# 2019-2020 Cornell Guide for the Integrated Management of Greenhouse Crops and Herbaceous Ornamentals

Cornell Cooperative Extension

*These guidelines are not a substitute for pesticide labeling. Always read and understand the product label before using any pesticide.*

# *Chapter Quick Find*

*To quickly find a chapter, match the black tabs to the right of a chapter title below with the gray tabs on the right-hand edge of the book. To find specific section, use Table of Contents.*

**4 BIOLOGY AND MANAGEMENT OF DISEASES OF GREENHOUSE CROPS AND HERBACEOUS ORNAMENTALS** *(continued)*

# 1 Pesticide Information

## 1.1 Pesticide Classification and Certification

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) created two classifications of pesticides – general-use and restricted-use. **General-use pesticides** may be purchased and used by anyone. **Restricted-use pesticides can** only be purchased by a certified applicator. Restricted-use pesticides must also be used by a certified applicator or someone under their supervision.

The same federal law that classifies pesticides divided applicators into two groups: private and commercial. **Private applicators** use or supervise the use of pesticides to produce agricultural commodities or forest crops on land owned or rented by the private applicator or their employer. A farmer must be certified as a private applicator in order to purchase and use restricted-use pesticides on agricultural commodities. (No certification is needed if a farmer does not use restricted-use pesticides.)

A **commercial applicator** uses or supervises the use of pesticides for any purpose or on any property not covered by the private applicator classification. In New York, a commercial applicator must be certified to purchase or use any pesticide whether it is general- or restricted-use.

Information about pesticide certification and classification is available from your Cornell Cooperative Extension office (cce.cornell.edu/localoffices), regional NYSDEC pesticide specialist (www.dec.ny.gov/about/ 558.html), the Pesticide Applicator Training Manuals (https://www.cornellstore.com/books/cornell-cooperative-ext-pmep-manuals), or the Pesticide Management Education Program (PMEP) at Cornell University (psep.cce.cornell.edu).

## 1.2 Use Pesticides Safely

Using pesticides imparts a great responsibility on the user to protect their health and that of others and to protect the environment. Keep in mind there is more to "pesticide use" than the application. Pesticide use includes mixing, loading, transporting, storing, or handling pesticides after the manufacturer's seal is broken; cleaning pesticide application equipment; and preparing a container for disposal. These activities require thoughtful planning and preparation. They are also regulated by state and federal laws and regulations intended to protect the user, the community, and the environment from any adverse effects pesticides may cause.

### 1.2.1 Plan Ahead

Many safety precautions should be taken *before* you actually begin using pesticides. Too many pesticide applicators are dangerously and needlessly exposed to pesticides while they are preparing to apply them. Most pesticide accidents can be prevented with informed and careful practices. **Always read the label on the pesticide container before you begin to use the pesticide.** Make sure you understand and can follow all directions and precautions on the label. Be prepared to handle an emergency exposure or spill. Know the first aid procedures for the pesticides you use.

### 1.2.2 Move Pesticides Safely

Carelessness in transporting pesticides can result in broken containers, spills, and contamination of people and the environment. Once pesticides are in your possession, you are responsible for safely transporting them. Accidents can occur even when transporting materials a short distance. You are responsible for a pesticide accident so take every effort to transport pesticides safely. Be prepared for an emergency.

### 1.2.3 Personal Protective Equipment and Engineering Controls

**Personal protective equipment** needs depend on the pesticide being handled. ***Required personal protective equipment (PPE) are listed on pesticide labels.*** The required PPE are based on the pesticide's toxicity, route(s) of exposure, and formulation. Label required PPE are the minimum that must be worn during the pesticide's use. Pesticide users can always wear more protection than the label requires.

The type of protective equipment used depends on the type and duration of the activity, where pesticides are being used, and exposure of the handler. Mixing/loading procedures often require extra precautions. Studies show you are at a greater risk of accidental poisoning when handling pesticide concentrates. Pouring pesticide concentrates from one container to another is the most hazardous activity.

**Engineering controls** are devices that help prevent accidents and reduce a pesticide user's exposure. One example is a closed mixing/loading system that reduces the risk of exposure when dispensing concentrated pesticides. Consult the product label for more information on using engineering controls in place of PPE.

### 1.2.4 Avoid Drift, Runoff, and Spills

Pesticides that move out of the target area can injure people, damage crops, and harm the environment. Choose weather conditions, pesticides, application equipment, pressure, droplet size, formulations, and adjuvants that minimize drift and runoff hazards. See product labels for specific application and equipment requirements.

# 2 Integrated Pest Management

## 2.1 Introduction

Integrated pest management (IPM) is a systematic approach to managing pests that focuses on long-term prevention or suppression with minimal impact on human health, the environment, and non-target organisms. IPM incorporates all reasonable measures to prevent pest problems by properly identifying pests, monitoring population dynamics, and using cultural, physical, biological, or chemical pest population control methods to reduce pests to acceptable levels. An upgrading of the facility may be the key to management of some pests. For example, building a screened cover for vents or heating the floor may solve pest problems. The site history determines an IPM strategy; correct pest identification and better understanding of pest biology are critical to successful IPM. With a long-term perspective it is easier to see that an investment in IPM can pay for itself in a higher-quality crop and a cleaner environment. In reality, all growers currently practice some level of IPM. It is a site-specific strategy for managing pests that relies on understanding pest biology.

## 2.2 Basics of Integrated Pest Management

Many floral crops require specific cultural conditions and preventive strategies for pest management. Learning to grow a crop may take several seasons of personal experience, absorbing the details from colleagues, suppliers, special classes, extension programs, and reading. Unique crop susceptibilities to insects and disease and the features of a particular greenhouse determine which IPM tools will be necessary, such as screening, seed or bulb treatment, careful examination of newly arrived stock plants, or ventilation to reduce humidity. Each operation must develop its own IPM strategy to produce high-quality crops and thrive economically. Continuous education is required as new pests, crops, and management techniques appear.

Through each year's experience and attendance at professional meetings, you will increase your understanding of the impacts of sanitation, early detection of pests, proper timing of sprays, and effective use of new products. You will adopt new IPM practices over time as you increase your knowledge and skill levels. Many of the methods incorporated in an IPM strategy are logical operating procedures and basic horticultural practices. The following methods will produce a healthier crop, prevent many pest problems, and isolate pests to smaller areas in the greenhouse: preseason cleanup, cultural practices in IPM, scouting, careful identification of pests, examination of plants upon arrival, and keeping records. The primary goal of IPM is to optimize pest management in an economically and ecologically sound way.

### 2.2.1 Preseason Cleanup

Before introducing a new crop into the greenhouse, it is extremely important to eliminate the pests from the previous crop. Remove all plant debris from the site and compost it to kill pathogens and insect and mite pests. Clean up spilled media on benches because it is likely to contain fungal spores, nematodes, or insect eggs, larvae, or pupae. Remove any weeds in the greenhouse by hand pulling or use an herbicide followed by removal. Please refer to Chapter 9- Weed Management in Greenhouses (and Table 9.2.1) before using an herbicide indoors and around the greenhouse to prevent damage to future crops. Clean the floor thoroughly. Next disinfest surfaces with a labeled product, being careful to wear goggles or other protective clothing as described on the label. Chlorine bleach may be used for pots or flats, but it is not approved for application to greenhouse walls, benches, or flooring. If using bleach, make up fresh solutions regularly because the active components will dissipate after two hours. If cut flowers are grown in ground beds, pasteurization of the soil by steam is recommended. See Table 2.3.2.

A fallow period of four weeks will reduce the pest load considerably, but having an empty greenhouse for even two weeks can help. The house should be free of both crops and weeds. To determine whether thrips, fungus gnats, or other insects are present, set up yellow sticky cards and indicator plants after watering all benches and the floor. Close up the greenhouse (turn on the heat to break dormancy in winter). Observe any insects that are trapped on the cards after two days.

### 2.2.2 Cultural Practices in Integrated Pest Management

Proper plant nutrition balance, water pH, and fertilizer salt concentration are critical to plant health. Many insects and diseases have an advantage when the plant is compromised by excess amounts of nitrogen, excess fertilizer salts in solution, or deficiencies in calcium or other nutrients. Floral crops differ in their temperature requirements; recording maximum and minimum temperatures will help determine whether the heating or cooling is set appropriately for the species grown. Appropriate growing conditions allow the plant to develop its natural resistance to the fullest. Plant defense mechanisms include the physical barriers of strong stems, sturdy cell walls, and waxy cuticle as well as the ability to manufacture toxic response compounds to discourage insect feeding and resist infection.

