2021-2022 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.

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Abbreviations and Symbols Used in This Publication

A ..... acre	G ..... granular	TBSP ..... tablespoon
AI ..... active ingredient	L ..... liquid	TSP ..... teaspoon
D ..... dust	ME ..... micro-encapsulated	W ..... wettable
DF ..... dry flowable	P ..... pellets	WDG ..... water-dispersible granules
DG ..... dispersible granule	REI ..... restricted-entry interval	WP ..... wettable powder
E ..... emulsion, emulsifiable	S ..... soluble	WSB ..... water soluble bag
EC ..... emulsifiable concentrate	SC ..... soluble concentrate	WSP ..... water soluble packet
F or FLO ..... flowable	SP ..... soluble powder	

* ..... Restricted-use pesticide; may be purchased and used only by certified applicators
† ..... Not for use in Nassau and Suffolk Counties
Δ ..... Rate or other application restrictions apply. See label for more information.

Cover photo by: Margery Daughtrey, Long Island Horticultural Research and Extension Center, Riverhead, NY

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

4 Biology and Management of Diseases of Greenhouse Crops and Herbaceous Ornamentals

4.1 Common Diseases

4.1.1 Powdery Mildew

Powdery mildew, one of the most easily recognized of all plant diseases, is characterized by the presence of a whitish, powdery mildew growth on the surfaces of leaves, stems, and sometimes petals. The fungal threads and the spores (which develop on short, erect branches) are visible with a strong hand lens. Under some conditions, however, the threads are so sparse that the mildew can be detected only by examination under strong light with a good lens or dissecting microscope. In some cases, the mildew develops only in small areas in which the leaf cells are killed and turn red, purple, brown or black.

The mildew spores are easily detached and carried by air currents to surrounding plants where they initiate new infections. On some plants, such as grape ivy, rose, and delphinium, the young foliage and stems often become severely distorted in addition to being covered by the whitish mildew growth.

Watch for this disease on susceptible crops, including verbena, gerbera, begonia, mini-rose, hydrangea, petunia, calibrachoa, New Guinea impatiens, zinnia, African violet, phlox and monarda. Seriously affected crops may lose their sales value. Don't forget that poinsettias are susceptible to a powdery mildew disease. The disease develops rapidly during the fall. While scouting for whiteflies on poinsettias, also watch for powdery mildew colonies on the upper or lower surface of older leaves. At times a yellow spot on the upper leaf surface may indicate a mildew colony growing on the undersurface. Pick off affected leaves and initiate fungicide treatment immediately.

Bioenvironmental Control

Unlike the spores of nearly all other fungi, powdery mildew spores can germinate and initiate infections on plant surfaces that are not visibly wet. Development of mildew following infection is most rapid and luxurious at higher humidities. As a deterrent to mildew in greenhouses, ventilation and heating should be adjusted to avoid high-humidity conditions. Heat at least one hour before sunset, and provide adequate ventilation. Horizontal airflow systems assist in management of powdery mildew. For both outdoor and indoor crops, provide sufficient space between plants and water early in the day.

Chemical Control

Under some conditions, fungicides are essential for mildew control. Systemic and nonsystemic protectant materials are available for spray application (see Section 4.5.32). Practice fungicide rotation among different mode of action groups.

4.1.2 Botrytis Blight

The common gray mold fungus, *Botrytis cinerea*, attacks a wide variety of ornamental plants, probably causing more losses than any other single pathogen. The fungus causes a brown rotting and blighting of affected tissues. It commonly attacks the stems of geranium stock plants and wounds on cuttings. Some plants (e.g. lily, tulip and peony) are susceptible to other more host-specialized species of *Botrytis* as well. As a result of *Botrytis cinerea* infection, very small seedlings can be rotted; stems of poinsettia, snapdragon, zinnia, exacum, angelonia or lisianthus can be girdled; and petal tissues of many plants, including carnations, chrysanthemums, roses, azaleas, geraniums and peonies, can be spotted and ruined. The fungus is usually identified by the development of fuzzy grayish spore masses over the surface of the rotted tissues, although such sporulation will not develop under dry conditions.

