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GREENHOUSE WEED CONTROL

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Weeds such as creeping woodsorrel (*Oxalis corniculata*), hairy bittercress (*Cardamine hirsuta*), prostrate spurge (*Euphorbia humistrata*), and others are persistent problems in greenhouses. Not only do these weeds detract from the perceived quality of plants produced, but some also are known to harbor insects, such as whitefly and thrips, and other pests such as mites, slugs and snails. Therefore the removal of weeds from greenhouse pots, benches and floors is important for aesthetic and pest management reasons. There are a number of options 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 sterile substrates (soils), introducing only "clean" plant materials, and practicing weed control outside of the greenhouse. Where possible, screen vents and other openings to limit the introduction of wind blown seed as well as flying pests. Concrete or mulched floors will also limit weed establishment. Some weeds will get into the greenhouse in spite of these measures. These weeds should be removed manually or by herbicide treatments before they go to seed.

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 dry up (solarization)
③ emptying the range and fumigating
④ using a postemergence herbicide

Each method (except fumigation) will only remove the vegetation which is present but does nothing to prevent reestablishment from seed that will be present. Even solarization rarely produces sufficient heat to effectively kill weed seed. Continuous removal is expensive and time consuming. Currently there are no residual herbicides labeled for greenhouse use. Where weeds are a continual problem, clean up the area, remove the soil or cover it with a 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.

However, if fumigation is considered for other reasons, be sure the conditions are right for weed seed control as well. Before fumigating, kill existing weeds and wash the interior walls, benches, and glass or plastic to remove and moisten weed seed. The soil and media should be moist but not wet and between 50 and 80 °F. The most effective, but most hazardous, fumigant is methyl bromide. If methyl bromide is to be used, it is advisable to contract out this work to a qualified fumigation specialist. In plant beds or under benches, steam pasteurization can be effective. Soil / substrate temperature must remain at or above 180 °F for at least 30 minutes to kill most weed seed. For more detailed guidelines on the use of fumigants in greenhouses consult the NCSU Plant Pathology Information Note #140, "Soil Treatments for Plant Beds and Greenhouse – Vegetable and Ornamental Crops."

Chemical Control of Greenhouse Weeds

Only four herbicides are labeled for use inside greenhouses. There are very specific restrictions on the use of herbicides in greenhouses. Read the label and carefully observe any precautions. Always wear personal protective equipment when applying pesticides in a greenhouse.

Reward (diquat) is a postemergent contact-type, non-translocated weed killer. It is good for killing small annual weeds. Large weeds will be burned but not killed. Reward is relatively toxic to people. Always use the recommended safety equipment when spraying Reward. Chief advantages of this product include rapid kill of seedling weeds; it may be used when a crop is present in the house; a relatively low cost; and small amounts of spray drift will cause only cosmetic damage to the crop but will not translocate to kill entire plants. The chief disadvantage is the relatively high mammalian toxicity and lack of control of perennial or well established weeds.

Scythe (pelargonic acid) is also a contact-type, non-translocated herbicide which controls small seedling weeds. Scythe works better when air temperatures are relatively high (>80 °F). Large weeds will be burned but not killed. Chief advantages of Scythe include lower toxicity (compared to Reward) and it may be used while a crop is in the house. Also, Scythe is the only herbicide which can be used to control weeds growing in woody plant production benches, such as rose benches. [The other herbicides are for use only under benches, in walk ways, or around the foundation]. In all applications, avoid contact with desirable vegetation. Chief disadvantages of Scythe are cost and it is somewhat less effective than Reward on larger weed seedlings. Additionally, the odor can persist and be offensive to some people.

In contrast to Scythe and Reward, **Roundup** or **Roundup-Pro** (glyphosate) is a systemic weed killer that kills annual and perennial weeds. It also has a lower mammalian toxicity than Reward. However, when applying any pesticide in a closed environment like a greenhouse, one should wear protective clothing, eye protection, and a respirator. The chief advantages of glyphosate products are the systemic kill of annual and perennial weeds and low mammalian toxicity. The chief disadvantage is that small amounts of spray drift can severely injure greenhouse crops. Therefore, it is advisable to use Roundup only in empty greenhouses (between crops) or to shut off ventilation and circulation fans to reduce drift. If drift occurs, wait six hours then wash the benches and sides of the house; otherwise, condensation containing Roundup may drip on plants.

Finale (glufosinate-ammonium) is also a nonselective, systemic, postemergent herbicide that may be used to control weeds on greenhouse floors, under benches, and around the foundation. Air circulation fans must be turned off during the application of Finale. Avoid aerial drift by using a low pressure, large droplet type nozzle. Finale is similar to Roundup, in that it is a translocated, nonselective herbicide with no soil activity in clay soils. However, in contrast to Roundup, Finale produces symptoms more rapidly (often within 48 hours) but may not control rhizomatous

Table 1. Herbicides labeled for use inside greenhouses.