Testing water and nutrient solutions for pH and electrical conductivity (EC) has become an industry standard practice since it is easy and inexpensive. Problems can be detected before a major crop loss. Where a large volume of any species is grown, such as chrysanthemum, snapdragon, or

# 3 Effective Pesticide Use

## 3.1 Sources of More Information on Pesticides

More information about pesticides is available from your Cornell Cooperative Extension educator, from the *Pesticide Handbook* published by the Entomological Society of America, P.O. Box AJ, College Park, Md. 20740, and from the *MeisterPro Crop Protection Handbook*, Meister Media Worldwide, Willoughby, Ohio 44094.

## 3.2 Compatibility of Pesticides

Insecticides, miticides, and fungicides in this publication are compatible with each other if these following guidelines are followed:

- Read the pesticide label carefully for compatibility statements.
- Avoid mixing different kinds of formulations; for example, do not mix emulsifiable concentrates and wettable powders.
- Do not mix pesticides with oils before compatibility is determined.
- Most pesticides are not compatible with alkaline solutions.
- Never mix herbicides with other pesticides. Apply herbicides with spray equipment reserved for their use only.

## 3.3 Phytotoxicity of Pesticides

Pesticide injury to the crop (phytotoxicity) can be avoided by following the pesticide label. If you are unsure of the effect of a certain pesticide on a crop or on a particular variety, apply the pesticide to a few trial plants before making a widespread treatment.

## 3.4 Pesticide Shelf Life

Pesticides should be purchased in reasonable quantities so that it is not necessary to store them for considerable periods. Most commercial formulations will retain their effectiveness for two or more years if stored above freezing temperatures under dry conditions with the container properly closed.

The symptoms of ineffectiveness are listed in Table 3.6.1, but they may be useful in determining the value of your pesticide supply. A pesticide may be ineffective without showing these typical symptoms. If you are not sure that a pesticide supply is still effective, dispose of the material properly rather than take a chance.

**Table 3.5.1. Typical indicators of deterioration for six types of pesticide formulations**

| Formulation | General Symptoms of Ineffectiveness |
|---|---|
| Emulsifiable concentrate (EC) | When a milky formation does not occur with the addition of water; when an insoluble sludge and/or separation or layering of the EC occurs. |
| Oil spray | When a milky formation does not occur with the addition of water and/or when an oil slick forms on the water surface. |
| Wettable powder | When lumping occurs and the powder will not suspend in water. |
| Dust | When excessive lumping occurs. |
| Granular | When excessive lumping or disintegration occurs. |
| Aerosol | Generally effective until the opening of the aerosol can becomes obstructed and no longer sprays or until the container is emptied. |

## 3.5 Pesticide Formulations and Application Methods

The basic goal of pesticide application is to apply the pesticide to the target in a safe and efficient manner. Before purchasing a pesticide application machine, make critical comparisons of the equipment available. You should observe the equipment in operation and handle it yourself. The application equipment selected should be suited to the size of your operation. No one piece of equipment can adequately handle every situation you may encounter. Operators should check chemical labels for equipment guidelines or to see if there are any restrictions on equipment use. Pesticide label rates based on dilution in a certain volume of carrier could limit the use of low-volume spray equipment. Current information on equipment is available from your Cornell Cooperative Extension educator.

### 3.5.1 Hydraulic Sprayers

Hydraulic sprayers operate with dilute sprays and with changeable pressures up to several hundred pounds per square inch. In applying pesticides with a hydraulic sprayer, nozzles should be free of obstruction and have minimal wear on their openings; pressure should be maintained to achieve a fine spray, which will result in uniform coverage and desired canopy penetration.

Research results indicate that it is difficult for hydraulic sprayers to treat both the upper and undersides of leaf surfaces.

general-use lawn pesticides. Commercial applicators and owners of garden centers should become familiar with the law and regulations found on-line at www.dec.ny.gov/chemical/8529.html. Contact the local county government where you intend to apply pesticides to determine if they've opted in to the Neighbor Notification Law.

## 1.12 Pesticide Use on School and Day Care Center Grounds

New York State Education and Social Service laws restrict the use of pesticides on playing fields, playgrounds, and turf at schools and day care centers. These laws allow only the following pesticide products to be used on these sites:

- Antimicrobials;
- Insecticides used to protect individuals from an imminent threat of a stinging or biting insect packaged in an aerosol can 18 ounces or smaller;
- Non-volatile insect and rodent baits in tamper resistant containers;
- Products containing boric acid or disodium octaborate tetrahydrate;
- Horticultural oils and soaps that do not contain synthetic pesticides or synergists; and
- Pesticides classified as exempt by the US EPA (minimum-risk or 25(b) pesticides).

State law provides for emergency exemptions if it's determined an emergency pesticide application is needed. These exemptions must be approved by the appropriate entity (county health department, NYS Department of Health, NYS Department of Environmental Conservation, or a local school board) as defined in the law.

More information on these restrictions can be found in the final guidance document from the NYSDEC available online at: www.dec.ny.gov/chemical/41822.html.

### 4.2.4 Begonia

- **Damping-off:** Collapse of young plants may be caused by *Pythium*, *Rhizoctonia*, or *Botrytis* species.
- **Botrytis leaf spot:** Large, irregularly outlined brown leaf spots, particularly common on large plants given insufficient spacing; stems may also be invaded, leading to wilt of the cankered portion.
- **Powdery mildew:** Fuzzy white patches on leaves or flowers. In some cases, leaf tissue shows dark, greasy-looking spots beneath a sparse colony of powdery mildew. Begonias are highly susceptible.
- **Bacterial leaf spot (*Xanthomonas axonopodis* pv. *begoniae*):** Dark, greasy spots appear on leaves, or brown V-shaped dead areas develop at leaf margins. Spots are surrounded by a speckled or chlorotic zone of leaf tissue. With high temperatures, disease may progress until plants collapse. Certain Elatior begonias are particularly susceptible; Non-Stop begonias may show less extensive leaf spotting.
- **Foliar nematodes (*Aphelenchoides fragariae*):** Sunken gray-green blotches that turn reddish brown or black. Infected leaves may wilt, die, and hang limply from the plant. Elatior begonias are extremely susceptible to foliar nematodes.
- **Fusarium wilt (*Fusarium foetens*):** This new disease causes dulling of foliage, internal stem discoloration and cankers at the base of stems. All or part of the plant will collapse as a result.
- ***Impatiens necrotic spot virus* (INSV):** Yellow variegation or round brown spots in leaves, chlorotic mottling, brown streaking along veins, and brown patches in the leaf at the petiole end. Control of the vector, the western flower thrips, is essential.

### 4.2.5 Bulb Crops for Forcing

- ***Botrytis*:** Occasionally, when aeration is insufficient during forcing, *Botrytis* may cause lesions on foliage and cripple the expansion of leaves. Good cultural conditions prevent this problem. Bulbs and roots may also be affected.
- **Tulip fire (*Botrytis tulipae*):** Foliar lesions on tulip may be caused by a host-specific species of *Botrytis* introduced via sclerotia on diseased bulbs. Destroy infected plants and protect others with appropriate fungicides during foliage expansion.
- **Iris ink disease (*Mystrosporium adustum*):** Scales are blackened. Destroy bulbs in which fleshy scales are affected. Not common in North America.
- **Bulb rots (*Penicillium* sp., etc.):** Portions of bulbs are discolored, most often resulting from invasion of stressed tissue by weak pathogens. Avoid bruising or overheating during handling or storage. *Phytophthora* spp. may cause rotting of the stem, basal plate, and roots; bulb scales are not affected.
- **Gray bulb rot (*Sclerotium tuliparum*):** A dry rot with sclerotia sometimes evident.
- **Flower break or mosaic:** Interruption of flower petal color by white streaks or yellow mottling of foliage. Caused by virus infections. Aphid control is important for preventing spread.

### 4.2.6 Calceolaria (*Calceolaria herbeohybrida*, *C. integrifolia*)

- ***Impatiens necrotic spot virus* (INSV):** Pale patches in lower leaves enlarge and brown with time; young plants may be more severely affected. Control of western flower thrips is essential.
- **Stem or crown rot:** Stem collapse, possibly resulting from infection by *Botrytis* or *Sclerotinia sclerotiorum*.