Spores of the causal fungus are produced on distinctive dark-colored, hairlike sporophores and are readily dislodged and carried by air currents to new plant surfaces. The spores will not germinate and produce new infections, however, except when in contact with water, whether from splashing, condensation, or exudation. Only tender tissues (seedlings, petals), weakened tissues (e.g. stubs left in taking cuttings), injured tissues (bases of cuttings), or old and dead tissues are attacked on most crops. Active, healthy tissues, other than petals, are seldom invaded. Petals shed from crops in hanging baskets may encourage Botrytis blight on leaves of crops grown below.

Bioenvironmental Control

Because high humidity is required for spore production and actual condensation is necessary for spore germination and infection, Botrytis blight is a particular challenge in the greenhouse. It can usually be controlled by watering early and by heating and ventilating to prevent any condensation on the plant surfaces. Because the fungus readily attacks old or dead tissues and produces tremendous quantities of airborne spores, the importance of strict sanitation cannot be overemphasized. All old blossoms and dead leaves should be removed, and all fallen leaves and plant debris on or under the benches should be gathered and disposed of in bags or other closed containers.

Chemical Control

Fungicides may be required to protect highly susceptible crops such as exacum, geranium, poinsettia, lisianthus, bacopa, angelonia and fuchsia if weather conditions are especially favorable. Fungicide resistance is reported for *Botrytis cinerea* (benzimidazole and dicarboximide materials, as well as fenhexamid).

the ones affecting basil or impatiens, but these diseases will all thrive under highly humid, rainy or heavily irrigated conditions.

4.2.14 Cyclamen (*Cyclamen persicum*)

- **Anthracnoses (*Gloeosporium* and *Cryptocline* spp.):** Round, brown spots on foliage or petals that spread via splashing.
- ***Botrytis*:** Petal spotting or petiole collapse from crown rot.
- **Cylindrocarpon root, corm, and petiole rot (*Cylindrocarpon* sp.):** Elliptical brown cankers at petiole base; brown discoloration inside corm; partial or entire wilting of plant. Remove infected plants. Sanitation is important.
- **Fusarium wilt (*Fusarium oxysporum* f. sp. *cyclaminis*):** Chlorosis of older leaves, followed by wilting and collapse of plants. Corm is firm but shows brown to purplish discoloration of vascular system when sliced open. Remove infested plants. Raise pH to 6.0, and avoid ammonium nitrogen fertilizers. Cultural controls to reduce wilt losses include using media with a pH of 6.0 or above, composted growing mix, and fertilizers low in ammoniacal nitrogen.
- ***Impatiens necrotic spot virus* or *Tomato spotted wilt virus* (INSV or TSWV):** Leaves may show round brown or black spots, "fingerprints" (ringspots of brown or yellow), or brown patches at the base of the leaf. Stems may show black bands. Control of the vector, the western flower thrips, is essential.
- **Soft rot (*Pectobacterium carotovorum*):** Soft, mushy decay of corm leading to plant collapse. Control fungus gnats, and plant shallowly in a well-drained mix.

