



Greenhouse Pesticides and Pesticide Safety

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Greenhouse environments provide a variety of benefits for plant production; however, many greenhouses favor pest development as well. The warm, humid conditions and abundant food are ideal for pest build up. Natural enemies that serve to keep some pests under control in the field are absent in the greenhouse. For these reasons, pest problems often develop more rapidly and are more severe in enclosed systems.

Pesticides are important tools in managing greenhouse pests. However, applications in enclosed spaces increase the risk of worker exposure. In poorly ventilated areas, danger of pesticide exposure by inhalation is greatly increased. To minimize the risk of pesticide exposure, the EPA has established the Worker Protection Standard (WPS) for agricultural pesticide usage. This law requires employers to provide employees with information about exposure to pesticides, personal protective equipment, and ways to mitigate exposure to pesticides.

Phytotoxicity, injury to plants by the pesticide, is also a greater concern in an enclosed environment. Plants growing rapidly in the greenhouse are more succulent, and thus more susceptible to pesticide phytotoxicity. Before using a new pesticide or a familiar pesticide on a new plant or plant variety, read the label and test it on a few plants to determine if phytotoxicity will be a problem. Furthermore, some pesticides are labeled such that the grower-user accepts all risks from phytotoxicity to greenhouse crops, because the risk is high.

Selecting Pesticides

Control of greenhouse pests begins long before they start to infest the plants. Do not rely **only** on chemical control of greenhouse pests. Cultural control measures are the cornerstones of greenhouse pest management; chemical controls cannot overcome poor or sloppy management. Cultural factors affecting

management of diseases and insects are covered in other Cooperative Extension Service publications.

When a pest is present in the greenhouse, the need for control will depend on several factors:

- ☐ the particular pest involved
- ☐ stage of the pest
- ☐ the presence of beneficial organisms
- ☐ type and location of damage to the crop
- ☐ crop age
- ☐ amount of damage likely to be caused by given numbers of the pest
- ☐ crop value
- ☐ risk to other crops
- ☐ potential for spread to field plantings

Potential benefits of an application, such as increased yield or quality, need to outweigh the hazard and expense of a pesticide application. Choosing the optimum pesticide and application method depends on the pest, equipment available, harvest intervals specified by the product label, legality of the pesticide on the specific crop or plant variety, and **safety**. Most of the pesticides registered for outdoor use on specific crops cannot be used on those same crops in the greenhouse. Many pesticides labeled for field use are prohibited for greenhouse use because of concerns about worker safety, crop injury, and/or pesticide resistance management.

Several types of cropping sites may be used to produce the same type of plant, including greenhouse, field, and float-plant systems. The types of available pesticides will vary enormously among sites. Although labeling for the float-plant system is unclear, the pesticide label must state that it is for use on that crop grown in the float-plant system or provide special instructions to address float water contamination. Disposal of water and plastic containing pesticide residues and the potential for crop injury are key issues limiting the availability of pesticides for the float-plant system.

In order for a pesticide to be recommended for use in the greenhouse, the pesticide label should state that the product is for use on that specific crop grown in the greenhouse.

Some greenhouse pesticides are highly toxic. For safety, particularly in an enclosed area (such as the greenhouse), managers should select pesticides based on signal words when possible. Signal words refer to the relative toxicity of the materials. Generally, materials labeled “CAUTION” are less hazardous than those labeled “WARNING”. Those labeled “DANGER” or “DANGER-POISON” are the most hazardous. Use a material with “CAUTION” on the label before “WARNING”, or “WARNING” before “DANGER”.

Pesticide registrations for greenhouse crops change frequently. Read the product label carefully before purchase and application to ensure that it is appropriate for the greenhouse crop. The pesticide label is the final authority; read and understand it carefully.

Greenhouse managers also should consider specific WPS requirements when choosing pesticides. Some applications prohibit workers and other persons from entering the entire enclosed area until the restricted entry interval (REI) expires, even if only a portion of the greenhouse was treated (Table 1). Restricted entry intervals may vary from 12 to 48 hours depending on the pesticide. While workers are allowed to enter treated areas with protective equipment during this period, only certain operations are permitted and hand labor is prohibited. Longer REI's

associated with some pesticides may interfere with planned greenhouse operations

Pesticides must be used safely. Always minimize exposure during mixing, application, and cleanup operations. Use protective equipment listed on the label and exercise common sense.

Formulations

Active ingredients in a pesticide are the chemicals that control the target pest. Pesticide formulations include both inert and active ingredients. A single active ingredient is often available in several different kinds of formulations such as Emulsifiable Concentrates (EC), Wettable Powders (WP), Granules (G), Aerosols, Flowables (F), Dusts (D), Baits (B), Soluble Powders (SP), and Microencapsulation (FM). A description of the different formulations as well as their relative advantages and disadvantages can be found in Extension publication *Applying Pesticides Correctly*.