### 4.2.7 Calibrachoa (*Calibrachoa* hybrids)

- **Pythium root rot:** Plants are stunted and may wilt. Roots are soft and mushy.
- **Phytophthora root rot:** Plants may grow normally until they suddenly wilt at flowering. The *Phytophthora* often attacks at the stem base.
- **Powdery mildew:** Lower leaves turn yellow, brown, and dry. This is a common problem, often misidentified.
- **Thielaviopsis root rot:** Plants are stunted, yellowed or purplish. Roots are also stunted and may be discolored. Infected plants will wilt. Very common on this plant.

### 4.2.8 Calla

- **Soft rot (*Pectobacterium carotovorum* or *P. aroideae*: previously called *Erwinia* spp.):** A soft, mushy, foul-smelling rot of rhizomes or stem bases. Cut out rotted spots before planting. Place rhizomes in separate containers and water individually if possible to reduce disease spread. Use a well-drained growing medium. Water sparingly.
- **Root rot (*Phytophthora* or *Pythium* spp.):** Roots are decayed back to the rhizomes.
- **Viruses:** Small plants, chlorotic foliar streaking, flower distortion. Discard affected plants.

### 4.2.9 Carnation (*Dianthus caryophyllus*)

***Note:*** For cut-flower carnations use culture-indexed plants, and steam-pasteurize or fumigate growing media and beds.

- **Fusarium wilt (*Fusarium oxysporum* f. sp. *dianthi*):** Stunting, wilting, foliar yellowing or browning, purplish vascular discoloration.
- **Rhizoctonia stem rot:** Brown canker at the soil line.
- **Alternaria leaf spot (*Alternaria dianthi*):** Ashy white spots with dark fungus spore structures on the center of older spots.
- **Bacterial wilt (*Pseudomonas caryophylli*):** Sudden wilting and drying of the top of the plant or of one branch. Vascular system shows yellow streaks. Root system also decays, and sticky cankered areas may

## 4.5.8 Cankers

**Where a concern:** On herbaceous ornamentals in greenhouse, nursery and landscape
**Time for concern:** Throughout production and in the garden
**Key characteristics:** Dieback is generally caused by fungi and is often more extensive when plants have been stressed by drought the previous growing season. Fungi causing leaf spots may in some cases infect stems as well. Bacterial cankers are more likely on woody ornamentals.

| *Management Option* | *Guideline* |
|---|---|
| **Cultural practices** | Attend to leaf spot diseases promptly. Avoid drought stress on crops. |
| **Environmental control** | Keep leaf wetness periods as short as possible by spacing plants and irrigating early in the day. |

**Compound(s)**
***Common name(FRAC Code)***

| Trade name | Use site(s)[1] | Comments |
|---|---|---|
| ***thiophanate-methyl (1)*** | | |
| *3336-F 42.5% | G, N, L | **Precautions for all thiophanate-methyl materials:** Do not use on Swedish ivy, Boston fern, or Easter cactus. **Rates:** Spray 16-32 oz/100 gal *OHP 6672 50 WP, *Nufarm T-Methyl SPC 50WSB; 16-24 fl oz/100 gal *3336-F; 14.5-20 fl oz/100 gal *OHP 6672 4.5F; or 16-20 fl oz/100 gal *Nufarm T-Methyl SPC 4.5F, all at a 7-14 day interval. Make drench applications for soilborne diseases at a dose of 0.5-2 pints/sq ft. . Cutting soak and bulb treatment information also on some labels. |
| *Nufarm T-Methyl SPC 4.5 F Fungicide | G, N, L | |
| *Nufarm T-Methyl SPC 50 WSB | G, N, L | |
| *OHP 6672 50WP | G, N, L | |
| *OHP 6672 4.5 F | G, N | |

[1] Key: G = greenhouse, L = landscape, N = nursery
* Restricted-use pesticide.

## 4.5.9 Cercospora Leaf Spot

**Where a concern:** Herbaceous ornamentals in greenhouse, nursery and landscape
**Time for concern:** Spring
**Key characteristics:** Leaf spots which are host-specific. Especially likely on pansies, violas.

| *Management Option* | *Guideline* |
|---|---|
| **Cultural practices** | Avoid wetting foliage; improve air circulation; scout for symptoms in plug trays and older crops. |
| **Environmental control** | Keep greenhouses at less than 85% relative humidity. |

**Compound(s)**
***Common name (FRAC Code)***

| Trade name | Use site(s)[1] | Comments |
|---|---|---|
| ***azoxystrobin (11)*** | | |
| Heritage | G, N, L | Spray 1-4 oz/100 gal as needed, with a 7 to 28 day interval. User should conduct small-scale tests to ensure safety when applying to plants not listed on the label. Conduct trials before using in a tank mix with any material. Do not use a silicone-based surfactant. For resistance management, do not make more than three sequential applications of Heritage; alternate with two applications of a non-strobilurin fungicide. Do not exceed 2 oz/100 gal on pansy. |
| ***azoxystrobin + benzovindiflupyr (11 + 7)*** | | |
| *Mural | G, N, NRL | Spray 4–7 oz/100 gal every 7 to 21 days. Make no more than 2 sequential applications (spray). Test before applying to young bedding plants. Injury has been seen on some Rieger begonias and African violets. Do not apply to leatherleaf fern or other ferns for cut foliage. |
| ***Bacillus amyloliquefaciens* D747 (*44*)** | | |
| Triathlon BA | G, N | This biological fungicide/bactericide is used as a foliar spray at 0.5-6 quarts/100 gal, applied as a spray to wet with minimal runoff every 3-28 days. Or use as a drench at 0.5 to 4.5 pints/100 gal on ornamentals or food crops every 14-28 days as needed. |

# 5 Biology and Management of Arthropod Pests of Greenhouses and Herbaceous Ornamentals

## 5.1 Introduction

Many species of insects and similar pests such as mites, slugs, and snails attack floriculture crops. Although it is beyond the scope of this publication to deal with every pest on an individual basis, information on the identification, type of damage, biology and life histories, and management strategies is given for several of the more common, general pests. Your Cooperative Extension educator can help you to identify these pests and can also help you to decide on appropriate control measures to be taken. Once you have identified the pest, are familiar with the biology and management information provided, and decide on chemical applications for control, see Section 5.6 for pesticides registered in New York State for options.

Growers who have successful pest control practices know how to identify the common pests and their damage, understand their biologies, and have their pest scouting and management strategies planned before crop production begins. They can therefore identify and respond to an infestation quickly and effectively. They also keep abreast of new developments in pest management. The following are a few suggestions for successful pest control.

Insofar as it is possible, crop production should begin in a greenhouse that is free of pests. Weeds should be eliminated at the beginning and throughout the duration of the crop. Incoming plant material should be inspected for pests or signs of their damage before placement into the production area if possible. Infested plants should be refused or isolated for pest control before placement into the production area. Once production begins, pests can gain entrance in a variety of ways, such as through open or unscreened vents, on plant material, or sometimes on clothing. A weekly routine of scouting plant material throughout all growing areas for signs of pests and their damage (a 10X hand lens can be indispensable for accurate identification), coupled with the weekly inspection of insect traps such as yellow sticky cards, can help detect infestations while they are small and more manageable. Control efforts should be implemented in a timely fashion.

The goal of chemical control is to deliver a sufficient amount of an effective pesticide to the target organism in order to cause its death or stop its damage. This statement contains several points that are important considerations for effective chemical control. (1) “Delivery”: The way that a pesticide is delivered, or applied, can greatly affect its efficacy. With many important pests, chemical control is more successful with application equipment that creates small pesticide droplets, distributes particles uniformly over the treated surfaces, provides good canopy penetration, and effectively covers the lower surfaces of leaves where many pests occur. The effectiveness of a pesticide application may also be enhanced if the pesticide used happens to have systemic or translaminar properties. The movement of systemic or translaminar pesticides in the plant may compensate somewhat for incomplete coverage.

(2) “Sufficient amount”: Obviously, the amount of pesticide used can affect its efficacy. The pesticide label is your guide for determining how much pesticide to use. For systemic insecticides placed in soil, be sure that irrigation water comes in contact with the granules to release the insecticide into the growing media to be taken up by the plant. The effectiveness of systemic insecticides can vary with the age of the plant and depends on how much insecticide is translocated to where the pests are. (3) “Effective pesticide”: Certain pesticides are effective against some pests but not others. For example, certain insecticides can be effective against mites, but often acaricides (miticides) are not very effective against insects. It is important to use an appropriate pesticide against each pest to avoid wasted time, money, and pesticide. The shelf life of a pesticide can also affect its efficacy. Consult the pesticide label or the manufacturer if you have a question regarding the shelf life of an insecticide. Of course, one of the major considerations with chemical control involves pesticide resistance in the pests. The misuse or overuse of effective pesticides can lead to problems with resistance and therefore the loss of yet another previously effective insecticide. Some considerations for managing resistance are presented later. (4) “To the target organism”: The target organism can refer to a certain pest species or, in many cases, a certain life stage of a pest species. Many pesticides are effective only against certain pests and often only against certain life stages. Pesticides applied against the wrong life stage are not likely to be very effective. This is one reason that it is important to know the correct identity of a pest as well as its life cycle and biology. Repeated applications may be necessary to gain control of pests that have overlapping life stages.