4.2.15 Foliage Plants

- **Root-knot nematodes:** Swollen, knobby areas on a stunted root system. Discard affected plants, pots, and soil.
- **Foliar nematodes:** Dark brown dead patches bounded by major leaf veins. Frequently seen on species and varieties of Peperomia and bird's nest fern.
- **Soft rot (*Pectobacterium* and *Dickeya* spp.):** Mushy decay of fleshy plant parts. Discard affected plants; space remainder. Keep foliage and stems dry; avoid splashing water. Sterilize soil and pots before reusing.
- **Fungal leaf spots (*Leptosphaeria, Colletotrichum, Myrothecium, Fusarium*):** Brown dead spots of various sizes on foliage, typically exhibiting fungus sporulation on the dead area. Generally controlled by keeping foliage dry to prevent infection. Wet plant surfaces (e.g., water in the whorl of dracaenas) promote fungal infection.
- **Stem rot at soil line (*Rhizoctonia*, *Sclerotium rolfsii* and *Sclerotium delphinii*):** Brown stem discoloration, sometimes showing black or brown sclerotia or white to tan mycelium of the causal fungus on the dead area.
- **Water mold root or leaf rot (*Pythium*, *Phytophthora*):** Black to brown portions of plant in a state of soft, wet decay. Pothos is especially susceptible to *Phytophthora*.
- **Impatiens necrotic spot virus (INSV):** Swedish ivy may show dark rings or spots, while peperomia may develop black stems or ringspots; additional foliage plants may also be hosts.

4.2.16 Freesia (*Freesia refracta*)

- **Fusarium wilt:** Plants turn yellow, wilt, and die. Corms show pink to brown discoloration.
- **Fluoride injury:** Dark streaking and tip dieback in foliage of plants, especially when grown at low pH. Increase pH to 6.0 to 6.5 for symptom reduction, and eliminate sources of fluoride (fluoridated water, perlite, etc.).

4.2.17 Fuchsia (*Fuchsia* x *hybrida*)

- **Botrytis blight:** Leaf infections during propagation can cause brown stem cankering and wilting and loss of cuttings. Keep *Botrytis* under control on stock plants to avoid losses during propagation.
- ***Phytophthora nicotianae*:** Particularly during the moist conditions that prevail during propagation, stems are rotted and leaf bases show brown decay.
- **Rust:** Bright yellow-orange sporulation is obvious on the underside of affected leaves, and the upper surfaces show tan leaf spots with a purple rim. Free moisture is necessary for infection, so losses are greatest during propagation.
- **Thielaviopsis root rot:** Wilting of all or portions of a good-sized plant is typical. Roots may be quite stunted and show areas of very black discoloration. The problem is most likely under conditions of high pH (pH below 5.5 discourages disease development) and in growing mixes that include some mineral soil.

4.2.18 Gardenia (*Gardenia jasminoides*)

- **Canker (*Phomopsis gardeniae*):** Swollen stem base; yellow discoloration beneath the bark.
- **Bacterial leaf spot (*Pseudomonas gardeniae*):** Leaf spots ranging from pinpoint dots to rounded brown spots (1/4 in. diameter) with water-soaked margins. Remove infested leaves.
- **Root-knot nematodes:** Swollen, knobby areas (galls) on a stunted root system. Discard infested plants.

4.2.19 Geranium (*Pelargonium* X *hortorum*)

- **Bacterial blight (*Xanthomonas hortorum* pv. *pelargonii*):** Tiny (1/16 in. diameter) round brown leaf spots, often surrounded by a chlorotic zone. Spots form when bacteria have been splashed onto the leaf surface. Subsequent systemic invasion of the plant leads to the

may result from virus infection, including dark brown or purple spotting on foliage. Spotting sometimes closely mimics infection by fungi or bacteria. Some of the most damaging orchid viruses are easily transmitted by routine handling of the plants, so the orchid collector should become familiar with special handling procedures that avoid transmission of viruses.

4.2.28 Pansy (*Viola x wittrockiana*)

- **Myrothecium crown rot (*Myrothecium roridum*):** Plants yellow and collapse, often after transplanting.
- **Phytophthora crown rot (*Phytophthora nicotianae*):** Softening and discoloration of stem base leads to browning of lower leaf bases and plant collapse.
- **Thielaviopsis root rot (*Thielaviopsis basicola*):** Scattered individual plants in plug tray or packs are stunted and yellowed; roots are stunted and may be blackened. Disease development is discouraged by pH levels below pH 5.5.
- **Cercospora leaf spot (*Cercospora violae*):** Leaf spots begin as small purple spots and enlarge to form large 1/4 in. diameter dark spots without a sharp circular outline (usually seen on lowest leaves). Rogue out immediately.
- **Downy mildew (*Peronospora violae*):** Pale areas of leaves, with sporulation on leaf undersurface.

