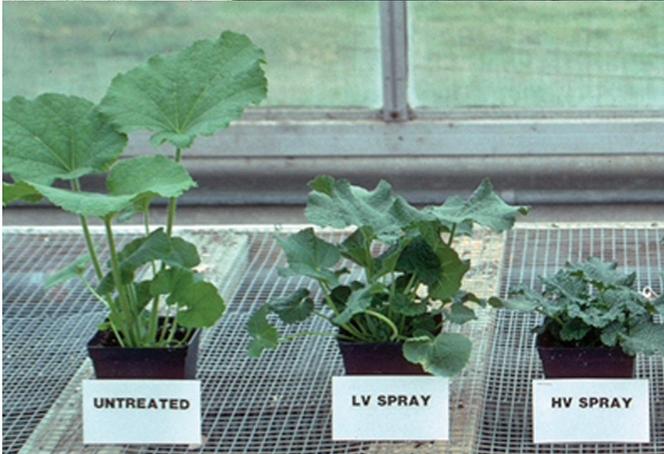


USING PLANT GROWTH REGULATORS ON CONTAINERIZED HERBACEOUS PERENNIALS



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Production of Herbaceous Perennials

There is a tremendous diversity of herbaceous perennial plant species being grown for both the retail and landscaping sectors of the industry. Because of the diversity of species grown, there is much more unknown about perennials production than is known. Growth regulation is of particular concern. In production settings, as well as in retail locations, herbaceous perennials grown in pots tend to stretch and become leggy or simply overgrow their pots before their scheduled market date. These plants are less marketable and harder to maintain. Many growers resort to pruning, which is not only costly in terms of labor, but also delays plant production for two to four weeks.

Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth and/or development. They are applied for specific purposes to bring about specific plant responses. Although there is much scientific information on using PGRs in the greenhouse, it is not an exact science. Achieving the best results with PGRs is a combination of art and science — science tempered with a lot of trial and error and a good understanding of plant growth and development.

Availability of chemical plant growth regulators for perennials is not a problem. All of the primary floriculture growth retardants are labeled for use on perennials. The issues are (1) lack of knowledge about rates, and (2) the wide disparity of plant responses to these PGRs. Even after years of research, many of the herbaceous perennials in the market have never been evaluated for their response to any of these chemicals (figure 1).



Figure 1. Greenhouse and nursery production of herbaceous perennials encompass hundreds of different crops. Growth management needs vary widely with species and cultivar.

This publication provides basic information on selecting and applying PGRs to affect growth, branching, and flowering — with an emphasis on their use on perennials — followed by a discussion of specific growth regulators used on herbaceous perennials. This discussion references a table located in the appendix that summarizes the results of research trials using PGRs on more than 100 perennial species/cultivars.

Choosing the Correct PGR

For best results, PGRs should be handled as production tools — like water and fertilizer. They should not be used as crutches for poor management of other cultural practices. PGRs should be an integrated part of your crop production cycle.

The selection of PGRs and their application rates will be affected by how your crop is grown. Especially with very vigorous plants, as many of the herbaceous perennials are, higher fertility and irrigation levels will increase the amounts of growth regulator required to prevent excessive growth. Shading, lower light levels, or tight plant spacing — especially under higher growing temperatures — will also increase plant stretch and reduce lateral branching. For the highest-quality plants, the use of PGRs must be integrated into your production plan.

PGRs are most effective when applied at the appropriate times to regulate plant growth or development. In other words, growth retardants cannot shrink an overgrown plant. They must be applied before the plant is overgrown to avoid plant stretch. When planning PGRs in your production schedule, consider what you want to accomplish with the treatment.

- Do you want to **regulate shoot growth** of the plant, resulting in a sturdier, more compact plant with improved color? If so, you probably want a **growth retardant**.
- Do you want to **increase plant branching** for enhanced cutting production or for a bushier potted plant or hanging basket? If so, you probably want to use a **branching agent** or “chemical pincher.”
- Do you want to **enhance flower initiation** or synchronize flowering? If so, you probably want to use **chlormequat chloride** or **gibberellic acid**.
- Do you want to **remove flowers** from stock plants to increase the number of vegetative cuttings? If so, you probably want to use an **ethylene generating compound**.