Herbicide	Mode of action	Time for symptoms	Use with crops in the house?	Use in soil beds or in benches?	Toxicological properties	REI*
Reward	contact	2 to 12 hr	yes	no	eye & skin irritant LD_{50}: 230 mg/kg	24 hr
Scythe	contact	1/2 to 2 hr	yes	yes, directed in roses & other woody crops	severe eye irritant LD_{50}: >5000 mg/kg	24 hr
Finale	systemic	≅ 2 days	yes	no	may cause eye or mild skin irritation LD_{50}: 3570 mg/kg	12 hr
Roundup-Pro	systemic	≅ 7 days	no	no	may cause mild skin or eye irritation LD_{50}: >5000 mg/kg	4 hr

*REI: Worker protection standard prescribed restricted-entry intervals. For this time interval following a herbicide application, workers are not to enter treated areas without wearing personal protective equipment (PPE) for activities that would bring them in contact with treated surfaces. Depending upon the herbicide, the PPE required may be as simple as shoes, socks, coveralls, and rubber gloves. Check the AGRICULTURAL USE REQUIREMENTS section of the product label for required PPE.

perennial weeds as well as Roundup. Do not use Finale in greenhouses containing edible crops.

Weed Control Outside of the Greenhouse

The primary objectives of weed control outside the greenhouse is to eliminate a major source of air borne weed seed and to prevent perennial weeds such as quackgrass or bindweed from growing under the foundation and into the greenhouse. Additionally, weed control around the greenhouse may also serve to reduce populations of flying insect pests. Many options are available for controlling these weeds. Mowing will prevent the majority of weed seed formation. However, a vegetation-free strip is recommended immediately adjacent to the foundation. Use a geotextile fabric covered with gravel or other inorganic mulch. As an alternative to the geotextile or as a supplement when weeds grow in the mulch, postemergent and soil residual herbicides may be used outside the greenhouse. Surflan (oryzalin) has been used successfully for residual weed control. Apply Surflan with a calibrated sprayer to achieve a dosage of 2 to 4 lb ai/A. Surflan may be mixed with Reward, Finale or Roundup for post and preemergent weed control. Do not use auxin-type herbicides, such as those labeled for broadleaf weed control in turf, near greenhouses. When spraying weeds around the greenhouse, close windows and vents to prevent spray drift from entering the greenhouse. Vents and windows may be opened almost immediately after spraying.

No herbicide controls all weeds, so some escapes will occur. Supplement the herbicide treatments with manual removal to keep the greenhouse clean. When sanitation, mulching, postemergence herbicides, and manual weed removal are combined into a comprehensive weed management program, the weed pressure will be reduced, thus resulting in less time spent removing weeds. This means lower costs for weed control and more grower time available for other jobs. In addition, the control of weeds under the benches will prevent weed introduction to plants growing on the benches, and reduce other weed-related pest problems such as whiteflies, mites, thrips, slugs, and snails.