4.2.29 Poinsettia (*Euphorbia pulcherrima*)

- **Powdery mildew:** This disease has caused major losses to growers who detected it late in the crop. White powdery spots appear on either the top or bottom surface of leaves or bracts. A yellow leaf spot may indicate the presence of a mildew colony on the undersurface. Monitor for powdery mildew colonies through the entire production season. Early detection will improve the effectiveness of control.
- **Stem rot (*Rhizoctonia solani*):** Brown stem cankers at the soil line or brown discoloration at the base of the cutting. Usually a problem during propagation.
- **Root and stem rot (*Pythium aphanidermatum*):** Soft brown decay of roots sometimes extending up into the stem to cause a brown or black basal canker. This species of *Pythium* is favored by hot summer growing conditions.
- **Root and stem rot (*Phytophthora drechsleri*):** Root rot and dark brown or black cankers at the stem base may be caused by *Phytophthora* as well as by *Pythium*. This species has been the most common problem in recent years.
- **Stem rot and wilt (*Phytophthora nicotianae*):** Tips of shoots wilt and blacken. Black lines may be observed running up the stem of younger plants. Reddish-brown cankers may be observed at the soil line even though roots generally appear healthy.
- **Bacterial stem canker (*Curtobacterium flaccumfaciens* pv. *poinsettiae*):** Black, water-soaked canker along the stem and spots and blotches on leaves. Uncommon under the cooler temperatures typical of poinsettia production in the northern United States.
- **Scab (*Sphaceloma poinsettiae*):** Round or elongated tan lesions with a purple margin on stems; puckered brown spots on leaves. Scout for symptoms during propagation.
- **Thielaviopsis root rot:** A blackened, stunted root system, longitudinal cracks at the stem base, and stunted or wilting plants. Use a soil pH of 5.5 or below to deter this disease. Poinsettias in growing mixes that do not contain mineral soil are unlikely to develop Thielaviopsis root rot.
- **Crud (physiological disorder):** Dried drops of plant sap (latex) occurring in the bracts may interfere with normal bract development and cause disfigurement of the flower head.
- **Alternaria leaf spot (*Alternaria euphorbiicola*):** Brown spots with yellow haloes; damage not usually significant in the northern United States.
- **Xanthomonas leaf spot (*Xanthomonas axonopodis* pv. *poinsettiicola.*):** Brown spots with yellow haloes; damage was significant recently in the northern United States. Scout for symptoms during propagation.

4.2.30 Rose (*Rosa hybrida*)

- **Powdery mildew:** White fuzzy patches of mycelial growth and sporulation on leaves, stems, and flowers.
- **Nematodes:** Stunted growth or symptoms of nutrient deficiency or swollen, knobby areas on the root systems. Because roses for cut flowers are still grown in ground beds, they are one of the few crops in New York that may be troubled by nematode infestations.
- **Cankers (*Coniothyrium fuckelii* and other fungi):** Brown discolored sections of canes often die back from a pruning cut or may be centered on a wound, sometimes around the graft union. Cankers generally bear sporulation of the causal fungus. Prune out the cankers, sanitize shears between cuts, and avoid both water stress and overhead watering of freshly pruned plants to minimize the chance of new infections.
- **Black spot:** Large black leaf spots with a fringed margin, especially concentrated along veins. Extensive spotting leads to leaf yellowing and leaf drop. Shoots may also be infected. This problem is generally not severe in greenhouses where overhead watering of the foliage can be avoided by subirrigation techniques; outdoors it is a major problem.
- **Verticillium wilt:** Wilting of leaves at shoot tips and yellowing or interveinal scorching of lower leaves; dieback. Vascular discoloration is usually not obvious within the stem, but some sparse black flecking may be observed. Symptoms appear when the plant is under stress, such as that caused by drought.
- **Downy mildew:** Angular dark patches between the leaf veins, usually surrounded by yellow areas. Defoliation may be extensive. Spots frequently resemble spray

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.

