed to the “runoff” point, area calculations may not be necessary. However, the volume of spray needed varies with the type and height of the plant material). Aerosol directions often indicate how long and in what direction a spray should be used.

After you have established the pesticide rate and the treatment area size, determine the equipment’s capacity (see Table A-3 on next page). Many spray tanks display a mark that indicates capacity. In the case of smokes, pesticide and equipment are one unit. Foggers and mist blower equipment include filling instructions based on greenhouse volumes.

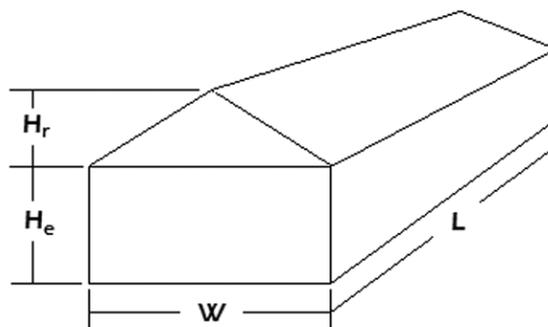


Figure A-1: Even-span structures

$$\text{Vol. in cubic feet} = \left[(H_e \times W) + \frac{W \times H_r}{2} \right] \times L$$

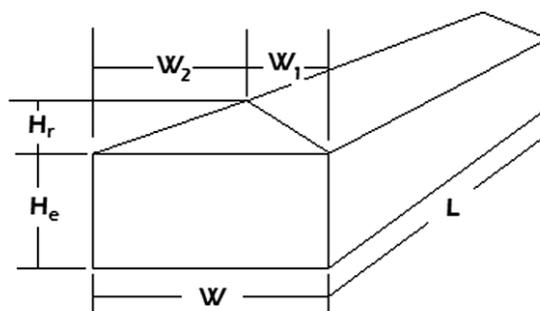


Figure A-2: Uneven-span structures

$$\text{Vol. in cubic feet} = \left[(H_e \times W) + \frac{W_1 \times H_r}{2} + \frac{W_2 \times H_r}{2} \right] \times L$$

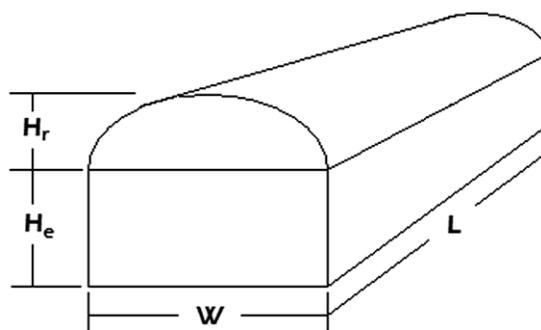


Figure A-3: Quonset structures

$$\text{Vol. in cubic feet} = \left[(H_e \times W) + \frac{3.14 \times H_r \times H_r}{2} \right] \times L$$

Table A-3: Calculating capacity of sprayer tanks

Type of Tank	Calculation of capacity (in gallons)
Cylinder tank (with round cross-section)	Multiply length in inches by square of diameter in inches; then multiply by 0.0034 to obtain gallons.
Tank with elliptical cross-section	Multiply length in inches, by short diameter in inches by long diameter in inches; then multiply by 0.0034 to obtain gallons.
Rectangular tank (with square or oblong cross-section)	Multiply length by width by depth, all in inches; then multiply product by 0.004329 to obtain gallons.

Once you know how much the tank can hold, you can calculate the amount of pesticide concentrate needed. Many tanks have a capacity of less than 100 gallons, although this is the figure generally used on pesticide labels. Use the following formula to adjust amounts of concentrate for smaller tanks.

Table A-4: Formula to calculate the capacity of pesticide application equipment tanks

Formula:			
$\frac{\text{Amount of pesticide recommended for 100-gal solution, expressed in oz or fl oz}}{100 \text{ gallons}}$	X	tank capacity in gallons	= amount of concentrate needed
Example:			
If 3 pounds of a wettable powder are recommended for 100 gallons of spray, how many pounds of WP are required for a 25-gallon tank?			
Note: First convert the 3 pounds to ounces: 3 lbs x 16 oz / lb = 48 oz			
$\frac{48 \text{ oz (of recommended concentrate)}}{100 \text{ gallons}}$	X	25 gallons/tank	= 12 oz of concentrate needed

Some pesticide labels list rates of product per acre. In greenhouses, space is more often calculated in square feet. Use the following formula to convert per-acre rates to per-sq ft rates.