Types of pesticide formulations may affect levels of control as well as safety. Concentrated liquid formulations are generally more hazardous to the applicator than dry formulations as they may be easily absorbed through the skin. Aerosols and fogs usually penetrate dense foliage better than conventional sprays so better pest control is achieved, but they pose greater risk to people of exposure through the eyes or by inhalation. Special metering or application equipment may be needed and some of the chemicals used are highly toxic. Minimum Worker Protection Standard

Table 1. Special Pesticide Application Restrictions in Greenhouses

| When a pesticide is applied: | Then workers and other persons are prohibited in: | Until: | After the expiration of the time in the previous column until the restricted-entry interval expires, the restricted area is: |
|---|--|-----------------------------------|---|
| 1. As a fumigant | Entire greenhouse plus any adjacent structure that cannot be sealed off from the treated area. | The ventilation criteria are met. | No entry restrictions after the ventilation criteria are met. |
| 2. As a smoke, mist, fog, or aerosol. | Entire enclosed area. | The ventilation criteria are met. | Entire enclosed area is the treated area. |
| 3. Under circumstances (other than in 1 or 2) for which the pesticide requires the applicator to wear a respirator. | Entire enclosed area. | The ventilation criteria are met. | Pesticide-treated area. |
| 4. Other than in 1, 2, or 3 but: from a height of greater than 12 inches from the plant medium, as a fine spray, or using a spray pressure greater than 40 pounds per square inch. | Pesticide-treated area plus 25-feet in all directions within the entire enclosed area. | Application is complete. | Pesticide-treated area. |
| 5. In any other manner. | Pesticide-treated area. | Application is complete. | Pesticide-treated area. |

requirements may vary for different formulations of the same active ingredient.

Treatments can be applied whenever the greenhouse can be closed for at least 2 hours without danger of causing a temperature increase that could harm the plants. The normal temperature range for best results with fogs or aerosols is 60° to 80°F. The temperature range may be more restricted for some chemicals. Early morning, late afternoon, or cloudy days are the best times to treat to maintain the proper temperature in a closed greenhouse.

Worker Protection

Employers and employees must comply with the EPA Worker Protection Standards. They should conduct safety training for pesticide handlers and agricultural workers before the greenhouse season begins. The criteria that must be covered during pesticide safety training can be found in *The Worker Protection Standard for Agricultural Pesticides - How To Comply*. This publication is available through your county Extension office or the Kentucky Department of Agriculture, Division of Pesticides. **Before applying any pesticides, employers must establish pesticide decontamination sites, conduct safety training for pesticide handlers, acquire necessary personal protective equipment for the employees, and establish a centralized location to display pesticide information.**

Below is pesticide information that must be displayed at a central location.

- ☐ A pesticide application list that includes:
 - the location and description of the area to be treated
 - product name, EPA registration number, and active ingredients
 - time and date the pesticide is scheduled to be applied
 - restricted-entry interval for the pesticide
- ☐ Emergency information, including the name, telephone number, and address of the nearest emergency medical facility
- ☐ An EPA-approved pesticide safety poster

Early Entry After Application

Entry into a treated area that remains under a restricted-entry interval is allowed only in a few specific work situations. When early entry is permitted, special protection must be given to workers.

Early entry involving contact with treated surfaces is permitted for:

- ☐ short-term tasks that last less than 1 hour and do not involve hand-labor.
- ☐ emergency tasks.
- ☐ specific tasks approved by EPA through a formal exception process.

Workers may enter treated areas before the restricted-entry interval has expired to do short-term tasks that do not involve hand labor, if provided with the required protections and protective equipment.

Each worker must:

- ☐ wait at least 4 hours after the pesticide application is completed before entering the treated area
- ☐ wait until any inhalation exposure level listed on the product labeling has been reached or any ventilation criteria specified by the Worker Protection Standards has been met
- ☐ spend no more than 1 hour in a 24-hour period on short-term early-entry tasks.

The employer must make sure that any early-entry worker has received pesticide safety training, as specified by the Worker Protection Standards, prior to entering a treated area during a restricted entry interval.

Pesticide Safety Equipment

There are two categories of personal protective equipment (PPE) to protect against pesticide exposures. PPE requirements for early-entry workers differ from those for pesticide handlers and applicators. Applicators must wear all the personal protective equipment specified on the product labeling for “pesticide applicators and other handlers.” PPE for early-entry workers is specified in the “Agricultural Use Requirements” box on the label. Always carefully follow all the label requirements.

The employer must provide and maintain this equipment. All PPE must be inspected each day of use for leaks, holes, tears, or worn places. Repair or discard any damaged equipment. If PPE will be reused, clean it each day according to the instructions from the manufacturer. If there are no instructions, wash the PPE thoroughly in detergent and hot water. Inform anyone who cleans the PPE that it may be contaminated with pesticides. Users should know potentially harmful effects of pesticides, how to protect themselves when handling contaminated PPE, and how to clean PPE properly.