## 5.2 Biological and Integrated Control

The dwindling pesticide arsenal and other problems associated with overreliance on pesticides have created the need for new pest control strategies that are economical, effective, and integrated. Researchers at Cornell and around the world are investigating promising pest control methods that integrate cultural, physical, biological, and chemical control strategies for commercial flower production systems. The future of pest control in greenhouses involves integrated pest management (IPM) systems. Growers should stay abreast of developments in this area, and Cornell Cooperative Extension will continue to provide up-to-date information as it becomes available. Nonchemical control suggestions are provided in the following sections where appropriate.

## *Armored Scales*

### Introduction

Armored scales are usually smaller than soft scales, and their shapes vary between species, from circular to an irregular shape resembling an oyster shell. Color may vary with life stage, sex, and/or species, and may be shades of white, gray, red, brown, or green. These insects secrete a hard, waxy shield over their bodies. This shield may be separated from the body of armored scales, whereas it is inseparable from the body of soft scales.

### Identification

Some common armored scale pests of greenhouses and interior plantscapes include oleander scale, Boisduval's scale, San Jose scale, Florida red scale, fern scale, greedy scale, purple scale, and cactus scale. Identification of the common armored scales can be made by your Cooperative Extension educator or through the Insect Diagnostic Laboratory.

### Damage

It is very important to detect the early stages of an infestation to maximize control efforts. Besides detecting the actual insects on the plants, knowing the symptoms of an infestation on the plant is very important. Armored scales can produce either yellow or brown spots or streaks on the leaves. They can cause general yellowing of the foliage, poor growth, and incrustations of both stems and leaves. In very high populations they can cause twig dieback or even kill the plant. Unlike mealybugs and soft scales, armored scales do not produce honeydew.

### Biology

Aspects of the biology and life cycle can vary significantly between species, but the following may be considered a generalized biology: The eggs are produced next to the female underneath her scale cover or shield. Some species give birth to living young. Females can produce anywhere from 20 to 400 eggs. These eggs hatch into crawlers, the stage that is susceptible to insecticides. Natural mortality of crawlers without an insecticide is rather high. Crawlers move a short distance from where they were hatched and find a suitable place to settle down and feed. They do not move again for the remainder of their lives. Females pass through two nymphal stages before adulthood. Males pass through two additional short pupal or resting stages. The tiny winged males do not live long. Females begin to produce eggs after mating. The entire life cycle can take anywhere from 60 to 120 days to complete, depending on temperature and the species. Several generations may occur during the year, with all life stages present at any one time.

## *Soft Scales*

### Identification

Soft scales can be fairly large (2-5 mm) and usually have a circular or oval shape. Colors are usually shades of gray or brown, and some species appear black. The shield cannot be detached from soft scales. Common species include black scale, soft brown scale, hemispherical scale, and Niger scale.

### Damage

Soft scales can produce distorted foliage from their feeding on young tissue, cause the leaves to turn yellow, and in high populations can cause twigs and branches to die back. Soft scales (and mealybugs) produce a sugary excretory product called honeydew, which can fall onto leaves and cause them to become shiny and sticky. Honeydew can support the growth of unsightly sooty mold. The presence of honeydew and sooty mold is a good indication of an infestation. Because ants are attracted to honeydew, their presence on the plants may also signal an infestation.

### Biology

A generalized life cycle for soft scales is fairly similar to that of armored scales. Eggs, or living young, are produced beneath the female's body, and females can produce more than 1,000 eggs. Crawlers hatch after one to three weeks, crawl over the leaf and stem for several days, and find a suitable feeding site at which they remain through adulthood. As with armored scales, the crawler stage is the most sensitive to mortality factors such as insecticides. Females progress through a total of three to four immature stages before adulthood; males pass through four immature stages. Adult males emerge as tiny, delicate, winged insects that live only a few days. There is roughly a 40- to 80-day life cycle depending on factors such as host plant, temperature, and species. All life stages may be present at any one time.

## *Mealybugs*

### Identification

Mealybugs are small (1-8 mm long), elongate-oval, soft-bodied insects that are not covered by a hardened cover or shield but with a layer of white, cottony wax. They can be found infesting all parts of a plant, including roots. Some produce short, spine-like filaments along the margins of their bodies, and on some species the posterior filaments can be quite long. Some mealybug pests of greenhouse crops include the citrus mealybug, obscure mealybug, and long-tailed mealybug. Your Cooperative Extension educator or the Insect Diagnostic Laboratory at Cornell can help you with identification.

### Damage

Mealybug infestations can cause leaf distortion, particularly on new growth. Some species inject a toxin as they feed that can produce necrotic areas, general yellowing, or leaf drop. They produce honeydew that can support the growth of sooty mold. Their production of white cottony wax and their very presence on leaf axils or undersides of leaves detract from the appearance of the plant. Again, because ants can be attracted to honeydew as with soft scales, their presence may signal a mealybug infestation.

## 5.6.25 Shore Flies

**Where a concern:** Greenhouse, herbaceous ornamentals in nursery and landscape

| **Compound(s)** ***Common name (IRAC Code)*** Trade name | Use Site(s) | Comments |
|---|---|---|
| ***azadirachtin (unknown)*** | | |
| AzaGuard | shadehouse, greenhouse, interiorscapes, nursery, commercial landscapes | Acts as an insect growth regulator and does not control adult insects. However, it also has repellency towards some adult insect species. See label for specific rates and instructions. Use as a foliar spray or a drench. May be applied using any powered or manual pesticide application equipment, including but not restricted to high-volume, low-volume, ultra-low volume, electrostatic, fogging, and chemigation. May be used on greenhouse food crops. Will break down in spray tank mixtures that have pH values exceeding 7.0. The optimum pH for application is a range of 5.5 to 6.5. If needed, the pH can be adjusted by use of a suitable buffering agent. Always use this product promptly after mixing with water. |
| Azatin O | indoor and outdoors use on ornamentals, vegetables, and other horticultural crops | Insect growth regulator that may be applied by high or low volume application equipment, drenches, or via chemigation. Follow label directions. |
| Molt-X | greenhouses, shadehouses, nurseries, landscape | Larvae. Molt-X is an insect growth regulator and does not control adult insects. However, Molt-X is also effective as a repellent towards adults of some species. Controls insects in the larval, pupal, and nymphal stages by interfering with the metabolism of ecdysone. For use as a drench. Molt-X will break down in the spray solution if not used within 8 hours. Molt-X will break down in spray tank mixtures that have pH values exceeding 7.0. The recommended pH range is between 5.5 and 6.5. Apply when insects appear or feeding is noticed. If needed, the pH of the water can be adjusted by use of a suitable buffering agent. See label for specific rates and instructions. |
| Ornazin 3% EC | greenhouse, shadehouse, interiorscape, nursery, outdoor ornamental | Product is an insect growth regulator and does not control adult insects. However, the product is also effective as a repellent towards some adult species. May be applied using any powered or manual pesticide application equipment, including but not restricted to high-volume, low-volume, ultra-low volume, electrostatic, fogging, and chemigation. Will break down in spray tank mixtures that have pH values exceeding 7.0. The optimum pH for application is a range of 5.5 to 6.5. May use a buffering agent to adjust pH. Follow label directions. |
| ***chlorpyrifos (1B)*** | | |
| *Duraguard ME | commercial greenhouses and nurseries | Do not use on kalanchoes. Can be applied as a foliar spray and as a coarse spray to soil surface. Direct treatment to some open blooms may cause petal drop. See label for plant list, specific rates, and instructions. |
| ***chlorpyrifos + cyfluthrin (1B + 3A)*** | | |
| *Duraplex TR | commercial greenhouses only | Labeled for use as a total release spray. May be used on bedding plants, cut flowers, hanging baskets, foliage plants, flowering plants, and ornamentals. For best results, apply during early evening when foliage is dry and temperature is between 60-80°F. See label for specific rates and instructions. |
| ***cyromazine (17)*** | | |
| Citation | landscape, container-grown, greenhouses, lath and shadehouses | For control of fungus gnat larvae in all listed sites and use for shore flies in greenhouse ornamental crops and interiorscapes only. Product is an insect growth regulator and will not kill adult insects. Rotate with insecticides that have different modes of action for leafminer control. Product comes in water-soluble bags. See label for specific rates and instructions. |

# 6 Weed Management for Herbaceous Ornamentals

## 6.1 Weed Management Options

This guide is intended to help the commercial grower and landscaper choose a safe and effective weed management program for herbaceous ornamentals. Every attempt has been made to provide updated information on the currently registered herbicides. It is the applicator's responsibility, however, to check the most current state and federal registration information and to read and follow label directions.