GROWTH REGULATORS FOR FLORICULTURAL CROPS

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Crop	Purpose	Chemical	Rate	Precautions and Remarks
Ageratum	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	Plug culture and flat culture differ in recommended rates. The rates shown in this table include both plug (lower rates) and flat culture (higher rates) recommendations. Apply ALL foliar sprays of plant growth regulators using 0.5 gallon per 100 square feet of bench area. Growers should refer to Horticulture Information Leaflet #528, Height Control of Greenhouse Crops, for application techniques and timing for growth regulators on floricultural crops. Contact floricultural specialists at N. C. State University for further application information.
		B-Nine	2,500 to 5,000 ppm spray (0.39 to 0.79 oz/gal)	
		Bonzi	5 to 45 ppm spray (0.16 to 1.44 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	20 to 30 ppm spray (5.12 to 7.68 fl oz/gal)	
Alternanthera (Joseph's-Coat)	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Amaryllis	To control plant height	Bonzi	23.66 mg a.i. drench for a 6 in. pot (6.4 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
Aster	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	5,000 ppm spray (0.79 oz/gal)	
Azalea	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	Contact floricultural specialists at N. C. State University.
	To promote flower initiation	B-Nine	1,500 to 2,500 ppm spray (0.24 to 0.39 oz/gal)	Apply solution when new growth from final pinch is 1 to 2 inches long.
		Cycocel	1,000 to 4,000 ppm spray (1.08 to 4.34 fl oz/gal)	Optimum rates are generally between 1,000 and 2,000 ppm. Two to six multiple sprays may be needed. Apply first application when new growth is approximately 2 inches long.
	To promote lateral shoot growth on vegetative plants	Off-Shoot-O	Use a 3 to 5% solution (8.6 to 14 fl oz/gal) solution in greenhouses; use 5 to 7% (14 to 20 fl oz/gal) outdoors. Apply as a foliar spray.	Be certain chemical covers shoot tip. Ineffective if microscopic flower buds are present.
	To increase lateral branching	Atrimmec	3,125 to 6,250 ppm spray (2 to 4 fl oz/gal)	Contact floricultural specialists at N. C. State University.
		Florel	2,471 to 4,943 ppm spray (8 to 16 fl oz/gal)	
	To control plant height, reduce bypass shoot elongation, and promote flower bud initiation	Bonzi	100 to 200 ppm spray (3.2 to 6.4 fl oz/gal)	To control plant height and promote flower bud initiation, apply after final shaping, when new growth is 1.5 to 2 inches long. To reduce bypass shoot development, apply after bud set, when bypass shoots are barely visible.
	To control plant height, reduce bypass shoot elongation, and promote flower bud initiation	Bonzi	0.59 to 1.77 mg a.i. drench for a 6 in pot (0.16 to 0.48 fl oz/gal of drench solution; apply 4 fl oz/6 in pot)	Drench application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
	To control plant height	Sumagic	10 to 15 ppm spray (2.56 to 3.84 fl oz/gal)	Apply at 1.5 quarts per 100 square feet of bench area. Contact floricultural specialists at N. C. State University for further application information.
	For partial or full substitution of cold	GibGro	250 to 1,000 ppm spray (1 to 4 fl oz/gal)	GibGro has 24(c) registration for distribution and greenhouse use only within North Carolina. Spray timing, concentration, and number of applications varies with cultivar as well as intended degree of cold substitution. Consult the label for exact recommendations.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Azalea, continued	To prevent flower bud initiation during vegetative growth	GibGro	100 to 750 ppm spray (0.4 to 3 fl oz/gal)	GibGro has 24(c) registration for distribution and greenhouse use only within North Carolina. Apply two to three sprays at 2 to 3 weeks intervals after each pinch.
Balsam	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
Bedding Plants (Not specifically listed in this table)	To control plant height	B-Nine + Cycocel	800 to 5,000 ppm B-Nine (0.13 to 0.79 oz/gal) + 1,000 to 1,500 ppm Cycocel (1.08 to 1.63 fl oz/gal) applied as a tank mix spray	It is recommended to use the highest rate of Cycocel that does not cause excessive leaf yellowing, and then adjust the B-Nine rate up and down within the labeled range to attain desired level of height control.
		Bonzi	30 ppm spray (0.96 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rates as needed for desired final plant height and duration of height control.
			0.118 mg a.i. drench for a 6 in. pot (0.032 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench applications are recommended only for bedding plants in 6 inch or larger containers.
		Cycocel	800 to 3,000 ppm spray (0.87 to 3.25 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rates as needed for desired final plant height and duration of height control.
Bedding Plant Plugs (Not specifically listed in this table)	To control plant height	B-Nine + Cycocel	800 to 5,000 ppm B-Nine (0.13 to 0.79 oz/gal) + 1,000 to 1,500 ppm Cycocel (1.08 to 1.63 fl oz/gal) applied as a tank mix spray	It is recommended to use the highest rate of Cycocel that does not cause excessive leaf yellowing, and then adjust the B-Nine rate up and down within the labeled range to attain desired level of height control.
		Bonzi	5 ppm spray (0.16 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rate as needed for desired final plant height and duration of height control. Plants should develop 1 to 2 true leaves prior to first application.
		Cycocel	400 to 1,500 ppm spray (0.43 to 1.63 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rates as needed for desired final plant height and duration of height control.
Begonia	To control plant height	B-Nine	5,000 ppm spray (0.79 oz/gal)	See Ageratum.
Begonia, Elatior	To increase lateral branching	Atrimmec	781 to 1,562 ppm spray (0.5 to 1.0 fl oz/gal)	
Bleeding Heart	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Bluebell (*Campanula rotundifolia*)	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Bougainvillea	To increase lateral branching	Atrimmec	1,562 ppm spray (1 fl oz/gal)	
Bromeliad	To promote flower initiation	Florel	2,471 ppm spray (8 fl oz/gal)	Contact floricultural specialists at N. C. State University.
Bulb Crops (Not specifically listed in this table)	To control plant height	Bonzi	100 ppm spray (3.2 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rate as needed for desired final plant height and length of height control.
			1.183 mg a.i. drench for a 6 in. pot (0.32 fl oz/gal of drench solution; apply 4 fl oz per 6 in. pot)	Drench application volumes vary with pot size.
			20 ppm bulb soak (0.64 fl oz/gal)	Soak for 15 minutes. Users should conduct trials on a small number of bulbs, adjusting the rate and soaking period (up to 1 hour) as needed for desired final plant height.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Caladium	To control plant height	Bonzi	100 to 200 ppm spray (3.2 to 6.4 fl oz/gal)	First spray applications should be made when plants are 2 to 4 inches tall.