Ventilation

After some types of pesticide applications, adequately ventilate the greenhouse before allowing workers to enter. If the pesticide is applied as a fumigant, smoke, mist, fog, aerosol, or requires the applicator to wear a respirator, then specific ventilation requirements apply. Make sure one of the following criteria is met before allowing persons to enter the greenhouse:

- ☐ the measured concentration of the pesticide in the air is less than or equal to any inhalation exposure level required on the labeling.

- ❑ if no inhalation exposure level is listed on the labeling, keep workers out until after:
 - 10 air exchanges, or
 - 2 hours of ventilation using fans or other mechanical ventilating systems, or
 - 4 hours of ventilation using vents, windows, or other passive ventilation, or
 - 11 hours of no ventilation followed by 1 hour of mechanical ventilation, or
 - 11 hours of no ventilation followed by 2 hours of passive ventilation, or
 - 24 hours with no ventilation

General Precautions

Growers should always **read the label carefully** before use and follow all directions and precautionary statements. Other general precautions include:

Pre Planning

1. Read the label thoroughly to determine what WPS personal protective equipment (gloves, hat, respirator, apron, etc.) is required for the pesticide handler.
2. Only select pesticides labeled for use in the greenhouse.
3. Be sure it is safe for use with your qualifications, experience, and training and that it is the correct pesticide for the problem you have.
4. Know the warning symptoms of poisoning by the chemicals being used.
5. Make sure the pesticide applicator is given information from the pesticide labeling and has access to the labeling itself. Instruct handlers in the safe operation of the equipment they will be using.
6. Calibrate application equipment and determine amount of material needed to avoid leftover spray and disposal problems.
7. Plan an application route. Finish near an exit and not at a dead end that will require you to exit through mists, fogs, dusts, vapors, or wet foliage.
8. Post warning signs at all entrances to the treated area 24 hours or less before the scheduled application.
9. Notify workers of the location and description of the treated area, time during which entry is restricted, and instructions not to enter the area until the restricted-entry interval has expired.

Application

1. Make sure that the pesticide is applied so that it does not contact, either directly or through drift, anyone except appropriately trained and equipped handlers.
2. Mix chemicals outdoors or in a well-ventilated room.
3. Use all the personal protective equipment for pesticide handlers called for on the label. Do not get pesticides near your mouth, eyes, or nose and avoid contact with skin.

4. Do not make sprays stronger or weaker than indicated by label instructions. This may result in poor pest control, illegal residues on the crops, or plant injury.
5. Use of pesticides with a “skull and crossbones” on the label requires that the pesticide handler be monitored during application.
6. Maintain constant voice or visual contact with anyone applying a fumigant in the greenhouse. This includes during fumigation, to operate ventilation systems, adjust tarps, or check air concentration levels. The person monitoring must be trained as a pesticide handler and have immediate access to the personal protective equipment that the fumigant labeling requires for applicators.
7. Never eat, smoke, or drink when handling a pesticide.
8. Stop and clean up spills immediately. If you spill the chemical on yourself, get out of the containment area immediately, remove soiled clothing, and wash yourself thoroughly with hot soapy water. Notify a doctor.

Post Application

1. Dispose of unused pesticides and empty containers according to label instructions. Do not save used containers.
2. Store pesticides in the original well-labeled containers in a safe place out of the reach of unauthorized or unwary persons. Store application equipment as you do pesticides.
3. Wash yourself thoroughly with soap and water and change clothes after using pesticides.
4. Keep persons out of a treated area during the restricted-entry interval (REI) prescribed on the label.
5. After some types of pesticide applications, adequately ventilate the greenhouse (see Ventilation) before allowing workers to enter.
6. Remove warning signs within 36 hours after the restricted-entry interval has expired.
7. If personal protective equipment is to be reused, clean it according to manufacturers’ instructions.

Pesticide Exposures

Pesticides can enter the body in three major ways: through the mouth (oral), through the skin (dermal), and through the lungs (inhalation). People may be poisoned without realizing the seriousness of the exposure, especially if pesticides enter through the skin or lungs. **In enclosed areas, danger of pesticide exposure by inhalation is greatly increased.**

Oral poisoning can be caused by:

- ❑ Mistaking the pesticide for food or drink.
- ❑ Accidentally applying pesticides to food.

- ☐ Carelessly splashing pesticides into the mouth.
- ☐ Not washing hands after handling pesticides or their containers.

Dermal poisoning can be caused by:

- ☐ Not washing hands after handling pesticides or their containers.
- ☐ Splashing or spraying pesticides on unprotected skin or eyes.
- ☐ Wearing pesticide-contaminated clothing.
- ☐ Wearing inadequate protective clothing and equipment.

Inhalation poisoning can be caused by:

- ☐ Exposure to pesticides in closed or poorly ventilated areas.
- ☐ Accidentally breathing vapors from fumigants and other toxic pesticides.
- ☐ Breathing fumes, dust, or mist, during application without appropriate protective gear.
- ☐ Inhaling fumes present immediately after a pesticide application (reentering too soon).
- ☐ Not having a good seal on your respirator or using an old or inadequate cartridge or canister.