Weed management is an integral and important part of all commercial production of herbaceous ornamentals. Weeds compete and interfere with plant growth and devalue the yield and quality of landscape-, container-, and field-grown ornamentals. It is important to develop a weed control strategy that uses all the available options at your disposal. These include preventive measures such as organic and inorganic mulches, preemergence herbicides, and sanitary practices that prevent weed seeds and vegetative parts from spreading. This is especially important in container operations where the potting medium is often soilless and initially weed-free.

Several pictorial guides and botanical identification keys are available to identify the most common weeds. It is essential to know the correct names to understand herbicide labels and control guidelines. Most weeds that infest ornamentals have one of four life cycles: summer annuals, which emerge in the spring, flower, and set seed before the first frost; winter annuals, which germinate at the end of the summer and overwinter as small dormant but green plants; biennials, which are similar to winter annuals but germinate earlier in the summer; or perennials, which survive more than two seasons and can propagate by seed or vegetative reproduction. Knowing the weed life cycle is key to determining the optimal timing of an herbicide application or cultural practice. It is important to scout the weed population during and after the growing season to assess the success of the weed control program. For instance, at the end of the season in the fall, escaped summer annuals and some perennials will be dead but can be identified by their characteristic "skeletons." Escaped winter annuals, biennials, and most perennial weeds will survive the winter as dormant rosettes, crowns, or underground rhizomes.

Several herbicides are available that can be used safely and legally to control weeds in herbaceous ornamentals. Herbicides are commonly classified by their mechanism of action and use pattern. Preemergence herbicides are applied before weeds emerge and generally provide residual control of weed seedlings for several weeks.

Postemergence herbicides, applied after the weeds have emerged, are of two types. *Contact herbicides* kill only the portion of the plant with which the herbicide actually comes in contact. Good spray coverage is important when using contact herbicides. *Systemic herbicides* are absorbed and move through the plant. These are useful for controlling the creeping roots and rhizomes of perennial weeds. With systemic herbicides, the weeds must be actively growing so that the herbicide can be fully translocated. The post emergence herbicides that are labeled for herbaceous ornamentals are nonresidual and have little or no soil activity.

In many situations, herbicides cannot be used or are not effective in controlling all the weeds. In these cases, cultivation and hand pulling are often the only available options. There are two important facts to remember about mechanical cultivation. Hoeing and tilling will control small annual weeds fairly well. However, successive flushes of germinating weeds, stimulated by the cultivation itself, need to be controlled on a two- to three-week cycle. Once residual herbicides are applied and activated with water, they need to be in intimate contact with the germinating weed seedlings to work well. Mechanical cultivation will often destroy this contact.

Hand pulling is often an important, if backbreaking, component of a weed management program. It should be considered when no other cultural or herbicide options are available and when weeds are present, that will disperse their seed by wind to weed-free areas.

## 6.2 Types of Herbaceous Ornamentals

Plant species that are listed on herbicide labels have been tested by independent researchers and approved or registered by state and federal agencies. Because of the great number of herbaceous species, it is possible to test only a small fraction of all plants that are commercially grown. Table 6.7.1 contains information regarding herbicides that are currently registered on herbaceous ornamentals, and Tables 6.7.2 and 6.7.3 contain information about efficacy.

Spring-flowering bulbs that are planted in the fall can be treated with preemergence herbicides shortly after planting and again in the spring. If the planting is late, herbicides can be applied in early spring before summer annual weeds germinate.

Annual bedding plants are generally seeded in the greenhouse and transplanted in the landscape bed in midspring. In most cases, preemergence herbicides should be applied after transplanting to weed-free soil and then irrigated in. Research has shown that cultivars of a species can respond differently to the same herbicides. If possible, always test any herbicide on a small area first.

Perennials are propagated in several ways – e.g., seed, transplants, vegetative division – and are grown in the landscape as well as containers and the field. Most preemergence herbicides should be applied soon after transplanting.

Cut flowers are usually started from transplants, divisions, or tubers but sometimes are grown in the field from seed. For the most part, preemergence herbicides should be

## Barricade

*Common Name:* prodiamine

*Formulations:* *65WG, 4FL

**Uses:** Selective preemergence residual control of many annual grasses and broadleaf weeds in landscapes, field-grown nursery stock, container-grown nursery stock, Christmas trees, and established turfgrass (excluding golf course putting greens), lawns, and sod nurseries.

| | *Amount of active ingredient* | *Amount by formulation* | |
|---|---|---|---|
| | | *65WG | 4FL |
| ***Per Acre*** | 0.65 to 1.5 lb. | 1 to 2.3 lb. | 21 to 48 oz. |
| ***Per 1,000 sq. ft.*** | | 0.37 to 0.83 oz. | 0.5 to 1.1 oz. |

**Major Weeds Controlled**: Annual grasses such as crabgrass, goosegrass, foxtails, barnyardgrass, and johnsongrass (from seed). Some annual broadleaf weeds such as carpetweed, chickweed, shepherdspurse, prostrate spurge, lambsquarters, and pigweed.

**Major Weeds Not Controlled**: Established weeds, perennial grasses, and large-seeded broadleaf weeds. Weak on galinsoga, common groundsel, ragweed, nightshades, and velvetleaf. High application rates are required for prostrate knotweed control.

**For Best Results**: Incorporated with ½ inch of rainfall or irrigation or with shallow cultivation as soon as possible after application. Incorporation should not be delayed more than 14 days after application. Irrigation or rainfall soon after application is necessary to activate herbicide and to wash residual off foliage. May be applied to shadehouses and uncovered polyhouses (must remain uncovered for 7 days).

**Cautions and Precautions**: On landscape ornamentals, no more than 1.5 lb. AI per acre may be applied. In newly planted nursery stock or landscapes, delay applications until the soil has settled around the base of the plants. This is especially important in transplant beds.

**Residual Activity**: Season-long annual grass control is provided in many situations. Control of many broadleaf weeds will be shorter.

**Volatility and Leaching Potential**: Photodecomposition and volatilization occur when the product remains on the surface for prolonged periods without incorporation. Strongly adsorbed by soil; not readily leached.

**Symptoms and Mode of Action**: Absorbed through roots and inhibits root and shoot growth through interference with cell division.

**Manufacturer:** Syngenta

**EPA Reg. No.:** *Barricade 65WG: 100-834
Barricade 4FL: 100-1139

*65 WDG only: Restricted-use pesticide; may be purchased and used only by certified applicators or used by someone under the direct supervision of a certified applicator.