Table A-5: Formula to convert per-acre pesticide rates to per-square-foot rates

Formula:			
$\frac{\text{Crop area to be treated, expressed in square feet}}{43,560 \text{ (# of square feet/acre)}}$	X	Amount of concentrate recommended per acre, expressed in oz or fl oz	= Amount of concentrate needed
Example 1:			
An insecticide is recommended at a rate of 2 gallons per acre. How much should be used on a 10,000 square-foot area?			
Note: First convert the 2 gal to fl oz: 2 gal = 128 fl oz/gal x 2 gal = 256 fl oz			
$\frac{10,000 \text{ square feet}}{43,560 \text{ square feet}}$	X	256 fl oz	= 58.75 fl oz of concentrate needed
Example 2:			
A granular pesticide is recommended at a rate of 15 pounds per acre. How much should be applied to 100 square feet?			
Note: First convert the 15 pounds to ounces = 15 lb x 16 oz/lb = 240 oz			
$\frac{100 \text{ square feet}}{43,560 \text{ square feet}}$	X	240 oz	= .55 oz of granules needed

Use Table A-6 on page A.10 when preparing pesticide spray formulations of emulsifiable concentrates (EC) in volumes of water less than 100 gallons. Example: If the pesticide label specifies 3 pints liquid concentrate in 100 gallons of water, then 3 teaspoons of the same preparation are needed in one gallon of water.

Table A–6: Amount of emulsifiable concentrate needed for volumes of spray smaller than 100 gallons

Water	Amount of concentrate*					
100 gals	0.5 pt	1 pt	2 pts	3 pts	4 pts	5 pts
50 gals	4 fl oz	1 cup	1 pt	1.5 pts	2 pts	2.5 pts
25 gals	2 fl oz	4 fl oz	1 cup	1.5 cups	1 pt	1.25 pts
5 gals	1 tbsp	2 tbsp (=1 fl oz)	4 tbsp (=2 fl oz)	6 tbsp (=3 fl oz)	8 tbsp (=4 fl oz)	10 tbsp (=5 fl oz)
1 gal	0.5 tsp	1 tsp	2 tsp	3 tsp	4 tsp	5 tsp

* see Table A–7 for key to abbreviations and conversion among quantities

Table A–7: Equivalent units useful for measuring small quantities of liquids. * all amounts across the table within one row are equal

Gallons (gal)	Quarts (qt)	Pints (pt)	Cups (c)	Fluid Ounces (fl oz)	Tablespoons (tbsp)	Teaspoons (tsp)	Milliliters (ml)
1	4	8	16	128			
	1	2	4	32			
		1	2	16	32		
			1	8	16	48	240
				1	2	6	30
					1	3	15
						1	5

* To ensure accuracy of measurement of liquid material, the purchase of graduated cylinders of 100 and 50 milliliter capacity is strongly suggested.

Note: Throughout this publication, ounces by weight are denoted by “oz,” fluid ounces by “fl oz.”

Spray Adjuvants

A spray adjuvant is a material added to another substance to increase the efficiency of that other substance. Several spray adjuvants are used in horticultural production. *Spreader*s increase the area that a given volume of liquid covers. *Sticker*s increase the retention of sprays on plants by resisting various weathering factors. *Activator*s accelerate or increase the effect of a pesticide. *Foam suppressants* reduce a chemical's tendency to foam in solution. *Wetting agents* increase a pesticide solution's ability to make complete contact with plant surfaces.

Spreader-stickers are the most common spray adjuvants used in greenhouse production. Spreader-stickers have two functions: to wet the leaf completely in order to promote good coverage by a pesticide mixture, and to make the pesticide stick to the leaf surface and reduce its weathering from the plant surface. In other words, spreader-stickers enhance the efficacy of pesticides.

Read pesticide labels for suggested adjuvants. Spreader-stickers can cause plant damage if they alter

the suspension chemistry of a pesticide, or if they are used in higher concentration than recommended. It is important to follow these five common sense rules to prevent damage:

1. Do not use an adjuvant if the pesticide you are using already contains one. Many emulsifiable and liquid products used on ornamentals contain adjuvants. Read labels carefully to determine if an adjuvant is already in the product.
2. Always try a new spreader-sticker on a small number of plants before using it on a whole crop. When making the test, use the product with the pesticide to be applied to the crop, and perform the trial under your normal spray conditions. For example, the product should not be applied on a hot, sunny day when the plants are most likely to suffer spray damage.
3. Experiment with dosage. Start at the low end of the stated dosage range and increase the amount through trial and error, until you are using enough adjuvant to wet the foliage completely according to your water supply, spray technique,

and spray equipment. Keep records of crops sprayed, pesticide products used and amount of adjuvant added.