If you have a person who has been poisoned or injured by a pesticide, get the person to an emergency medical facility that can provide assistance. Give the physician or emergency room personnel the product name, EPA registration number, active ingredients, antidote, first aid, statement of practical treatment, and other medical or emergency information from the product labeling. Describe the way the pesticide was being used and the circumstances of the victim's exposure to the pesticide. The following emergency numbers can provide pharmacological information on pesticides to health professionals.

Kentucky Regional Poison Control Center of
Kosair Children's Hospital
Call Toll-free: **1-800-722-5725**
In Metro Louisville call 589-8222

Making Dosage Calculations

Some of the information not included on the label but needed to calculate and apply the proper dosage of pesticides in the most economical and safe way include:

1. Floor area of the greenhouse.
2. Volume of the greenhouse.
3. Gallons of spray needed to thoroughly cover a crop at the different stages of plant growth (Preparing excess spray is uneconomical and creates a disposal problem).

Mist and Aerosol Calculations

Some aerosol and fog application rates are based upon house volume (cubic feet). Determine how many ounces of pesticide are needed to treat that volume. For fog generators, pour the required number of ounces of pesticide into the tank that are needed to treat the calculated space and apply according to label instructions.

Rates for Total Release Insecticide Aerosol Generators are based on floor area of the house (square feet). Each unit will cover a given number of square feet. The square footage of the house will determine the number of units required for proper coverage. Check label for precautions on lights, pilots, or electrical sparks.

House Volumes and Areas

Volume (cubic feet) is found by multiplying the end area (square feet) of the house by the length (feet). The following table, taken from AEN-9, gives the end areas for various sizes and styles of greenhouses.

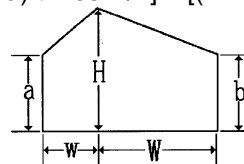
Greenhouse floors are rectangular. The area is found by multiplying the width (feet) times the length of the house (feet).

Table 2. Estimating Greenhouse Ventilation Requirements

| Width (W) Feet | Figure 1 | Figure 2 | Figure 3 | Figure 4 | Figure 5 |
|----------------------|----------|----------|----------|----------|----------|
| 12 | 90 | 56 | 70 | | |
| 16 | 128 | 100 | 126 | | |
| 20 | 170 | 157 | 198 | | |
| 24 | 216 | 226 | 260 | 180 | |
| 28 | 226 | 308 | 360 | | |
| 32 | 320 | 402 | 475 | 256 | |
| 36 | 378 | 509 | 640 | | 270 |
| 40 | 440 | 628 | 792 | 340 | |
| 48 | | | | 432 | 384 |
| 56 | | | | 532 | |
| 60 | | | | 586 | 510 |
| 64 | | | | 640 | |
| 72 | | | | 756 | 648 |
| 80 | | | | 880 | |
| 84 | | | | | 798 |
| 96 | | | | | 960 |
| 108 | | | | | 1134 |
| 120 | | | | | 1320 |

If the house is an unequal span style, its end area can be calculated using the following formula:

$$\text{Area} = [(H+a) \text{ times } w/2] + [(H+b) \text{ times } W/2]$$



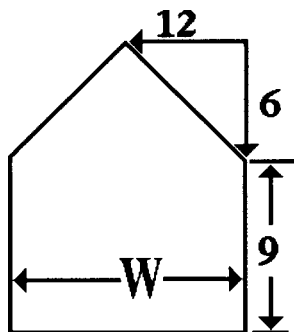


Figure 1.

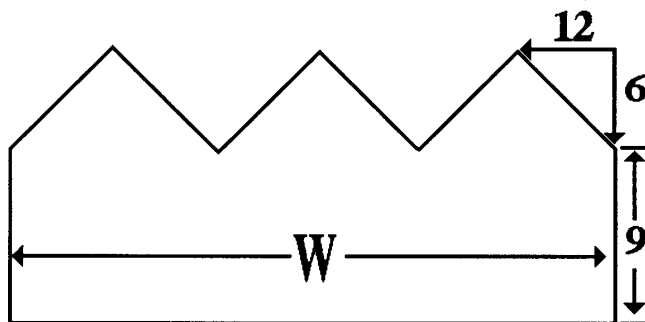


Figure 5.

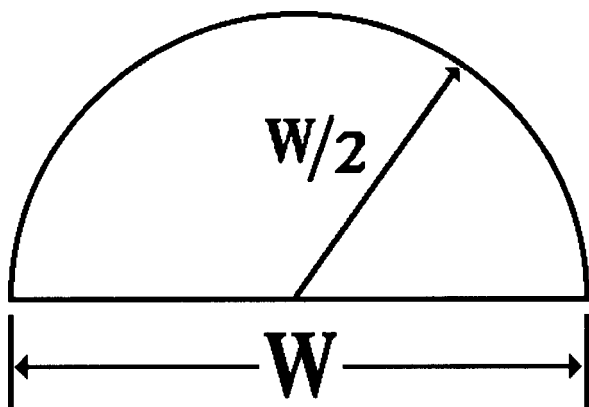


Figure 2.