Answering these questions will indicate what type of PGR you need to use to accomplish your goal and the most appropriate timing of the application. Then you will need to select a specific PGR in that class and determine the appropriate dosage and application method to attain the desired response. We'll get into those details later.

Regulating Shoot Growth

Most PGRs used in the greenhouse or nursery are used to regulate shoot growth of containerized crops. These PGRs are referred to as “growth retardants.” Typical growth retardants are daminozide (B-Nine or Dazide), chlormequat chloride (Citadel or Cycocel), ancymidol (Abide or A-Rest), flurprimidol (Topflor), paclobutrazol (Bonzi, Downsize, Paczol, Piccolo, or Piccolo 10 XC), and uniconazole (Concise or Sumagic) (table 1).

These PGRs control plant height by inhibiting the production of gibberellins — the primary plant hormones responsible for cell elongation. Therefore, these growth-retardant effects are primarily seen in stem, petiole, and flower stalk tissues. Lesser effects are seen in reductions of leaf expansion, resulting in thicker leaves with a darker green color (figure 2).

Other benefits of using these PGRs in plant production include improved plant appearance by maintaining plant size and shape in proportion with the pot. Plant growth retardants also increase the tolerance of plants to the stresses of shipping and handling, as well as drought or temperature stresses common during retail marketing, thereby improving shelf life and extending plant marketability.

Generally, growth-retarding PGRs should be applied just prior to rapid shoot growth. This is usually one to two weeks after transplanting a plug/liner, after the roots are established and as the plant resumes active growth. On pinched plants, it is after the new shoots are visible and starting to elongate.

This is where the art of plant growth regulation is most important. You must learn how your crop grows and when to intervene to obtain the desired results. Remember to note details of crop development in your records of PGR treatments. For example, due to weather conditions, next year you may need to treat at seven days after transplanting instead of at 10 days after transplanting, which you used this year. You must gauge when rapid elongation will likely occur and treat to counter it.



Figure 2. *Digitalis* 'Foxy' untreated (left) and treated with 15 ppm uniconazole (right). Plant growth regulators “green up” plants by concentrating chlorophyll into smaller leaf cells, improving plant color and appearance.

Enhancing Lateral Branching

Another group of PGRs used in floricultural crops are those that enhance branching, including ethephon (Collate, Florel), benzyladenine (BA; Configure), dikegulac sodium (Atrimmec), and methyl esters (Off-Shoot-O) (table 2). These PGRs are frequently called “chemical pinchers” because they generally inhibit the growth of the terminal shoots or enhance the growth of lateral buds, thereby increasing the development of lateral branches. They can be used to replace mechanical pinching of many crops like *Vinca* vine, *Verbena*, *Lantana*, and English ivy (*Hedera*). Often, this increased branching will also reduce the overall height of the plant.

The ethylene released inside the plant by ethephon also inhibits internode elongation, keeping treated plants more compact than untreated plants. Ethephon also affects flowering (see Enhancing Plant Flowering). Configure is a synthetic cytokinin (6-benzyladenine), which is a plant hormone that stimulates lateral branching. If you are looking for enhanced branching, you must have sufficient growth on the plant to allow for sites of lateral development. They cannot enhance lateral branching if there are no laterals on the plant. Timing of the application is critical to a good branching response.

Again, read the label for details of when to apply for optimum response. Always consider the side effects of treatments. As mentioned in tables 1 and 2, some of these PGRs reduce or eliminate flowering.

Table 1. Plant growth regulators used to reduce plant height during the production of floricultural crops.