4. If you repeatedly spray a crop over a period of several days, either use an adjuvant with the first pesticide application only, or use a reduced rate of adjuvant with each spray. Repeated use can cause a buildup that may burn plant tissue.
5. Some adjuvants may heighten dermal absorption and exposure of a pesticide, causing increased incidence of skin rashes and other reddening. Each person who applies a pesticide solution containing an adjuvant should be aware of this possible problem.

GROUNDWATER PROTECTION

In recent years people have become very concerned about groundwater contamination by pesticides. This has resulted in numerous studies at both the state and federal level to better understand the extent of the problem and what preventive measures are necessary.

Many factors affect pesticide persistence and movement in soils. These factors should be considered when developing a pest management strategy, in order to protect both crops and our ground and surface water resources.

Some pesticides are more soluble in water than others. Highly soluble pesticides have a greater tendency to move by runoff or leaching from the point of application. Pesticide persistence is usually expressed in terms of *half-life*, which is the typical length of time needed for one-half of the total amount of chemical applied to break down to non-toxic substances. Sunlight, temperature, soil and water pH, microbial activity and other soil characteristics may affect the breakdown of pesticides. Microbial degradation is the breakdown of chemicals by microorganisms. Soil organic matter and soil properties such as moisture, temperature, aeration, and pH all affect microbial degradation. Weather is also an important factor, as it affects both the persistence and movement of pesticides. Rainfall and irrigation can move surface-applied pesticides into the soil. The longer a pesticide persists in the environment, the longer it is subject to movement deeper into the soil profile. Runoff is the movement of chemicals in water over a sloping surface. Runoff can carry pesticides mixed in water or bound to eroding soil. In addition, pesticides can move from the point of application by volatilization and plant uptake.

Adsorption is the binding of chemicals to soil particles. Pesticide adsorption varies with the properties of the chemical, as well as the soil's texture (relative proportions of sand, silt and clay), moisture level and amount of organic matter. Soils high in organic matter or clay tend to be most adsorptive and sandy soils low in organic matter tend to be least adsorptive.

Groundwater contamination occurs when pesticides move with the infiltrating water through the soil profile to the water table. The closer the water table is to the surface, the greater is the risk that it may become contaminated. In some situations, pesticides that are tightly bound to the soil may only move a few inches from the point of application regardless of the amount of infiltrating water, while in other situations pesticides have been shown to move many feet. Pesticides that are highly water soluble, relatively persistent, and not readily adsorbed by soil particles have the greatest potential for movement. In addition, relatively level sandy soils low in organic matter are the most vulnerable to groundwater contamination due to their lower adsorptive capacity and higher infiltration rates.

WORKER PROTECTION STANDARD

The EPA Worker Protection Standard (WPS) affects employers, handlers and workers working in greenhouses. The following is only a summary; contact your State Lead Agency or Cooperative Extension for more information.

Greenhouse means any operation engaged in the production of agricultural plants inside any structure or space that is enclosed with nonporous covering and that is of sufficient size to permit worker entry. This term includes, but is not limited to, polyhouses, mushroom houses, rhubarb houses, and similar structures. It does not include such structures as malls, atriums, conservatories, arboretums, or office buildings where agricultural plants are present primarily for aesthetic or climatic modification.

Agricultural Plants are plants grown or maintained for commercial or research purposes. Examples include food, feed, and fiber plants, trees, turfgrass, flowers, shrubs, ornamentals and seedlings.

Agricultural Employer means any person who hires or contracts for the services of workers, for any type of compensation, to perform activities related to the production of agricultural plants or any person who is

an owner of or is responsible for the management of an agricultural establishment that uses such workers.

Handler means any person, including a self-employed person, who is employed for any type of compensation by an agricultural establishment or commercial pesticide handling establishment that contracts to greenhouses and who is

- mixing, loading, transferring, applying or disposing of pesticides or pesticide containers;
- handling opened pesticide containers;
- cleaning, adjusting, handling or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues;
- assisting with the application of pesticide residues; and/or
- assisting with the application of pesticide or entering a greenhouse or other enclosed areas after the application to operate ventilation equipment; to adjust or remove coverings used in fumigation; to monitor air levels.

In greenhouses, any *handler* who is working with a fumigant must be in constant visual or voice communication with another trained *handler* who has access to the proper *Personal Protective Equipment* (PPE) needed in order to permit rescue. The *employer* must provide handlers with at least the amount of PPE required on the pesticide label, and must ensure that it fits correctly, is intact, clean and in good operating condition, and is *used correctly!*

Cleaning and Maintaining PPE

The employer must make sure that

- PPE is cleaned, inspected and repaired before each use;
- PPE is cleaned according to manufacturer's instructions;
- PPE that is nonreusable or cannot be cleaned is disposed of (dispose by shredding the PPE or rendering it unusable and following state regulations for disposal);
- clothing drenched with pesticide concentrates labeled DANGER or WARNING is disposed of;
- PPE is washed, and stored separately from personal clothing;
- clean PPE is dried appropriately; and
- respirator filters, cartridges, and canisters are replaced as often as required.