Table 5.3.1 Mode of Action Classification of Insecticides and Miticides in New York State Greenhouses and Herbaceous Ornamentals

IRAC Code	Primary Site of Action	Chemical Class	Trade Name(s) (Active Ingredient)
1A	Acetylcholineesterase inhibitors	carbamates	*Mesurol (methiocarb)
1B		organophosphates	*Acephate 97 UP, 1300 OrtheneTR, (acephate)
2A, 2B	GABA-gated chloride channel antagonists	none used on ornamentals	–
3A	Sodium channel modulators	pyrethroids	Attain, *Talstar S, *Wisdom (bifenthrin) Decathalon (cyfluthrin) *Discus (cyfluthrin+imidacloprid) *Tame (fenpropathrin) *Astro, *Perm-Up 3.2EC, *Pounce 25WP (permethrin) *Mavrik Aquaflow (fluvalinate) *Scimitar GC (lambda-cyhalothrin)
		pyrethrins	Pyrethrum TR (pyrethrins + piperonyl butoxide)
4A	Nicotine acetylcholine receptor (NACHR) competitive modulators	neonicotinoids	TriStar (acetamiprid) *Discus (cyfluthrin+ imidacloprid) *Benefit 60WP, *Lada 2F, *Marathon (imidacloprid) *Safari (dinotefuran) *†Flagship (thiamethoxam)
4B		none used on ornamentals	–
4C		none used on ornamentals	–
5	Nicotine acetylcholine receptor (NACHR) allosteric modulators (not Group 4)	spinosyns	Conserve (spinosad)
6	Glutamate-gated chloride channel (GLUCL) allosteric modulators	avermectins	Ardent, Avid, Quali-Pro Abamectin 0.15EC (abamectin) Sirocco (bifenazate + abamectin)
7A	Juvenile hormone mimics	juvenile hormone analogues	Enstar AQ (kinoprene)
7B		fenoxycarb	Preclude TR (fenoxycarb)
7C		pyriproxyfen	Defiance, Distance, Fulcrum (pyriproxyfen)
8A	Compounds of unknown or non-specific mode of action (fumigants)	alkyl halides	–
8B		none used on ornamentals	–
8C		none used on ornamentals	–
9A	Chordotonl organ TRPV channel modulators	none used on ornamentals	–
9B		pymetrozine	Endeavor (pymetrozine)
9C		flonicamid	*Aria
10A	Compounds of unknown or non-specific mode of action (mite growth inhibitors)	clofentazine	Notavo (clofentazine)
		hexythiazox	*Hexygon Miticide, *Hexygon IQ Miticide, *Hexcel, (hexythiazox)
10B		etoxazole	Beethoven TR, *TetraSan, Eschaton (etoxazole)
11A	Microbial disruptors of insect midgut membranes (including transgenic plants expressing *Bacillus thuringiensis* toxins)	*B.t.* var *israelensis*	Gnatrol (*B.t.* var. *israelensis*)
11A		*B.t.* var *kurstaki*	BioBit HP, Dipel PRO DF, Javelin WG, Leprotec (*B.t.* var. *kurstaki*)
11B	*Bacillus sphaericus*		
12ABC	Inhibitors of oxidative phosphorylation, disruptors of ATP formation	none used on ornamentals	–
12B		organotin miticides	–