Common name/ Trade names ¹	Application methods	Comments	Concerns
Ancymidol	Foliar spray	Broad-spectrum label.	Very safe.
Abide (Fine Americas Inc.)	Bulb dip	Very active on many bedding plants; commonly used on plugs.	Maximum spray rate is 132 ppm. ² Do not add wetting agent.
A-Rest (SePRO Corp.)	Drench	Abide label prohibits spray applica- tions in shadehouses or nurseries.	Follow all label directions for all chemigation uses.
	Chemigation	Drench applications can be made indoors or outdoors.	Do not reuse pots, trays, or media pre- viously treated with ancymidol.
	Injection	A-Rest labeled for use as spray or drench on containerized ornamentals grown in nurseries, greenhouses, sha- dehouses, and interiorscapes.	
Daminozide	Foliar spray	Apply uniformly to all foliage.	Safe; few incidences of phytotoxicity or overstunting.
B-Nine 85WSG (OHP Inc.)	Cutting dip	No soil activity. Effective on a broad list of species, but low-level activity and short residual; multiple applications generally required.	Do not overhead irrigate within 24 hours after treatment.
Dazide 85WSG (Fine Americas Inc.)		Increased activity when tank-mixed with chlormequat chloride. B-Nine 85WSG is labeled for use on beds and containers in greenhouses, shadehouses, and nurseries. Limited to containerized plants in uncovered pro- duction areas. Dazide 85WSG is labeled for use in greenhouses and other enclosed struc- tures where spray drift cannot occur.	Do not tank-mix daminozide with compounds containing copper or apply daminozide within 7 days of such treatments.
Chlormequat chloride	Foliar spray	Standard for geraniums, poinsettias, and hibiscus; enhances flowering of geranium and hibiscus.	Causes transient discoloration of leaves, especially with rates above 1,500 ppm; phytotoxicity reduced in tank mix with daminozide.
Citadel (Fine Americas Inc.)	Drench	Label allows use on a broad spectrum of crops in the greenhouse.	Less effective under high-temperature conditions.
Cycocel (OHP Inc.)		Activity is low; multiple applications generally required. Maximum number of applications varies with crop (check labels for specifics). Increased activity when tank-mixed with daminozide. Only Cycocel is labeled for use as a spray on containerized plants in the outdoor nursery (max 3,000 ppm, 3 times in any crop production cycle).	See Cycocel label for outdoor-use restrictions.

Table 1. Plant growth regulators used to reduce plant height during the production of floricultural crops. (cont.)

Common name/ Trade names ¹	Application methods	Comments	Concerns
Flurprimidol Topflor (SePRO Corp.)	Spray Drench Chemigation Subirrigation	Labeled for use as spray or drench on containerized ornamental plants grown in nurseries, greenhouses, and shadehouses.	Applications not to exceed 3 pounds a.i. ³ per acre, per year. Do not use wetting agents. Do not reuse pots, trays, or media previously treated with flurprimidol.
Paclobutrazol Bonzi (Syngenta Crop Protection) Downsize (Greenleaf Chemical LLC) Paczol (OHP Inc.) Piccolo (Fine Americas Inc.) Piccolo 10 XC (Fine Americas Inc.)	Spray Media spray (Paczol only) Drench Bulb dip Liner soak (Paczol, Piccolo, only) Chemigation Subirrigation	Labeled for use as spray or drench on containerized ornamental plants grown in nurseries, greenhouses, shadehouses, and interiorscapes. Downsize is labeled only for drench applications indoors or outdoors, manually or through chemigation. Piccolo and Piccolo 10 XC spray applications are limited to enclosed areas (greenhouses) to eliminate drift. Much more active than above PGRs; measure accurately. Spray procedure and uniformity greatly affects results. Apply uniformly to cover stems (not absorbed by leaves). Very soil-active as a drench. Piccolo 10 XC (4% a.i.) is a clear concentrate that requires less agitation.	Spray volume critical to establishing rates due to drench effect of runoff. Use higher rates under high-temperature conditions. Late applications can reduce flowering. Consistently agitate the spray/drenching solution to ensure uniform distribution during application. Phytotoxicity includes overstunting. Avoid drift onto nontarget plants. Follow all label directions for all chemigation uses. Do not reuse pots, trays, or media previously treated with paclobutrazol.
Uniconazole Concise (Fine Americas Inc.) Sumagic (Valent USA Corp.)	Spray Media spray Drench Bulb dip Liner soak (Concise only)	Labeled for use as spray or drench on containerized ornamental plants grown in greenhouses, lathhouses, and shade structures. Sumagic is also labeled for some greenhouse-grown vegetable transplants (see Supplemental Label). Apply uniformly to cover stems (not absorbed by leaves). Spray procedure and uniformity greatly affects results. Very soil-active as a drench.	Spray volume is critical to establishing rates due to drench effect of runoff. Use higher rates under high-temperature conditions. Do not add wetting agents. Late applications can reduce flowering. Phytotoxicity includes overstunting. Avoid drift onto nontarget plants. High leaching potential. Do not apply to pots on dirt floors. Do not reuse pots, trays, or media previously treated with uniconazole.