			1.183 to 2.366 mg a.i. drench for a 6 in. pot (0.32 to 0.64 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	First drench applications should be made when plants are 1 to 2 inches tall. Drench application volumes vary with pot size.
Calla Lily	To control plant height	Bonzi	1.183 to 3.549 mg a.i. drench for a 6 in. pot (0.32 to 0.96 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	See Caladium.
			20 ppm rhizome/tuber soak (0.64 fl oz/gal)	Soak the rhizomes/tubers for 15 minutes prior to planting.
Celosia	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	2,500 ppm spray (0.39 oz/gal)	
		Bonzi	4 to 50 ppm spray (0.13 to 1.60 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	10 to 20 ppm spray (2.56 to 5.12 fl oz/gal)	
Chrysanthemum, Cut	To reduce "neck" stretching	B-Nine	2,500 ppm spray (0.39 oz/gal)	Spray upper foliage 5 weeks after start of short-day treatment.
Chrysanthemum, Potted	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	Contact floricultural specialists at N. C. State University.
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
		B-Nine	1,000 ppm preplant foliar dip (0.16 oz/gal)	Contact floricultural specialists at N.C. State University.
			1,250 to 5,000 ppm spray (0.20 to 0.79 oz/gal)	Spray when new growth from pinch is 1 to 2 inches long. Some varieties may require another application 3 weeks later.
		Bonzi	50 to 200 ppm spray (1.6 to 6.4 fl oz/gal)	Contact floricultural specialists at N. C. State University.
			0.118 to 0.473 mg a.i. drench for a 6 in. pot (0.032 to 0.128 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
		Sumagic	2.5 to 10 ppm spray (0.64 to 2.56 fl oz/gal)	Contact floricultural specialists at N. C. State University.
Chrysanthemum, Garden	To increase lateral branching	Florel	500 ppm spray (1.619 fl oz/gal)	Florel applications will provide some growth retardant effects. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Clematis	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Cleome	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
Clerodendrum	To increase lateral branching	Atrimmec	1,042 to 2,083 ppm spray (0.67 to 1.33 fl oz/gal)	
Coleus	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Coleus, continued	To control plant height	Bonzi	5 to 45 ppm spray (0.16 to 1.44 fl oz/gal)	See Ageratum.
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	10 to 20 ppm spray (2.56 to 5.12 fl oz/gal)	
Columbine	To control plant height	A-Rest	66 to 132 ppm spray (32 to 64 fl oz/gal)	
Cornflower	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
Cosmos	To control plant height	B-Nine	5,000 ppm spray (0.79 oz/gal)	See Ageratum.
Crossandra	To control plant height	B-Nine	2,500 ppm spray (0.39 oz/gal)	
Daffodil	To control plant height	Bonzi	2.366 to 4.732 mg a.i. drench for a 6 in. pot (0.64 to 1.28 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	See Caladium.
		Florel	1,000 to 2,000 ppm spray (3.24 to 6.47 fl oz/gal)	Contact floricultural specialists at N. C. State University.
Dahlia	To control plant height	A-Rest	0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
		B-Nine	5,000 ppm spray (0.79 oz/gal)	See Ageratum.
		Bonzi	5 to 45 ppm spray (0.16 to 1.44 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	10 to 20 ppm spray (2.56 to 5.12 fl oz/gal)	
Delphinum	To control plant height	A-Rest	33 to 132 ppm spray (16 to 64 fl oz/gal)	See Ageratum.
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
Dianthus	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		Bonzi	5 to 60 ppm spray (0.16 to 1.92 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
Dracaena	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Dusty Miller	To control plant height	B-Nine	5,000 ppm spray (0.79 oz/gal)	See Ageratum.
Easter Lily	To control plant height	A-Rest	33 to 66 ppm spray (16 to 32 fl oz/gal)	Contact floricultural specialists at N. C. State University.
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
		Sumagic	10 to 25 ppm spray (2.56 to 6.4 fl oz/gal)	Contact floricultural specialists at N. C. State University.
			0.03 to 0.06 mg a.i. drench for a 6 in. pot (0.065 to 0.13 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Exacum	To control plant height	B-Nine	2,500 ppm spray (0.39 oz/gal)	
Fatshedera	To control plant height	A-Rest	66 to 132 ppm spray (32 to 64 fl oz/gal)	
Flowering/Foliage Plants, Herbaceous Species (Not specifically listed in this table)	To control plant height	Bonzi	30 ppm spray (0.96 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rate as needed for desired final plant height and length of height control.
			0.118 mg a.i. drench for a 6 in. pot (0.032 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench application volumes vary with pot size.
		Cycocel	800 to 4,000 ppm spray (0.87 to 4.34 fl oz/gal)	Optimum rate depends on species, desired amount of height control, and environmental conditions. The suggested initial rate for small-scale trials is 1,250 ppm. Example herbaceous species known to respond to cycocel are Achimenes, Aster, Astilbe, Begonia (hiemalis), Begonia (tuberous), Calceolaria, Carnation, Chrysanthemum, Columbine, Easter lily, *Gynura aurantiaca*, Ivy, Kalanchoe, *Lilium* spp., Morning glory, Pachystachys, *Pilea* spp., Pentas, *Salvia* spp., Schefflera, *Sedum* spp., and Sunflower.
			2,000 to 4,000 ppm drench	Drench application volumes vary with pot size. See label for recommended volumes. Herbaceous species known to respond to cycocel are listed above.
Flowering/ Foliage Plants, Woody Species (Not specifically listed in this table)	To control plant height	Bonzi	50 ppm spray (1.6 fl oz/gal)	Users should conduct trials on a small number of plants, adjusting the rate as needed for desired final plant height and length of height control.
			0.237 mg a.i. drench for a 6 in. pot (0.064 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench application volumes vary with pot size.
		Cycocel	800 to 4,000 ppm spray (0.87 to 4.34 fl oz/gal)	Optimum rate depends on species, desired amount of height control, and environmental conditions. The suggested initial rate for small-scale trials is 1,250 ppm. Example woody species known to respond to cycocel are *Baleria cristata*, Bougainvillea, Camellia, Gardenia, Fuchsia, Hollies, Hydrangea, Lantana, *Pseuderanthemum lactifolia*, Rhododendron, and Roses (potted).
			2,000 to 4,000 ppm drench	Drench application volumes vary with pot size. See label for recommended volumes. Woody species known to respond to cycocel are listed above.
Freesia	To control plant height	Bonzi	100 to 300 ppm corm soak (3.2 to 9.6 fl oz/gal)	Soak corms in the solution for 1 hour before planting.
Fuchsia	To increase lateral branching	Atrimmec	781 to 2,343 ppm spray (0.5 to 1.5 fl oz/gal)	
		Florel	500 ppm spray (1.619 fl oz/gal)	Florel applications will provide some growth retardant effects. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Gardenia	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
		B-Nine	5,000 ppm spray (0.79 oz/gal)	
	To increase lateral branching	Atrimmec	2,343 to 4,687 ppm spray (1.5 to 3.0 fl oz/gal)	