**Table 6.7.2. Weed susceptibilities to PREemergence herbicides.**

| **KEY:**<br>ful =Full control is expected.<br>par =Partial control is expected. | | Barricade | Biathlon | *†Dacthal | Devrinol | *ΔDimension | Pendulum | *†Pennant Magnum | *Ronstar | Surflan | Treflan | XL 2G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Genus, species** | **Common name** | | | | | | | | | | | |
| **Broadleaves** *(continued)* | | | | | | | | | | | | |
| *Trifolium pratense* | clover, red | | | | | | | | | | | |
| *Trifolium procumbens* | clover, hop | | | | | | ful | | | | | |
| *Trifolium repens* | clover, white | | | | | | | | | | | |
| *Urtica dioica* | nettle, stinging | | | | | | | | | | ful | |
| *Urtica urens* | nettle, burning | | | ful | | | | | | | | |
| *Veronica arvensis* | speedwell, corn | | | | | ful | ful | | | | | |
| *Veronica persica* | speedwell, Persian/birdseye | ful | | | | | | | | | | |
| *Veronica* spp. | speedwell species | | | | | | | | ful | | | |
| *Xanthium strumarium* | cocklebur, common | | | | | | | | | | | |
| **Grasses and Sedges** | | | | | | | | | | | | |
| *Avena fatua* | oats, wild | | | | ful | ful | | | ful | ful | ful | ful |
| *Avena sativa* | oats, volunteer | | | | | | | | | | | |
| *Barbarea vulgaris* | rocket, yellow | | | | | | | | | | | |
| *Bromus catharticus* | rescuegrass | par | | | | ful | | | | | | |
| *Bromus mollis* | brome, soft | | | | ful | ful | | | | | | |
| *Bromus rigidus* | brome, ripgut | | | | ful | ful | | | ful | | | |
| *Bromus secalinus* | brome, cheat | | | | ful | ful | | | | | ful | |
| *Bromus tectorum* | brome, downy | | | | ful | ful | | | | | | |
| *Cynodon dactylon* | bermudagrass | | | | | | | | | | | |
| *Cyperus compressus* | sedge, annual | | | | | | | ful | ful | | | |
| *Cyperus esculentus* | nutsedge, yellow | | | | | | | ful | | | | |
| *Dactylis glomerata* | orchardgrass | | | | | | | | | | | |
| *Digitaria ischaemum* | crabgrass, smooth | ful | | ful | ful | ful | ful | ful | ful | ful | ful | ful |
| *Digitaria sanguinalis* | crabgrass, hairy/large | ful | ful | ful | ful | ful | ful | ful | ful | ful | ful | ful |
| *Echinchloa crus-galli* | barnyardgrass | ful | ful | par | ful | ful | ful | ful | par | ful | ful | ful |
| *Eleusine indica* | goosegrass | ful | ful | par | ful | ful | ful | ful | ful | ful | ful | ful |
| *Elytrigia repens* | quackgrass | | | | | | | | | | | |
| *Eragrostis* spp. | lovegrass/stinkgrass | ful | | ful | ful | | par | | | ful | ful | ful |
| *Festuca arundinacea* | fescue, tall | | | | | | | | | | | |
| *Hordeum jubatum* | barley, foxtail | | | | | ful | | | | | | |
| *Hordeum leporinum* | barley, wild/hare | | | | ful | ful | | | | | ful | |
| *Hordeum pusillum* | barley, little | | | | | ful | | | | ful | | ful |
| *Hordeum vulgare* | barley, volunteer | | | | | ful | | | | | | |
| *Leptochloa uninervia* | sprangletop, red | ful | ful | | ful | | ful | ful | | ful | ful | ful |
| *Lolium multiflorum* | ryegrass, Italian/annual | | | | ful | ful | | | | | | ful |
| *Lolium perenne* | ryegrass, perennial | | | | | ful | | | | | | |
| *Panicum capillare* | witchgrass | ful | | ful | ful | | ful | ful | | ful | ful | ful |
| *Panicum dichotomiflorum* | panicum, fall | ful | ful | | ful | | ful | ful | ful | ful | ful | ful |
| *Phalaris canariensis* | canarygrass | | | | | | | | | | | |
| *Phleum pratense* | timothy | | | | | | | | | | | |
| *Poa annua* | bluegrass, annual | ful | ful | par | ful | ful | ful | ful | ful | ful | ful | ful |
| *Poa pratensis* | bluegrass, Kentucky | | | | | | | | | | | |
| *Setaria faberi* | foxtail, giant | ful | | | ful | | ful | ful | | ful | ful | ful |

# 7 Weed Management in Greenhouses

## 7.1 Weeds in the Greenhouse

Weeds such as creeping wood sorrel (*Oxalis corniculata*), hairy bittercress (*Cardamine hirsuta*), prostrate spurge (*Euphorbia humistrata*), and others are persistent problems in greenhouses. Wood sorrel, in particular, can rapidly spread throughout a greenhouse crop. Dehiscent seed pods which disperse seeds by propulsion allow seed to be spread throughout the greenhouse. Not only do these weeds detract from the perceived quality of plants produced, but some are also known to harbor insects such as whiteflies, mites, and thrips. Therefore, the removal of weeds from greenhouse pots, benches, and floors is important for aesthetic and pest management reasons. Several options are available to the greenhouse manager for controlling these pests. The first and most important control measure is sanitation. Keep weed propagules out of the greenhouse by using pasteurized soil or other seed-free growing media, introduce only "clean" plant materials, and use management strategies to control weeds outside of the greenhouse. Where possible, screening vents and windows will limit the introduction of wind-blown seed as well as insect movement. Concrete, gravel or mulched floors will also limit weed establishment. Despite these measures, some weeds will get into the greenhouse. These should be removed manually or by herbicide treatment before seed set. If the weeds are already established in the greenhouse they can be killed by (1) manual removal, (2) emptying the range and allowing the weeds to desiccate, or (3) using a postemergence herbicide (see Table 7.2.1). Each method will remove only the vegetation that is present; it does nothing to prevent reestablishment from seed that is present. Continuous removal can be expensive and time consuming. Currently, no residual herbicides are labeled for greenhouse use. Where weeds are a continual problem, clean up the area, remove soil and organic matter, or cover soil with gravel or mulch. Geotextile fabrics covered by gravel (or other mulches) have been successfully used in many greenhouses. Only under extremely rare circumstances would fumigation be recommended for weed control.

Slimes, algae and molds are not weeds, but their growth may also be a nuisance in the greenhouse. These organisms can establish in pots, beds or walkways under damp conditions. Surface growth of bacteria, algae or fungi may interfere with water penetration into growing media or create unsafe footing in walkways. New products that destroy membrane integrity of slimes and moldsare now available for enhanced control of these infestations both inside and outside the greenhouse.

## 7.2 Chemical Control of Greenhouse Weeds

A few herbicides are currently labeled for use inside greenhouses in New York State (see Table 7.2.1). There are very specific restrictions on the use of herbicides in greenhouses. Read the label and carefully observe any precautions. When applying any herbicide, the greenhouse should be well ventilated (but not so strongly that air currents will cause drift) or empty at the time of treatment. Although organic-type products, such as acetic acid herbicides, are now available for use outside the greenhouse, they are not labeled for use in the house. These products should be applied only external to the greenhouse, but with the same precautions: greenhouse windows and vents should be closed during external application to minimize drift and volatility issues.

## 7.3 Outside the Greenhouse

The primary objective of weed control outside the greenhouse is to eliminate a major source of airborne weed seed that can enter through doors or vents. Perennial weeds such as quackgrass or bindweed may also grow under the foundation and enter the greenhouse through openings or cracks. Many options are available for controlling these weeds outside the greenhouse. Mowing carefully around the greenhouse and perimeter will prevent the majority of weeds from setting seed. However, a vegetation-free strip is recommended immediately adjacent to the foundation. After application of a systemic herbicide such as Round Up Pro, use a geotextile fabric covered with gravel or other inorganic mulch to suppress annual and perennial weed growth. As an alternative to the geotextile or as a supplement when weeds grow in the mulch, postemergent and soil residual herbicides may be used. Treflan, Surflan (oryzalin), and others are often used successfully for short-term annual grass control. Apply Surflan with a calibrated sprayer to achieve a dosage of 2 to 4 lb. AI/A. Surflan may also be mixed with either *ΔReward or Roundup to obtain both pre- and post-emergent weed control. It is generally inadvisable to use auxin-type herbicides, such as those labeled for broadleaf weed control in turf, near greenhouses because of their volatility and the exceptional sensitivity of greenhouse crops to phenoxy herbicides. When spraying weeds around the greenhouse it is best to close windows and vents to prevent spray drift from entering the greenhouse. Vents and windows may be opened almost immediately after spraying.

Because no herbicide will provide complete control, some escapes will occur. Supplement the herbicide treatments with manual removal to keep the greenhouse clean. When sanitation, mulching, postemergence herbicide application, and manual weed removal are combined in a comprehensive weed management program, weed pressure will be reduced, thus resulting in less time spent removing weeds and lower costs for production. In addition, control of weeds under the benches will likely prevent weed infestation in plants growing on the benches and reduce other associated problems such as whitefly, mite, and thrips infestation. Try to prevent weeds in outdoor locations near the greenhouse from setting seed; frequent mowing will aid in prevention of seed formation and dissemination.

# 8 Growth Regulation of Greenhouse Crops and Herbaceous Ornamentals

## 8.1 Introduction

Growth regulation is the use of chemical or cultural techniques to alter plant form. This section discusses several aspects of crop growth regulation, such as promotion of growth and flowering, controlling plant height, promotion of branching, defoliation, and promoting longevity. Chemical plant growth regulators (PGRs) are regulated as pesticides in New York State by the Department of Environmental Conservation.