5.6.11 Grasshoppers

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

Compound(s) ***Common name (IRAC Code)*** Trade name	Use Site(s)	Comments
Beauveria bassiana strain GHA + pyrethrins (3A)		
BotaniGard Maxx	greenhouse, nursery, landscape, interiorscape	Typically, it takes 2-5 days after the first spray to see control. Application rates, frequency, spray coverage and insect numbers impact the speed at which acceptable control is achieved. Product is most effective when used early, before high insect populations develop. Reapply as necessary under a pest management program that includes close scouting. Do not apply to point of runoff, and do not apply to poinsettias after bract formation. Test for phytotoxicity before widespread use on herbs. Follow all label directions.
bifenthrin (3A)		
*OnyxPro	nursery, landscape, interiorscape	Not for use on golf courses or sod farms on Long Island. See label for specific rates and instructions.
*Talstar S	greenhouse, nursery, landscape ornamentals	Use of an alternate class of chemistry in a treatment program is recommended to prevent or delay pest resistance. May not be effective against some aphid populations due to insecticide resistance. Thorough coverage is important. Product can be used for larval control in potting media of containerized plants – see label for preventative and curative treatment recommendations. See label for specific rates and instructions.
*Wisdom Flowable	greenhouse, nursery, landscape ornamentals	Use of an alternate class of chemistry in a treatment program is recommended to prevent or delay pest resistance. May not be effective against some aphid populations due to insecticide resistance. Thorough coverage is important. See label for specific rates and instructions.
canola oil + pyrethrins (3A + UN)		
Pycana	greenhouse, shadehouse, nursery	Broadly labeled. Do not spray to the point of runoff, do not apply more than 10 times per season, and do not use within 21 days of sulfur application. See label for complete lists of pests and use restrictions.
cyfluthrin (3A)		
*Decathlon 20WP	nurseries, greenhouses, landscapes, interior plantscapes	Good spray coverage is necessary to provide the most effective level of control. See label for specific rates and instructions.
pyrethrins (3A)		
PyGanic Specialty	greenhouse, nursery	Use spray equipment that will provide the best coverage and direct contact with as many insects as possible. Kills only at time of application. Insect pests must be directly contacted to be effective. Do not wet plants to the point of drip or runoff. Follow label directions.

* Restricted-use pesticide. May be purchased and used only by certified applicators.
Δ Rate or other application restrictions apply. See label for details.

5.6.12 Lace Bugs

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

Compound(s) ***Common name (IRAC Code)*** Trade name	Use Site(s)	Comments
acephate (1B)		
1300 Orthene TR	commercial greenhouses	Apply during early evening when foliage is dry. Greenhouse temperatures should be between 60° and 80°F for best results. Greenhouse should be ventilated before reentry. See label for complete plant list, rates, and specific 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: ful =Full control is expected. par =Partial control is expected.		Barricade	Biathlon	*†Dacthal	Devrinol	*ΔDimension	Pendulum	*†Pennant Magnum	*Ronstar	Surflan	Treflan	XL 2G
Genus, species	**Common name**											
Broadleaves *(continued)*												
Lamium amplexicaule	henbit	ful				ful	ful			ful		ful
Lamium purpureum	deadnettle			par								
Lepidium perfoliatum	pepperweed, yellowflower											
Lepidium virginicum	pepperweed, Virginia		ful									
Malva spp.	mallow			par					ful	par		par
Marchantia spp.	liverwort								par			
Matricaria matricarioides	pineappleweed				ful	ful						
Medicago hispita	burclover											
Medicago lupulina	medic, black					ful						
Mollugo verticillata	carpetweed	ful		ful	ful	ful	ful	ful	ful	ful	par	ful
Montia perfoliata	lettuce, miners											
Moss (several genera)	moss											
Oenothera laciniata	eveningprimrose, cutleaf								par			
Oenothera spp.	eveningprimrose						ful		par			
Oxalis corniculata	woodsorrel, creeping					ful						
Oxalis stricta	woodsorrel, yellow	ful	ful			ful	ful		ful	ful		ful
Physalis spp.	groundcherry											
Plantago spp.	plantain species											
Polygonum aviculare	knotweed, prostrate	ful		par	ful	ful	ful			ful	ful	ful
Polygonum convolvulus	buckwheat, wild											
Polygonum pensylvanicum	smartweed, Pennsylvania						ful		ful	par		par
Polygonum persicaria	ladysthumb/smartweed									par		par
Portulaca oleracea	purslane, common	ful		ful	ful	ful	ful	par	ful	ful	ful	ful
Raphanus raphanistrum	radish, wild											
Richardia scabra	pusley, Florida	ful		ful			ful	ful		ful	par	ful
Rumex acetosella	sorrel, red											
Rumex crispus	dock, curly											
Sagina procumbens	pearlwort, birdeye		ful									
Salsola kali	thistle, Russian										ful	
Senecio vulgaris	groundsel, common		ful		ful			par	ful	ful		ful
Sida spinosa	sida, prickly											par
Sinapis arvensis/Brassica kaber	mustard, wild					ful				par		
Sisymbrium altissimum	mustard, tumble											
Sisymbrium irio	rocket, London					ful	ful			ful		ful
Solanum nigrum	nightshade, black			par				ful		par		par
Solanum nodiflorum	nightshade, Am. black											
Solanum sarachiodes	nightshade, hairy							par				
Sonchus arvensis	sowthistle		ful									
Sonchus oleraceus	sowthistle, annual				ful				ful	par		par
Spergula arvensis	spurry, corn											
Spergularia rubra	sandspurry, red											
Stellaria media	chickweed, common	ful	ful	ful	ful	ful	ful			ful	ful	ful
Taraxicum officianale	dandelion		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