Geranium	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		Bonzi	10 to 30 ppm spray (0.32 to 0.96 fl oz/gal)	Apply to zonal geraniums when new growth is 1.5 to 2 inches long. Apply to seed geraniums approximately 2 to 4 weeks after transplanting.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Geranium, continued	To control plant height	Cycocel	800 to 1,500 ppm spray (0.87 to 1.63 fl oz/gal)	First application should be made 2 to 4 weeks after planting plugs or rooted cuttings (after stems have started elongating). Multiple applications may be needed.
		Sumagic	3 to 6 ppm spray (0.77 to 1.54 fl oz/gal) for cutting geraniums and 2 to 4 ppm spray (0.51 to 1.02 fl oz/gal) for seed geraniums	See Ageratum.
	To promote earlier flowering in seed geraniums	Cycocel	1,500 ppm spray (1.63 fl oz/gal)	Make two applications at 35 and 42 days after seeding. Treated plants should flower earlier, be more compact, and more well-branched than untreated plants.
	To increase lateral branching	Atrimmec	1,562 ppm spray (1 fl oz/gal)	Labeled for ivy geraniums only.
		Florel	500 to 1,000 ppm spray (1.619 to 3.24 fl oz/gal)	Labeled for zonal and ivy geraniums. Use the lower concentration for ivy geraniums. Florel will also provide some growth retardant effect. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Gerbera Daisy	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
Gomphrena	To control plant height	Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	See Ageratum.
Grape Ivy	To increase lateral branching	Atrimmec	781 to 1,562 ppm spray (0.5 to 1 fl oz/gal)	
Hibiscus	To control plant height	Bonzi	30 to 150 ppm spray (0.96 to 4.8 fl oz/gal)	Application should be made when laterals are 1 to 4 inches long. Single applications control lateral growth for 3 to 6 months.
		Cycocel	200 to 600 ppm spray (0.22 to 0.65 fl oz/gal)	Multiple applications starting prior to first pinch are recommended.
Holly	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
Hyacinth	To reduce stem topple	Florel	1,000 ppm spray (3.24 fl oz/gal)	Contact floricultural specialists at N. C. State University.
Hybrid Lily	To control plant height	Bonzi	250 to 500 ppm spray (8.0 to 16.0 fl oz/gal)	See Caladium.
			1.183 to 2.366 mg a.i. drench for a 6 in. pot (0.32 to 0.64 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	
			20 to 30 ppm bulb soak (0.64 to 0.96 fl oz/gal)	Soak bulbs in the solution for 15 minutes prior to planting.
Hydrangea	To control plant height	B-Nine	2,500 to 7,500 ppm spray (0.39 to 1.18 oz/gal)	Contact floricultural specialists at N. C. State University.
Hypoestes	To control plant height	Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	See Ageratum.
Iberis	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
Impatiens	To control plant height	Bonzi	5 to 45 ppm spray (1.44 to 2.02 fl oz/gal)	See Ageratum.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Impatiens, continued	To control plant height	Sumagic	5 to 10 ppm spray (1.28 to 2.56 fl oz/gal)	See Ageratum.
Jerusalem Cherry	To control plant height	Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	See Ageratum.
Kalanchoe	To increase lateral branching	Atrimmec	1,042 to 2,343 ppm spray (0.67 to 1.5 fl oz/gal)	
Lantana	To increase lateral branching	Atrimmec	781 to 1,562 ppm spray (0.5 to 1 fl oz/gal)	
		Florel	500 ppm spray (1.619 fl oz/gal)	Florel applications will provide some growth retardant effects. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Liatris	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
Lipstick Vine	To increase lateral branching	Atrimmec	521 to 1,042 ppm spray (0.33 to 0.67 fl oz/gal)	
Marigold	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	2,500 to 5,000 ppm spray (0.39 to 0.79 oz/gal)	
		Bonzi	10 to 60 ppm spray (0.32 to 1.92 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	10 to 20 ppm spray (2.56 to 5.12 fl oz/gal)	
Monstera	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Montbretia	To control plant height	Bonzi	20 to 30 ppm corm soak (0.64 to 0.96 fl oz/gal)	Soak corms in the solution for 15 minutes prior to planting.
Nastursium	To control plant height	Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
Nepthytis, Green & Green Gold	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Pansy	To control plant height	Bonzi	1 to 15 ppm spray (0.03 to 0.48 fl oz/gal)	See Ageratum.
		Sumagic	1 to 6 ppm spray (0.26 to 1.54 fl oz/gal)	
Petunia	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	2,500 to 5,000 ppm spray (0.39 to 0.79 oz/gal)	
		Bonzi	5 to 60 ppm spray (0.16 to 1.92 fl oz/gal)	
		Sumagic	25 to 50 ppm spray (6.4 to 12.79 fl oz/gal)	
Philodendron	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Phlox	To control plant height	B-Nine	5,000 ppm spray (0.79 oz/gal)	
Pilea	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Poinsettia	To control plant height	A-Rest	0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Contact floricultural specialists at N. C. State University.
		B-Nine	2,000 to 3,000 ppm spray (0.31 to 0.47 oz/gal)	Not effective in our studies.
		B-Nine + Cycocel	800 to 2,500 ppm B-Nine (0.13 to 0.39 oz/gal) + 1,000 to 1,500 ppm Cycocel (1.08 to 1.63 fl oz/gal) spray	Use the higher rates of this tank mix spray on stock plants and for finishing crops in very warm regions. Outside of very warm areas, growers should use the lower rates. Too late of an application can delay flowering and reduce bract size.
		Bonzi	10 to 30 ppm spray (0.32 to 0.96 fl oz/gal)	Contact floricultural specialists at N. C. State University.
			0.237 to 0.473 mg a.i. drench for a 6 in. pot (0.064 to 0.128 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench volume vary with pot size. Consult the label for recommended volumes.
		Cycocel	800 to 1,500 ppm spray (0.87 to 1.63 fl oz/gal)	For natural season crops in N.C., do not apply cycocel after Nov. 1. Late applications can reduce bract size and delay flowering.
			3,000 to 4,000 ppm drench (3.25 to 4.34 fl oz/gal of drench solution)	Drench volume vary with pot size. Consult the label for recommended volumes.
		Sumagic	2.5 to 10 ppm spray (0.64 to 2.56 fl oz/gal)	Contact floricultural specialists at N. C. State University.
Pothos	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Purple Passion (*Gynura aurantiaca*)	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Salvia	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	5,000 ppm spray (0.79 oz/gal)	
		Bonzi	5 to 60 ppm spray (0.16 to 1.92 fl oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	5 to 10 ppm spray (1.28 to 2.56 fl oz/gal)	
Schefflera	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
			0.25 to 0.5 mg a.i. drench for a 6 in. pot (1 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
	To increase lateral branching	Atrimmec	3,125 ppm spray (2 fl oz/gal)	Labeled for *Schefflera arboricola* only.
Shrimp Plant	To increase lateral branching	Atrimmec	781 to 1,562 ppm spray (0.5 to 1 fl oz/gal)	
Snapdragon	To control plant height	Bonzi	5 to 90 ppm spray (0.16 to 2.88 fl oz/gal)	See Ageratum.
		Sumagic	25 to 50 ppm spray (6.4 to 12.79 fl oz/gal)	
Spathiphyllum	To induce flower initiation	GibGro	250 ppm spray (1 fl oz/gal)	GibGro has 24(c) registration for distribution and greenhouse use only within North Carolina. One application should be made during the non-seasonal blooming period, typically June through January.