## 8.2 Chemical Growth Regulators

A chemical plant growth regulator is a natural or synthetic chemical substance that in very small quantities regulates or controls some aspects of plant growth, such as stem length, rooting, flowering, leaf abscission, fruiting, and winter hardiness. Regulators either promote or retard plant growth and development, depending on the chemical chosen and the concentration used.

In commercial production of greenhouse crops and herbaceous ornamentals, PGRs are used primarily to enhance rooting of cuttings, control plant size (i.e. growth retardants), and induce branching. Growth retardants may be primarily used to reduce stem elongation but sometimes also have the desirable effects of strengthening stems and and darkening foliar color. Depending on the product, PGRs may be applied as a spray on the foliage, as a drench to the root substrate, or as a dip for bulbs or cuttings. Table 8.12.1 summarizes label-approved uses of growth-regulating chemicals.

PGRs are not substitutes for good cultural practices. When intelligently used, however, they cut labor and overall production costs and create a better crop than could be achieved otherwise. Categorization of chemicals as stimulants or retardants of plant growth and development is not absolute. For example, ethylene occurs naturally in plants. Low concentrations may promote rooting of cuttings when used in combination with auxins. Elevated concentrations reduce postharvest life of floral crops, distort foliage of growing crops, retard elongation of some bulb crops, induce flowering of bromeliads, promote branching and retard flowering of stock plants of geraniums, and cause leaf abscission.

It should be noted that height management must take place while a plant is actively growing/elongating. Chemical growth regulators cannot be used to reduce the existing size of a plant, only to promote or reduce future growth. Because of the potentially detrimental effects of growth regulators on the crop (phytotoxicity of leaves or flowers), the environment, and the grower, label instructions should be read and followed carefully. When using a material for the first time on a crop or under unique environmental conditions, always conduct trials to determine optimal rates as indicated on the labels. Purchase growth regulators only in required quantities to ensure fresh stocks of chemicals. Consult the label for storage instructions. Once mixed with water, chemicals should be used immediately because solutions deteriorate if stored. ALWAYS CONSULT THE CHEMICAL LABEL FOR SPECIFIC INSTRUCTIONS ON APPLICATION.

## 8.3 Growth Promotion

Growth is an irreversible increase in plant size. This increase can be accomplished in several ways, including elongation of cells and stems, thickening of leaves, and addition of branches. For greenhouse crops, growth promotion usually refers to promotion of cell elongation. Rarely are extraordinary steps taken to promote growth. Providing an optimal growing environment usually is sufficient.

Several factors promote stem elongation:

- An optimal growing environment (warm temperature) increases the number of nodes on a stem.
- Low light (shady) conditions
- Excessively long production schedules which provide more time for crop growth.
- Long or short day lengths (for photoperiodic crops). For short day plants (those induced to flower under daylengths less than 12 hours); a long day length increases the number of nodes present at first flower. For long day plants (those induced to flower under daylengths greater than 12 hours); a short day length increases of the number of nodes present at first flower.
- Warm day temperatures and cool night temperatures (referred to as a positive DIF)
- Cold treatment. For some crops, vegetative dormancy is broken; growth for crops such as bleeding heart is promoted.
- Chemical Gibberellin application. Internodes are elongated; high doses may also distort growth or cause weak stems.

## 8.4 Chemical Growth Promoters

Auxins, some of which are found naturally in plants, are a group of growth regulators that promote root initiation and branching as well as promote growth in cell length. Plants may react to auxins in other ways such as fruit development without pollination, and fruit thinning. Indoleacetic acid (IAA), indolebutyric acid (IBA), naphthaleneacetic acid (NAA), and phenoxyacetic acids (e.g., the herbicide 2,4-D) are auxins. Several hormone products that promote root formation are registered for use in New York State. These products are available at different chemical strengths. Consult product labels for specific instructions. See Table 8.12.1. Historically these products have been used as powder for dipping the basal portion of cuttings. When dipping cuttings in a rooting product, transfer enough material for one use to a separate container. Discard

include: chrysanthemum, poinsettia, cosmos, and zinnia. Long-day plants flower sooner under a long day-length, examples include: many pansy and petunia cultivars.

Applying growth regulators sometimes also promotes flowering (Table 8.12.1). Chemical promotion occurs in one of several ways: ethylene supplied by Ethephon materials (*Collate, SA-Florel, Pistill) directly induces flowering on bromeliads and aroids such as Calla lily and spathiphyllum; gibberellin (GibGro, ProGibb) can break dormancy of certain rosette plants that normally require cold treatment to induce flower shoot growth; several growth retardants can promote uniform flower bud initiation of Florist's azalea.

## 8.9 Management of Flower Size

A flower grows larger if immediately adjacent flowers in a spray are removed when the buds are young (about pea-sized). Disbudding to a single flower on a stem is performed manually on some cultivars of crops such as carnation, chrysanthemum, and rose.

In some cases, chemical growth regulators can promote a larger flower size. For certain plants the application of gibberellin containing products (ProGibb, GibGro) promotes cell expansion and thus final flower size. The synthetic cytokinin 6-benzyladenine (Configure) can promote an increase in the number of flower buds in Christmas cactus (Schlumbergera spp.). A formulation of gibberellin and benzyladenine (Fascination) can be used to promote bract size in poinsettia.

## 8.10 Suppression of Senescence

Leaves, flower buds, and flowers can sometimes be retained on plants and cut flowers longer with chemical treatment. Leaf yellowing after storage, flower bud drop, and deterioration of open flowers is delayed in some crops by application of an inhibitor of ethylene action (EthylBloc) or gibberellin/benzyladenine formulation (Fascination).

## 8.11 Crop Defoliation

Crop defoliation is sometimes desirable for prevention of disease during storage. This procedure is also used to store rose bushes and dormant hydrangea plants. Ethylene (apple) gas, ethylene-generating products such as SA-Florel/Pistill (see Table 8.12.1), and several other chemicals have been successfully used for this purpose.

## 8.12 Growth Regulators for Greenhouse Crops and Herbaceous Ornamentals

**Table 8.12.1. Growth regulators for greenhouse crops and herbaceous ornamentals**

| Common Name | Brand Name | Formulation | EPA Reg. No. | REI§ |
|---|---|---|---|---|
| ***Defoliation*** | | | | |
| **ethephon** | *Collate | 21.7% F | 85678-9-82917 | 48 |
| | Southern Ag Florel | 3.9% L | 264-263-829 | 48 |
| | *Verve | 21.7% L | 228-660 | 48 |
| Registered crops: greenhouse, shade house, and field-grown floriculture crops | | | | |
| Registered method of application: spray | | | | |
| Registered rates of application: determine optimal rates through trials as specified on the labels; see label for rates and methods for rose. | | | | |
| ***Promoters of Stem Elongation*** | | | | |
| **gibberellic acid** | GibGro 4LS | 4% L | 55146-62 | 4 |
| | N-LARGE | 4% L | 57538-18 | 4 |
| | ProGibb T&O | 4% L | 73049-15 | 12 |
| Registered crops: ornamental crops, bedding plants, annual and perennial potted crops, field grown ornamentals and bulb crops, cut flowers, and turfgrass | | | | |
| Registered methods of application: spray | | | | |
| Registered rates of application: determine optimal rates through trials as specified on the labels; see label for rates and methods for pompom chrysanthemum peduncles, and stems of aster, delphinium, larkspur, Queen Anne's lace, stock, and sweet william and additional cut flowers. | | | | |
| **benzyladenine + gibberellins A4A7** | Fascination | 1.8%+1.8% L | 73049-41 | 4 |
| Registered crops: bedding plants, annual and perennial potted crops, bulb crops | | | | |
| Registered method of application: spray | | | | |
| Registered rates of application: determine optimal rates through trials as specified on the labels | | | | |