Table 8.12.1. Growth regulators for greenhouse crops and herbaceous ornamentals

Common Name	Brand Name	Formulation	EPA Reg. No.	REI§
Suppressants of Flower Initiation and Development *(continued)*				
gibberellic acid *(continued)*				
	ProGibb TVO	4% L	73049-15	12
Registered crops: used on azalea to inhibit flower bud initiation during vegetative growth				
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 azalea				
Suppressants of Senescence (Reduction of Leaf Yellowing; Promotion of Flower Bud and Flower Longevity)				
benzyladenine + gibberellins A4A7	Fascination	1.8%+1.8% L	73049-41	4
	Fresco	1.8%+1.8% L	62097-6-82917	4
Registered crops: Easter, LA hybrid, and Oriental lilies				
Registered method of application: spray				
Registered rates of application: determine optimal rates through trials as specified on the labels; see labels for rates for Easter, LA hybrid, and Oriental lilies.				
1-methylcyclopropene	EthylBloc	0.14%WP + mixing buffer solution	71297-1-32258	ventilation requirements must be met
	EthylBloc Sachet	0.014%WP	71297-5-32258	
Registered crops: cut flowers, potted flowers, bedding, nursery, and foliage plants				
Registered method of application: fumigation in enclosure				
Registered rates of application: see label for partial list of flowers and plants effectively treated, as well as rates of application based on enclosure characteristics and exposure time				
Suppressants of Stem Topple				
ethephon	*Collate	21.7% F	85678-9-82917	48
	Florel Brand Pistill	3.9% L	54705-8	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: foliar spray				
Registered rates of application: determine optimal rates through trials as specified on the labels; see labels for rates for daffodil and hyacinth.				