The employer must also make sure that the handler cleaning PPE is informed of possible pesticide residues on PPE, of the potentially harmful effects of pesticides, and of the correct ways to handle and clean PPE.

No *handler* may wear home or take home any PPE that is contaminated with pesticides. The *employer* must clean and maintain PPE. *Employers* must provide handlers with a decontamination site which consists of enough good-quality water to wash the entire body, liquid detergent, disposable towels, and a clean change of clothing. Water for flushing eyes should also be available.

Worker means any person, including a self-employed person, who is employed for any type of compensation and who is performing activities relating to the production of plants in an agricultural establishment. Worker tasks include watering, fertilizing, pruning, and potting.

In greenhouses, no worker may enter or remain in an area being treated, and, under some application conditions (See Table A-6 on page A.10), workers must remain a specified distance from the area being treated or must remain out of the entire greenhouse until it has been adequately ventilated. For greenhouses, EPA-approved signs must be posted for all applications when workers are present. *Workers* must also be supplied with a decontamination kit except for change of clothing.

Training must be done for *handlers* and *workers* every 5 years unless they are certified applicators. Training must be done by a certified applicator, or someone who has completed a train-the-trainer class or, in the case of workers only, a trained *handler*. Training must be done in a language understandable to the employees.

Pesticide Safety Training

Handlers and workers must be trained every (5) years unless they are certified applicators.

Handlers must be trained before they do any handling activity.

Workers must receive either basic pesticide safety information or full WPS worker pesticide safety training before they enter an area on the agricultural establishment which has been treated or been under a restricted entry interval (REI) in the last 30 days. When basic pesticide safety information is given, workers must still receive the full WPS pesticide safety training within 5 days.

Notification of Workers

In greenhouses, all treated areas must be posted with WPS warning signs. Post signs so they can be seen from all points where workers usually enter the treated area, including doorways, aisles, and other walking routes in and through greenhouses. If the pesticide labeling requires both types of notification, then employers must also notify workers orally.

GREENHOUSE ENTRY RESTRICTIONS

Table A-8 on page A.14 presents details of restricted entry intervals (REIs), and applies to the three points below:

1. When a pesticide application described in column A in Table A-8 takes place in a greenhouse, the agricultural employer shall not allow or direct any person, other than an appropriately trained and equipped handler, to enter or to remain in the area specified in column B of Table A-8 until the time specified in column C of Table A-8 has expired.
2. After the time specified in column C in Table A-8 has expired or until the expiration of any restricted entry interval, the agricultural employer shall not allow or direct any worker to enter or to remain in the treated area as specified in column D of Table A-8, except as provided in part 170.112 of the Worker Protection Standard.
3. When column C in Table A-8 specifies that ventilation criteria must be met, ventilation shall continue until the air concentration is measured to be equal to or less than the inhalation exposure level that the labeling requires to be achieved. If no inhalation exposure level is listed on the labeling, ventilation shall continue until after one of the following has transpired:
 - Ten air exchanges
 - Two hours of ventilation using fans or other mechanical ventilating system
 - Four hours of ventilation using vents, windows, or other passive ventilation
 - Eleven hours with no ventilation followed by one hour of mechanical ventilation
 - Eleven hours with no ventilation followed by two hours of passive ventilation
 - Twenty-four hours with no ventilation

Table A–8: Greenhouse entry restrictions associated with pesticide applications.

If any information disagrees with the label, follow the label.

A. When a pesticide is applied:	B. Workers are prohibited in:	C. Until:	D. After the expiration of time in column C until the restricted entry interval expires, the entry-restricted area is:
(1) As a fumigant	Entire greenhouse plus any adjacent structure that can not be sealed off from the treated area.	The ventilation criteria of paragraph (c) (3) of this section are met.	No entry restrictions after criteria in column C are met.
(2) As a –Smoke, or –Mist, or –Fog, or –Aerosol	Entire enclosed area.	The ventilation criteria of paragraph (c) (3) of this section are met.	Entire enclosed area is the treated area.
(3) Not in 1 or 2 above and for which a respiratory protection device is required for application by the product labeling	Entire enclosed area.	The ventilation criteria of paragraph (c) (3) of this section are met.	Treated area.
(4) Not in 1, 2, or 3 above, and –From a height of greater than 12 in. from the planting medium, or –As a fine spray, or –Using a spray pressure greater than 40 psi	Treated area plus 25 feet all directions in the enclosed area.	Application is complete.	Treated area.
(5) Otherwise	Treated area.	Application is complete.	Treated area.