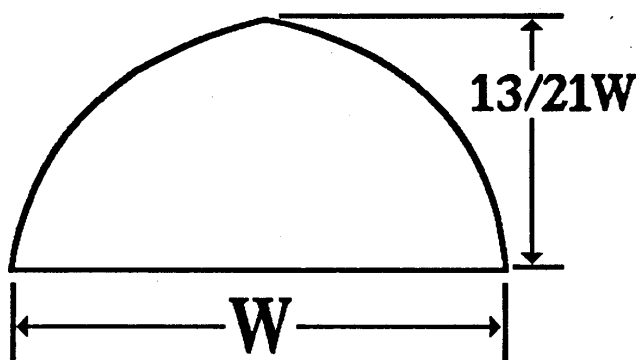


Figure 3.

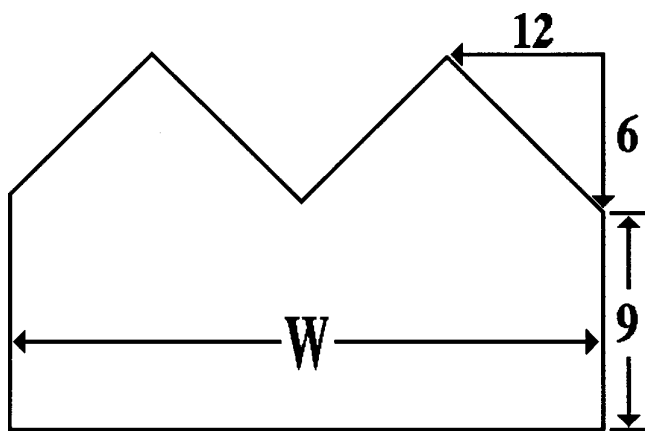


Figure 4.

Mixing Small Spray Gallonages

If a pesticide label only gives mixing proportions for 100-gallon or other large batches of spray, you can use the following rules-of-thumb for mixing smaller gallonages:

1. For every pint EC recommended per 100 gal. of finished spray, use 1 tsp of EC per gallon of finished spray.
2. For every pound of WP recommended per 100 gal. of finished spray, use 1 level Tbsp of WP per gallon of finished spray. (This rule is subject to varying degrees of error because all wettable powders do not have the same density.)

Fungicides and Nematicides Registered for Control of Diseases of Certain Greenhouse Crops*

This list of chemicals is not a recommendation. Although specific diseases and pathogens are presented here, in many cases the chemicals listed can only be used on a few specific plants. These plants are listed on the pesticide label. Because some chemicals may be inappropriate for certain crops, or may injure plants or leave illegal residues, growers must consult the pesticide label for legal uses before applying chemicals to greenhouse crops.

NOTE: Vegetable and tobacco transplants are not considered bedding plants.

Banrot is a broad spectrum combination fungicide consisting of etridiazole plus thiophanate-methyl. The 40% wettable powder is used for drenching the soil or growing medium. The 8% granular is incorporated into the growing medium before planting. Use to control root rots caused by *Pythium*, *Phytophthora*, *Rhizoctonia*, *Fusarium* and *Thielaviopsis*. Follow labeled dosages carefully, noting differences in treating different plant types. It is labeled mainly for

ornamentals, but is not labeled for vegetables or tobacco.

Botran is a broad spectrum fungicide recently re-labeled. It has greenhouse uses for some vegetable crops including cucumbers, lettuce, and tomato for botrytis and sclerotinia. It is not labeled for tobacco.

Captan (Orthocide) is a broad spectrum fungicide with limited registrations for use in greenhouses, although previously it was labelled for greenhouse use. It can be used as a pre-planting soil treatment for prevention of damping-off and root rot diseases in a few crops, but is not labeled for use on vegetables or tobacco.

Chitin-protein (Clandosan 618) is a biological control for nematodes.

Chlorothalonil (Daconil 2787, Exotherm Termil) is quite good for the control of *Botrytis* and other leaf spotting fungi on certain ornamental and vegetable crops, but not tobacco. Daconil 2787 is commonly sold as a flowable (F) formulation. Exotherm Termil is a smoke bomb form of chlorothalonil. Fumigate in the evening and close the vents overnight. Don't enter during fumigation and ventilate two hours before working in the greenhouse.

Dodemorph (Milban) is an EC fungicide that is currently registered only for powdery mildew control on several ornamentals, but not on vegetables or tobacco. Be sure to wear eye protection when using this Restricted Use material. Do not mix dodemorph with other chemicals in the spray tank.

Etridiazole (Truban, Terrazole) is specific for water mold control. It is often combined with other materials in a soil drench program. It is formulated as wettable powder, emulsifiable concentrate, or flowable for drench uses and as a 5% granular for pre-plant incorporation into growing media. Follow drench applications with an additional irrigation to improve the penetrability of the material into the soil. Follow labeled dosages closely, using low ends of dosage ranges for normal, preventive drenches. It is not labeled on vegetables or tobacco.