Notes:
* Restricted-use pesticide.
§ = in hours

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	BM02	
Actinovate SP	*Streptomyces lydicus* WYEC 108	524-641	4	BM02	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	71962-2	4	33	
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	12	BM02	OMRI
*Astun	isofetamid	71512-23-59807	12	7	
Atticus Artavia 2SC	azoxystrobin	91234-74	4	11	
Auron DF	sulfur	62562-4-94100	24	M02	OMRI
Aviv	*Bacillus subtilis* IAB/BS03	91473-1-86182	4	BM02	OMRI
Azoxy 2SC Select	azoxystrobin	89442-21	4	11	
Banner MAXX II	propiconazole	100-1326	12	3	
Banol Turf and Ornamental Fungicide	propamocarb	432-942	24	28	
Bio-Tam 2.0	*Trichoderma asperellum* ICC 012 and *Trichoderma gamsii* ICC 080	80289-9	4/0	BM02	OMRI
*Banrot 40 WP	etridiazole + thiophanate-methyl	58185-10	12	14+1	
*Banrot 8G	etridiazole + thiophanate-methyl	58185-23	12	14+1	
BotryStop	*Ulocladium oudemansii* (U3 Strain)	75747-2-68539	4	NC	OMRI
*†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	BM02	OMRI
*Chipco 26019 Flo (Bayer)	iprodione	432-888	12/24	2	
Chlorothalonil-Zn	chlorothalonil	19713-709	12	M05	
Compass Fungicide	trifloxystrobin	432-1371	12	11	
Cosavet-DF Edge	sulfur	70905-1	24	MO2	OMRI
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	
Dart Fungicide EC	capric acid and caprylic acid	51517-11	24	NC	OMRI
Decree 50 WDG	fenhexamid	66330-35-67690	12	12	
*Dexter Max	mancozeb + azoxystrobin	70506-329	24	M3+11	
Dexter SC	azoxystrobin	70506-351	4	11	

Table 10.3.2 Herbicides for use on herbaceous ornamentals mentioned in this publication listed by active ingredient

Active Ingredient	Trade Name	EPA Reg. No.	REI[1] (hr.)	Group Number(s)[2]	Organic-approved
benefin + oryzalin	XL 2G	70506-45-38167	24	3	
bentazon	Basagran T&O	7969-45	48	6	
clethodim	*ΔEnvoy Plus	59639-132	24	1	
clopyralid	*†ΔLontrel	62719-305	12	4	
DCPA	*†Dacthal Flowable	5481-487	12	3	
dithiopyr	*ΔDimension 2EW	62719-542	12	3	
	*ΔDimension Ultra40	62719-445	12	3	
diquat	*Diquat SPC 2L	228-675	24	22	
	*Littora	67690-53	24	22	
fenoxaprop	Acclaim Extra	432-950	24	1	
fluazifop-P-butyl	Fusilade II	100-1084	12	1	
	Ornamec OTT	2217-728	4	1	
glufosinate-ammonium	†Finale	432-1229/7969-444	12	10	
glyphosate	Glyfos 4EC	4787-31	12	9	
	Roundup Pro	524-475	4	9	
	Roundup ProMax	524-579	4	9	
indaziflam	*†Marengo	432-1518	12	29	
	*†Marengo G	432-1523	12	29	
	*†Specticle Flo	432-1518	12	29	
	*†Specticle G	432-1523	12	29	
napropamide	Devrinol 2-XT	70506-301	24	15	
oryzalin	Surflan AS	70506-44	24	3	
	Surflan Flex	70506-308	24	3	
oxadiazon	*Ronstar Flo	432-1465	12	3	
	*Ronstar G	432-886	12	3	
oxyfluorfen + prodiamine	Biathlon	59807-12	24	14+3	
pelargonic acid	Scythe	10163-325	12	17	
pendimethalin	*Corral	58185-179	24	14	
	Pendulum 2G	241-375	24	14	
	Pendulum 3.3EC	241-341	24	14	
	Pendulum Aquacap	241-416	24	14	
prodiamine	Barricade 4FL	100-1139	12	3	
	*Barricade 65WG	100-834	12	3	
sethoxydim	Segment	7969-317	12	1	
	Segment II	7969-398	12	1	
s-metolachlor	*†Pennant Magnum	100-950	24	15	
trifluralin	Treflan	961-405	see label	21	

NOTES:

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

† Not for use in Nassau and Suffolk Counties; pesticide labels that indicate "Not for use on Long Island, N.Y." means that use is prohibited in Nassau and Suffolk Counties only.

Δ Rate or other application restrictions apply. See label for more information.

[1] Restricted-entry interval in accordance with Worker Protection Standard for Agricultural Pesticides.

[2]WSSA Classification of Herbicides according to Mode of Action