Crop	Purpose	Chemical	Rate	Precautions and Remarks
Sunflower	To control plant height	Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
Tulip	To control plant height	A-Rest	0.125 to 0.5 mg a.i. drench for a 6 in. pot (0.5 to 2 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench rates and application volumes vary with pot size. Contact floricultural specialists at N. C. State University.
		Bonzi	0.591 to 4.732 mg a.i. drench for a 6 in. pot (0.16 to 1.28 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	Drench application volumes vary with pot size.
			2 to 5 ppm bulb soak (0.064 to 0.16 fl oz/gal)	Soak bulbs for 1 hour prior to planting.
Verbena	To control plant height	B-Nine	5,000 ppm spray (0.79 oz/gal)	See Ageratum.
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
	To increase lateral branching	Atrimmec	521 to 1,042 ppm spray (0.33 to 0.67 fl oz/gal)	
		Florel	500 ppm spray (1.619 fl oz/gal)	Florel applications will provide some growth retardant effects. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Vinca (*Catharanthus*)	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		B-Nine	2,500 ppm spray (0.39 oz/gal)	
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	
		Sumagic	1 to 3 ppm spray (0.26 to 0.77 fl oz/gal)	
Vinca Vine (*Vinca spp.*)	To increase lateral branching	Florel	500 ppm spray (1.619 fl oz/gal)	Florel applications will provide some growth retardant effects. A delay in flowering will also occur with the use of Florel. Read the label for restrictions on timing of applications.
Viola	To control plant height	Sumagic	1 to 5 ppm spray (0.26 to 1.28 fl oz/gal)	See Ageratum.
Wandering Jew	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	
Woody Landscape Plants (Not specifically listed in this table)	To control plant height	Bonzi	0.473 mg a.i. drench for a 6 in. pot (0.128 fl oz/gal of drench solution; apply 4 fl oz/6 in. pot)	See Bedding Plants
			100 ppm spray (3.2 fl oz/gal)	
Zinnia	To control plant height	A-Rest	26 to 132 ppm spray (12.6 to 64 fl oz/gal)	See Ageratum.
		Cycocel	400 to 3,000 ppm spray (0.43 to 3.25 fl oz/gal)	