Fenarimol (Rubigan) is a locally systemic fungicide for control of powdery mildew of commercial greenhouse roses.

Ferbam (Carbamate) is a broad spectrum fungicide with a few labeled uses in the greenhouse, including tobacco transplants.

Fixed Copper (Kocide 101) is a "fixed copper" fungicide that is generally safe to use but sometimes causes plant damage. It has a wide range of activity against many leaf spots and blights, but few specific crop registrations in the greenhouse.

Iprodione (Chipco 26019). Many greenhouse ornamentals can be sprayed for *Botrytis* with this 50% WP fungicide. There are a few other foliar spray uses on the label as well. As a drench, iprodione can be used at seeding or at transplanting for *Rhizoctonia* control. Be sure to treat only labeled crops and note that the

drench rate per 100 gallons is lower than the foliar spray rate. Fungi may develop resistance to iprodione, and to similar chemicals such as vinclozolin. A related product is Rovral. Neither product is labeled for vegetables or tobacco.

Mancozeb (Fore, Dithane M-45, Manzate 200) is a dithiocarbamate fungicide for control of leaf spots and blights. The product is a broad spectrum material but leaves a heavy residue. It is labeled on many crops including selected vegetables and tobacco.

Metalaxyl (Subdue) is a fungicide that is systemic and is effective for downy mildew, *Pythium*, or *Phytophthora* diseases at extremely low rates. It is available as an emulsifiable concentrate or as a granular. Use the product at the lower end of the rate ranges given on the label for various ornamental crops. Do not apply more often than directed on the label. Subdue 2E can be combined with other materials in a preventive soil drench program to broaden the spectrum of pathogens controlled. In general, it is not labeled for greenhouse use if Ridomil (a related compound) is labeled for field use because of increased risk of developing metalaxyl resistance. Ridomil use in the greenhouse is specifically prohibited by the label.

Oxamyl (Vydate L, Oxamyl G) is a systemic nematocide that has ornamental crop registrations for root nematodes. Vydate L can be used as a foliar spray, as a pre-plant soil treatment, or as a soil drench in pots in selected crops. It is highly toxic, so use it carefully if spraying in the greenhouse, much more toxic than most other disease control chemicals. Make sure the Oxamyl G (granular) is washed off foliage or off the soil surface after application.

Oxycarboxin (Plantvax) is a systemic fungicide that is very effective in controlling rust on ornamentals.

Piperalin (Pipron) is a fungicide to control powdery mildew of ornamentals in commercial greenhouses.

Quintozene (Terraclor, PCNB) is used as a pre-plant soil drench to control *Rhizoctonia* and some other stem and root rotting fungi in ornamentals, but is not labeled on tobacco or vegetables. Quintozene is not effective against water molds. It should be combined with metalaxyl or etridiazole in a general pre-plant soil drench or incorporation program.

Streptomycin sulfate (Agri-strep) is a bactericide with many out-door plant bed uses labeled, but at press time it has no specific labels for greenhouse use.

Sulfur (Flotox) is for powdery mildew suppression in ornamental crops. Flowers of sulfur can be used in electric fumigators or vaporized from steam lines. Sulfur sprays, such as Flotox, or dusts may also be used. Sulfur leaves a residue and may cause plant injury. It is not labeled on tobacco or most vegetables.

Thiophanate-methyl (Cleary's 3336-F and WP, Domain FL) is similar in mode of action to benomyl. It is labeled as a foliar spray for anthracnose, *Botrytis*,

and a few other diseases of ornamentals, but not on vegetables or tobacco. As a drench, it is used for *Rhizoctonia* and other stem, root, and crown rots. Bulbs and corms of some plants can also be soaked immediately after digging for control of certain bulb rots. Resistance of greenhouse crop disease fungi to benomyl is widespread; these fungi are also resistant to thiophanate-methyl.

Triadimefon (Strike) is a systemic fungicide that is quite effective for its labeled uses. Label directions must be followed closely. Overdoses of triadimefon will stunt plants and darken foliage. Few uses are labeled currently.

Triforine is an EC fungicide that wets foliage well without the need for an additional spreader-sticker. Wear eye protection when using this material.

Vinclozolin (Ornalin, Ronalin) is a 50% WP fungicide that is effective for control of *Botrytis* and *Sclerotinia* spp. on ornamental crops grown in greenhouses. It is not labeled on vegetables or tobacco in the greenhouse. It is similar in action to iprodione but does not leave as noticeable a residue. Fungi may develop resistance to vinclozolin, and similarly to iprodione. It is labeled for professional use only as a foliar spray, as a bulb and corm dip, and as a post-harvest spray for many cut flowers.

Zyban (Zyban, Duosan) is a broad spectrum systemic and contact fungicide consisting of a mixture of 15% WP thiophanate-methyl and 60% WP mancozeb. Fungi may develop resistance to thiophanate-methyl. It is labeled for professional use only on ornamentals in greenhouses. A good spreader-sticker is recommended for use on hard-to-wet foliage. Do not use on French marigold or gloxinia.