# 10 Pesticide Index

## 10.1 Fungicides and Bactericides

**Table 10.1.1. Fungicides and bactericides mentioned in this publication ordered by trade name.**

| Trade Name | Active Ingredient | EPA Reg. No. | REI (hours) | FRAC Code | Organic-approved |
|---|---|---|---|---|---|
| *26GT (Bayer) | iprodione | 432-888 | 12 or 24 | 2 | |
| *3336 DG Lite | thiophanate-methyl | 1001-70 | 12 | 1 | |
| *3336-F | thiophanate-methyl | 1001-69 | 12 | 1 | |
| *6672 4.5F | thiophanate-methyl | 59807-5 | 12 | 1 | |
| *6672 50WP | thiophanate-methyl | 59807-6 | 12 | 1 | |
| Actino-Iron | *Streptomyces lydicus* WYEC 108 | 73314-2 | 4 | NC | |
| Actinovate SP | *Streptomyces lydicus* WYEC 108 | 524-641 | 4 | NC | OMRI |
| *Adorn | fluopicolide | 59639-141 | 12 | 43 | |
| Affirm WDG | polyoxin D zinc salt | 68173-3-1001 | 4 | 19 | |
| *Agri-Fos | Mono- and di-potassium salts of phosphorous acid | 71962-1 | 4 | 33 | |
| *Agri-Mycin 17 | streptomycin | 55146-96 | 12 | 25 | |
| Aliette WDG Brand Fungicide | fosetyl-Al | 432-890 | 12 | 33 | |
| *Alsa Propiconazole 14.3 EC | propiconazole | 64014-14 | 12 | 3 | |
| Alude 53.6% | phosphite | 55146-83 | 4 | 33 | |
| *Areca | aluminum tris (O-ethyl phosphonate) | 53883-320-59807 | 12 | 33 | |
| *Armada 50WDG | triadimefon and trifloxystrobin | 432-1513 | 12 | 3 + 11 | |
| Asperello T34 Biocontrol | *Trichoderma asperellum* T34 | 87301-1-91594 | 4 | NC | |
| *Astun | isofetamid | 71512-23-59807 | 12 | 7 | |
| Aviv | *Bacillus subtilis* IAB/BS03 | 91473-1-86182 | 4 | 44 | OMRI |
| Banner MAXX II | propiconazole | 100-1326 | 12 | 3 | |
| Banol Turf and Ornamental Fungicide | propamocarb | 432-942 | 24 | 28 | |
| *Banrot 40 WP | etridiazole + thiophanate-methyl | 58185-10 | 12 | 14+1 | |
| *Banrot 8G | etridiazole + thiophanate-methyl | 58185-23 | 12 | 14+1 | |
| *†Broadform | fluopyram + trifloxystrobin | 432-1537 | 12 | 7+11 | |
| Camelot O | copper octanoate | 67702-2-67690 | 4 | M1 | OMRI |
| Cease | *Bacillus subtilis* QST 713 | 264-1155-68539 | 4 | 44 | OMRI |
| *Chipco 26019 Flo (Bayer) | iprodione | 432-888 | 12/24 | 2 | |
| Companion Liquid Biological Fungicide Greenhouse Nursery and Ornamental Crops (2-3-2)_ | *Bacillus subtilis GBO3* | 71065-3 | 4 | 44 | |
| Companion Liquid Biological Fungicide Turf & Professional Landscape Use | *Bacillus subtilis GBO3* | 71065-3 | 4 | 44 | |
| Companion Biological Fungicide Wettable Powder | *Bacillus subtilis GBO3* | 71065-4 | 4 | 44 | OMRI |
| Compass Fungicide | trifloxystrobin | 432-1371 | 12 | 11 | |
| CuPRO 5000 Fungicide/ Bactericide 61.3 DF | copper hydroxide | 80289-2-67690 | 48 | M1 | USDA-NOP |
| Cuproxat FL Copper Fungicide | basic copper sulfate | 55146-151 | 48/24 | M1 | |
| Cyflufenamid 10SC | cyflufenamid | 8033-104 | 4 | U6 | |
| Daconil Ultrex | chlorothalonil | 50534-202-100 | 12 | M5 | |
| Daconil Weather Stik | chlorothalonil | 50534-209-100 | 12 | M5 | |
| *Dexter Max | mancozeb + azoxystrobin | 70506-329 | 24 | M3 + 11 | |
| *†Disarm 480SC Fungicide | fluoxastrobin | 66330-64 | 12 | 11 | |
| *Dithane 75DF Rainshield | mancozeb | 62719-402 | 24 | M3 | |
| Decree 50 WDG | fenhexamid | 66330-35-67690 | 12 | 12 | |
| Drexel Sulfur 90 WDG | sulfur | 19713-238 | 24 | M2 | |
| *†Eagle 20 EW | myclobutanil | 62719-463 | 24 | 3 | |
| Echo 720 T&O | chlorothalonil | 60063-7 | 12 | M5 | |

**Table 10.2.2. Insecticides mentioned in this publication listed by active ingredient**

| Active Ingredient | Trade Name | EPA Reg. No. | REI[1] | IRAC Code[2] | Organic-approved |
|---|---|---|---|---|---|
| **abamectin** | Ardent 0.15EC | 100-896 | 12 | 6 | |
| | *Avensis Insecticide/Miticide | 5481-627 | 12 | 6 | |
| | Avid 0.15EC | 100-896 | 12 | 6 | |
| **acephate** | 1300 Orthene TR | 499-421 | 24 | 1B | |
| | *Acephate 97 UP | 70506-8 | 24 | 1B | |
| | *Orthene TTO 97 | 5481-8978 | 24 | 1B | |
| | *Orthene TTO WSP | 5481-8971 | 24 | 1B | |
| **acequinocyl** | Shuttle O | 66330-38-59807 | 12 | 20B | |
| **acetamiprid** | TriStar 30 SG | 8033-94 | 12 | 4A | |
| | TriStar 70 WSP | 8033-22 | 12 | 4A | |
| | *TriStar 8.5 SL | 8033-106-1001 | 12 | 4A | |
| **azadirachtin** | Aza-Direct | 71908-1-10163 | 4 | UN | OMRI |
| | AzaGuard | 70299-17 | 4 | UN | OMRI |
| | Azatin O | 70051-9-59807 | 4 | UN | OMRI |
| | Molt-X | 68539-11 | 4 | UN | OMRI |
| | Neemix 4.5 | 70051-9 | 4 | UN | OMRI |
| | Ornazin 3%EC | 5481-476-67690 | 12 | UN | |
| ***Bacillus thuringiensis* subsp. *israelensis*** | Gnatrol WDG | 73049-56 | 4 | 11A | OMRI |
| ***Bacillus thuringiensis* subsp. *kurstaki*** | DiPel PRO DF | 73049-39 | 4 | 11A | OMRI |
| | Javelin WG | 70051-66 | 4 | 11A | OMRI |
| | Leprotec | 89046-12-88847 | 4 | 11A | |
| | BioBit HP | 73049-54 | 4 | 11A | OMRI |
| | Thuricide N/G | 70051-53-59807 | 4 | 11A | Organic |
| ***Beauveria bassiana* strain GHA** | BotaniGard 22WP | 82074-2 | 4 | Biological | |
| | BotaniGard ES | 82074-1 | 4 | Biological | |
| **pyrethrins + *Beauveria bassiana* strain GHA** | Mycotrol ESO | 82074-1 | 4 | Biological | |
| | Mycotrol WPO | 82074-2 | 4 | Biological | |
| ***Beauveria bassiana strain ANT-03*** | BioCeres WP | 89600-2 | 4 | Biological | |
| ***Beauveria bassiana strain ANT-03 +Pyrethrins*** | BotaniGard Maxx | 82074-5 | 12 | 3A + Biological | OMRI |
| **bifenazate** | Floramite SC | 400-508-59807 | 12 | 20D | |
| **bifenazate + abamectin** | Sirocco | 400-582-59807 | 12 | 6 + 20 | |
| **bifenthrin** | Ascertain | 91234-70 | 12 | 3A | |
| | Attain TR | 499-472 | 12 | 3A | |
| | *ΔMenace GC 7.9% Flowable | 228-458 | 12 | 3A | |
| | *OnyxPro | 279-4269 | 12 | 3A | |
| | *Talstar S | 279-3155 | 12 | 3A | |
| | *ΔMenace GC 7.9% Flowable Insecticide | 228-451 | 12 | 3A | |
| | *Up-Star SC | 70506-23 | 12 | 3A | |
| | *Wisdom Flowable | 5481-519 | 12 | 3A | |
| | *Talstar Nursery Granular | 279-3130 | 12 | 3A | |
| **buprofezin** | *†Talus 70 DF | 71711-21-67690 | 12 | 16 | |
| **canola oil + pyrethrins** | Pycana | 67702-53-59807 | 12 | 3A + UN | |
| **carbaryl** | Carbaryl 4L | 34704-447 | 12 | 1A | |
| | Drexel Carbaryl 4L | 19713-49 | 12 | 1A | |
| | Sevin SL | 432-1227-10404 | 12 | 1A | |