1997 NCCFGA Dues were due 1 January 1997. Please return payment as soon as possible if you have not done so already. Dues must be received prior to 1 April 1997 for inclusion in the 1997 Membership Directory.

INSECT CONTROL IN THE GREENHOUSE

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(The following article is based on a presentation to the New Jersey Flower Growers Meeting and Trade Show November 7 and it is a summary of the different kinds of control practices used in greenhouses today. Last Issue of the Bulletin included a listing of pesticides for chemical control of greenhouse pests. Stay tuned for articles in the next issue of the NCCFG Bulletin on screening and biocontrols.)

Careful as a grower may be, sooner or later an insect or mite will come in on the clothes of workers, on cuttings, in pots, or in soil. Control of pests in greenhouses is difficult because of lush, sheltered growing conditions. Insects, mites, and slugs reproduce more rapidly at warmer temperatures, and what was once a single pest soon becomes a severe infestation in the greenhouse environment.

Chemical Control

The application of pesticides is almost essential to stay in business. However, total reliance on pesticides for pest control is labor intensive and often very hard on the plants. Even though there are practical and philosophical problems with chemical control of insect and mite pests in greenhouses (such as pesticides periodically as "insurance" against accidental infestations), pesticides will remain important in greenhouse pest management in the foreseeable future.

Integrated Pest Management

IPM uses all suitable methods to reduce insect and mite populations to the lowest acceptable level. IPM is often more complex to explain than it is to do because each crop must be considered individually, but some basic practices apply to most greenhouse crops. Eliminating weeds inside and outside and screening doors and vents make it harder for pests to fly in and lay eggs or feed. Despite these precautions, however, pests may become established.

Clothing: An effort should be made to avoid carrying insects into the greenhouse by wearing clothes that are brown, red or black. Do not wear white, yellow or green, as these colors are attractive to aphids, thrips, whiteflies, leafminers, and darkwinged fungus gnats. Light to dark blues also are attractive to aphids and thrips.

Quarantine: Before any plant material is brought into the greenhouse, it should be thoroughly inspected for insects, mites, and diseases. If practical, new plants should be kept in a separate section for a week or so before being incorporated into the production. Such highly resistant pests as aphids, western flower thrips, and whiteflies move readily on plant material. The movement of infested plant material is without doubt the major way resistant thrips, aphids, and whiteflies are transported throughout the greenhouse industry.

Screening: Exclusion demonstrations at North Carolina State University have shown that western flower thrips and whiteflies can be significantly excluded by woven fabrics such as BugBed 110 (available from Green Thumb Group, 1-800-240-3371) and NoThrips (available through greenhouse suppliers). With screening, the finer the mesh, the greater is the tendency to restrict air flow into the greenhouse. Thus screens should be properly sized to allow sufficient ventilation.

Pest Recognition: Probably the most frequently mixed up pests are shore flies and darkwinged fungus gnats. Shore flies are of little economic consequence in the greenhouse but are

very resistant to pesticides. Thus a grower can waste effort and pesticides trying to chemically control shore flies rather than controlling algae the shore flies are breeding in. Another example of mis-identification is the assumption that parasitized aphids are some sort of new "tan" aphid. Parasitized aphids adhere to the plant, so in spite of repeated applications, these "tan" aphids seem to be impossible to kill. Trade journals and Extension publications (such as Baker, 1994) can help with pest identification.