Insecticides Registered for Control of Insects and Mites of Certain Greenhouse Crops*

This list of chemicals is not a recommendation. Although specific insect and mite pests are presented here, in many cases the chemicals listed can only be used on a few specific kinds of plants. These plants are listed on the pesticide label. Because some chemicals may be inappropriate for certain crops, or may injure plants or leave illegal residues, growers must consult the pesticide label for legal uses before applying chemicals to greenhouse crops.

NOTE: Vegetable and tobacco transplants are not considered bedding plants.

Abamectin (Avid 0.15EC) is an insecticide/miticide registered for control of spider mites and leaf miner

larvae on ornamental plants. Use the higher rates against leafminers. The active ingredient is derived from a naturally-occurring soil microorganism. It is not labeled on vegetables or tobacco.

Acephate (Orthene, Pt 1300) is a broad spectrum organophosphate insecticide that is effective against chewing and sucking insects. It is an excellent insecticide but phytotoxicity has occurred on several chrysanthemum cultivars and foliage plants. Be careful when applying this material to any new cultivar. Wait two weeks for symptoms to occur. It is labeled for use on tobacco in the greenhouse but not for vegetables.

Bacillus thuringiensis* var. *azawi is a microbial insecticide that is effective against many species of caterpillars. It is registered for use against armyworms, loopers, and *Heliothis* sp.

Bacillus thuringiensis* var. *Kurstaki is a microbial insecticide that is effective against many species of caterpillars. The pest must eat this material so thorough coverage is essential. Caterpillars stop feeding soon after eating treated foliage but may not die for two or three days. When used as directed, no plant injury has been reported. An example is Dipel 2X Worm Killer.

Bacillus thuringiensis* var. *Israelensis (Gnatrol) is a microbial insecticide that is registered for controlling fungus gnat larvae and is applied as a drench.

Bendiocarb (Dycarb, Ficam, Turcam) is a carbamate insecticide registered for control of several common insect and mite pests on a wide range of ornamentals. Avoid use of alkaline water for maximum effectiveness. It is not labeled on vegetables or tobacco.

Bifenthrin (Attain, Talstar 10WP) is a pyrethroid insecticide/miticide that is effective in controlling most aphids, spider mites, whiteflies, mealybugs, scales, and caterpillars found in floral crops. It is particularly effective against mites. Talstar has no known systemic or vapor effect so thorough coverage is necessary for good control. It is not labeled on vegetables or tobacco.

Chlorpyrifos (Dursban 50WP, Pageant, PT 1325ME Duragard) is a broad spectrum organophosphate insecticide registered on most greenhouse ornamentals. It is not labeled on vegetables or tobacco.

Cyfluthrin (Tempo 2, Tempo 20WP, Decathalon) is a broad spectrum pyrethroid that is available in two formulations to control whiteflies, caterpillars, thrips, and some aphid species. May cause minor skin irritation which can be counteracted by vitamin E cream. It is not labeled on vegetables or tobacco.

Cyromazine (Citation 75WP) is an insect growth regulator (IGR) that is registered just for leafminer control on container-grown chrysanthemums. It has some systemic effects but should be applied as a high volume spray.

Diazinon (Knox Out 2FM Pt 265, Knox-out PT

1500R) is registered as microencapsulated and fogging formulations. The microencapsulated formulation has been quite effective against mealybugs and scales. It is not labeled on vegetables or tobacco.

Dibrom (Naled 8E), an organophosphate insecticide, is registered for vapor or fog treatments. The concentrate is highly corrosive to metals. It is not labeled on vegetables or tobacco.

Dichlorvos (Vapona, DDVP) is an organophosphate insecticide that can be used as a vapor, fog, or mechanical mist. Some ornamentals may be injured, particularly if greenhouse temperatures are too high. Dichlorvos is effective at 60° to 65° F. It is not labeled on vegetables or tobacco.

Dicofol (Kelthane 35, Kelthane 50) is registered as a foliar spray or fog for two-spotted spider mite control. Repeat applications often during warm weather. It is not labeled on vegetables or tobacco in the greenhouse.

Dienochlor (Pentac WP, Pentac Aquaflow) is registered as a foliar spray or fog for two-spotted spider mite control. Repeat applications often during warm weather. It acts very slowly. It is not labeled on vegetables or tobacco.

d-Phenothrin (Sumithrin, Pt 1400) is a pyrethroid registered for whitefly, aphid, spider mite, and mealybug control on a wide range of plants. Repeat applications are necessary to maintain control. It is not labeled on vegetables or tobacco.

Endosulfan (Thiodan) is a foliar spray that is effective at higher greenhouse temperatures. The EC formulation has injured some chrysanthemum and geranium cultivars. It is labeled for tomatoes in the greenhouse, but not other vegetables and tobacco.