Monitoring: Some growers treat only when they discover pests, but growers should survey the plants on a daily or every-other-day basis to guard against insects, mites, or slugs. One employee or could be assigned the responsibility of scouting for insects and other pests on a regular basis (perhaps weekly during the winter and twice weekly during the summer). Written records of where various pests are found should be kept. Pests can be monitored by using yellow and blue sticky cards, by using yellow pan traps, and by examining the foliage, flowers, and occasionally the roots. Light traps outside can be used to monitor for European corn borer, corn earworm, and beet armyworm moths.

Record Keeping: A written log should be kept of pest type, location, abundance, and pesticides applied. Such records can be of long-term benefit as many pests tend to appear at about the same time each year. However, the short-term benefits of written records may be greater. Knowing what pests survive a pesticide application alerts the grower to the possibility of poor timing, poor application, or pesticide resistance in the pest population. A change can be made before the crops are significantly damaged.

Biological Control: Some growers use beneficial organisms for biological control where appropriate. Unfortunately, there are no really effective organisms available for managing the western flower thrips. Encarsia formosa parasitic wasps infest whiteflies and Amblyseius predatory mites, used for spider mites, also feed on thrips. Bacterial and nematode organisms can be readily integrated into a traditional pest controls, whereas other biological controls are more fragile. Aphytis wasps, Aphidoletes maggots, and green lacewings are available for aphid suppression. Bacillus thuringiensis kurstaki pesticides are available for caterpillars. Steinernema carpocapsae nematodes suppress darkwinged fungus gnats. Cryptolaemus and Delphastus lady beetles (when available) can be used for mealybugs and whiteflies. Parasitic wasps are available for soft scale management and predaceous mites are available for spider mite suppression. Many firms such as IPM Laboratories, Inc., P. O. Box 0099, Locke, NY 13092-0099 (telephone: 315-497-3129) have a wide supply of biological control organisms available. Except for Bacillus thuringiensis, the use of biologicals is usually not compatible with the use of chemical sprays. It is possible to integrate sprays of soaps and oils with Encarsia formosa by timing pesticide applications to coincide with the "black or brown scale" stage of the parasite's development. Also the "brown mummy" stage of aphids infected with Aphytis wasps are resistant to soaps and oils.

Organic Control

Organic growers usually don't rely on pesticides for routine pest management. Organic growers tend to be highly receptive to the basic integrated pest management practices (screening, biological control, and monitoring). The pesticides organic growers can use is limited to those certified to be "organic" by various organizations such as the California Certified Organic Farmers. Some of these chemicals work well and others are marginally effective. Finding a variety of formulations that are certified as organic and that are actually labeled for greenhouse use is also a problem. Some organic growers in North Carolina use screening to exclude pests and methods such as irrigation to dislodge and destroy mites and aphids or washing the produce by hand at harvest to remove pests.

Organic Chemicals: Soaps and oils can be used for aphid suppression. Soaps, oils, neem extracts, and pyrethrum sprays and aerosols are moderately toxic to whiteflies. Bacillus thuringienses kurstaki pesticides and pyrethrum sprays, and aerosols are effective for caterpillar control. Soaps and pyrethrum pesticides suppress mealybugs. Spider mites are susceptible to soaps and oils. Pyrethrum sprays and aerosols help suppress thrips.

Required Reading

Baker, J. R. (ed.) 1994. Insect and Related Pests of Flowers and Foliage Plants. NC Coop. Ext. Serv. pub. AG-136. 106 pp.

Shearin, E. A. and J. R. Baker. 1995. computer program for sizing insect exclusion screens for greenhouses. N.C. Flower Growers' Bull. 40 (1): 10.

Willits, D. H. 1993. Greenhouse cooling. N. C. Flower Growers' Bull. 38 (2): 15-8.

CALENDAR OF EVENTS

Event	Date	Time	Location and contacts
Southeast Greenhouse Conference and Trade Show	Thursday–Saturday 12–14 June		Palmetto Expo Center, Greenville, S.C. Contact Charles Hall at 800-453-3070 for further information.
NCCFGA Board Meeting	Friday June 13	TBA	At the SGCTS in Greenville, S.C. Contact Bonnie Holloman for further details at 919-779-4618.
NCSU Bedding Plant Field Day	Wednesday 30 July	9:00 am to 3:30 pm	Horticulture Field Laboratory, Raleigh, N.C. Contact Bonnie Holloman for further details.
NCCFGA General Membership Meeting	Wednesday 30 July	3:30 pm	McKimmon Center, Raleigh, N.C. Bonnie Holloman for further details.
NCCFGA Board Meeting	Friday June 13	4:00 pm	McKimmon Center, Raleigh, N.C. Contact Bonnie Holloman for further details.

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