Fenoxycarb (PT 2100TR) is an insect growth regulator. Apply during early evening when foliage is dry and the temperature is between 60°F and 80°F. It is not labeled on vegetables or tobacco.

Fenpropathrin (Tame 2.4EC) is a pyrethroid insecticide/miticide that is active against many pests. It is often combined with Orthene for control of whiteflies. It is not labeled on vegetables or tobacco.

Fluvalinate (Mavrik Aquaflow) is a pyrethroid insecticide/miticide that has given fair to good control of many aphids, thrips, and spider mites. Mavrik may

cause throat inflammation if respirators do not fit properly. It is not labeled on vegetables or tobacco.

Horticultural oil (Sunspray) can be applied to growing crops for control of a range of insect and mite pests including spider mites and whiteflies.

Imidacloprid (Marathon 1G) is a systemic chloronicotinyl insecticide used to control insects with piercing-sucking mouthparts such as aphids, mealybugs, thrips, and whiteflies. It is not labeled on vegetables or tobacco.

Insecticidal Soap contains potassium salts of fatty acids. It is registered for control of aphids, mealybugs, whiteflies, earwigs, and spider mites.

Kinoprene (Enstar 5E, Enstar II) is an insect growth regulator used to control whiteflies, aphids, mealybugs, and fungus gnats. If whitefly populations are well established, combine Enstar with a pyrethroid to reduce adult numbers. It is not labeled on vegetables or tobacco.

Metaldehyde, which is used for slug control on and underneath benches, is available in several formulations. Follow label directions.

Neem (Margosan-O) is a botanical insecticide that acts as an insect growth regulator. It is used as a spray or drench to control whiteflies, thrips, leafminers, and loopers. It is not labeled on vegetables or tobacco.

Permethrin (Pramex, Pounce), a pyrethroid, will control most whiteflies, caterpillars, and leafminer adults. It is not labeled on vegetables or tobacco in the greenhouse.

Pyrethrin (PT 1100 Pyrethrum, X-clude PT 1600A, Pyrenone Crop Spray, Pyronyl Crop Spray), a natural botanical insecticide, also contains the synergist piperonyl butoxide. It is especially effective against whiteflies. There is virtually no residual effect so applications must be repeated frequently.

Resmethrin (SBP 1382, PT 1200) is a pyrethroid material registered for use as a foliar spray, aerosol, or fog. Best results are obtained when greenhouse temperatures are cool (50°F-72°F). Rapid control results after application but residual life is short. It is not labeled on vegetables or tobacco.

Sulfotepp (Dithio, Dithione, Plantfume 103) is used as a fog or smoke generator. Follow label directions. It is not labeled on vegetables or tobacco.

**This list is presented for information only. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. Be sure to read pesticide labels for lists of crops allowed.*

Dilution Tables

Wettable Powders

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

| 100.0 gal | 10.0 gal | 5.0 gal | 2.0 gal | 1.0 gal |
|-----------|----------|---------|---------|---------|
| 0.5 lb | 0.8 oz | 0.4 oz | 0.2 oz | 0.1 oz |
| 1.0 lb | 1.6 oz | 0.8 oz | 0.3 oz | 0.2 oz |
| 2.0 lb | 3.2 oz | 1.6 oz | 0.6 oz | 0.3 oz |
| 3.0 lb | 4.8 oz | 2.4 oz | 1.0 oz | 0.5 oz |
| 4.0 lb | 6.4 oz | 3.2 oz | 1.3 oz | 0.6 oz |
| 5.0 lb | 8.0 oz | 4.0 oz | 1.6 oz | 0.8 oz |

Emulsifiable Concentrates

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

| 100.0 gal | 10.0 gal | 5.0 gal | 2.0 gal | 1.0 gal |
|-----------|------------|-----------|-----------|-----------|
| 1.0 pt | 1.6 fl oz | 0.8 fl oz | 0.3 fl oz | 0.2 fl oz |
| 1.0 qt | 3.2 fl oz | 1.6 fl oz | 0.7 fl oz | 0.3 fl oz |
| 2.0 qt | 6.4 fl oz | 3.2 fl oz | 1.3 fl oz | 0.6 fl oz |
| 1.0 gal | 12.8 fl oz | 6.4 fl oz | 2.6 fl oz | 1.3 fl oz |

Mist Blower

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

| If amount per 100 gal for a high volume spray is: | Use this amount in a mist blower for: | | | |
|--|---------------------------------------|----------|-----------|-----------|
| | 25.0 gal | 10.0 gal | 2.0 gal | 1.0 gal |
| 1.0 pt | 6.25 pt | 2.5 pt | 8.0 fl oz | 4.0 fl oz |
| 1.0 qt | 6.25 qt | 5.0 pt | 1.0 pt | 8.0 fl oz |
| 2.0 qt | 3.13 gal | 5.0 qt | 1.0 qt | 1.0 pt |
| 1.0 gal | 6.25 gal | 2.5 gal | 2.0 qt | 1.0 qt |

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