Notes:

1. Mention of specific products does not imply endorsement. However, some products that have not been tested by the authors have been omitted.
2. ppm = parts per million
3. a.i. = active ingredient

Table 2. Other plant growth regulators used in the production of floricultural crops.

Common name/ Trade names ¹	Application methods	Comments	Concerns
Ethephon Florel brand Growth Regulator (Monterey Lawn and Garden Products Inc.) Collate (Fine Americas Inc.)	Foliar spray	Promotes lateral branching, thereby reducing stem elongation. Also aborts flowers; improves stock plant branching and cutting yield. Use early in crop cycle to increase branching and remove early flowers (6-8 weeks before flowering).	The pH of spray solution should be below 5.0. Use within 4 hours of mixing. Results less predictable under high-temper- ature conditions. Do not treat plants under environmental stress conditions.
Benzyladenine Configure (Fine Americas Inc.)	Foliar spray	Enhances lateral branching of green- house-grown, containerized ornamentals. Not labeled for chemigation.	May need to add wetting agent for waxy crops. Eye hazard! Follow label directions for per- sonal protection. Not translocated in the plant, so thorough plant coverage required. Short residual. Multiple applications may improve response at 2-week intervals.
Benzyladenine/ GA₄₊₇ Fascination (Valent USA) Fresco (Fine Americas Inc.)	Foliar spray	Growth promoter and reduced yellow- ing of lily leaves. Labeled for growth promotion to overcome growth-retardant effects on containerized and field-grown ornamentals.	Effective dose strongly affected by volume (soil-active). Do not reuse media from plants treated with these products. Thorough coverage required. Do not tank-mix. Avoid application to plants under condi- tions of environmental stress. For perennials, start with low rates, 1-3 ppm. ² Repeat in 5 days if necessary.
Gibberellic acid (GA₃) Florgib 4L (Fine Americas Inc.) GA₃ 4% (Greenleaf Chemical LLC) ProGibb T&O (Valent USA)	Foliar spray	Growth promoter. Broad-use label on containerized and field-grown ornamentals. ProGibb T&O and GA₃ 4% are labeled for growth promotion to overcome growth-retardant effects on container- ized and field-grown ornamentals.	Overapplication or incorrect timing can cause weak stems and excessive stem elongation. Very potent growth promoter. Start with 1 ppm on most crops. Water should always have a pH less than 8.5. Do not reuse media from plants treated with these products.
Dikegulac sodium Atrimmec (PBI Gordon)	Foliar spray	Broad label lists greenhouse, nursery, and landscape production sites. Inhibits terminal growth, thereby pro- moting lateral development. Apply to actively growing plants with at least 2 nodes to provide sufficient lateral development.	May delay plant development at higher rates. Causes leaf chlorosis that may be persistent at high rates. Do not pinch or prune soon after treatment. Do not add wetting agents.

Table 2. Other plant growth regulators used in the production of floricultural crops.

Common name/ Trade names ¹	Application methods	Comments	Concerns
Methyl esters of fatty acids Off-Shoot-O (Cochran Corp.)	Foliar spray	Labeled for chemical pinching of actively growing azalea, cotoneaster, juniper, ligustrum, <i>Rhamnus</i> , and <i>Taxus</i> .	Ensure coverage of growing points. Do not spray more than once.
Notes:			
1. Mention of specific products does not imply endorsement. However, some products that have not been tested by the authors have been omitted.			
2. ppm = parts per million			

Enhancing Plant Flowering

Plant growth regulators can be used to enhance flowering (GA₃ products). To improve flowering, Florigib 4L or ProGibb T&O, which contains the growth promoter gibberellic acid (GA₃), can be used to substitute for all or part of the chilling requirement of some woody and herbaceous ornamentals typically forced in the greenhouse, including azalea for florist crops and *Aster* for cut flowers. These compounds can also improve flowering and/or bloom size of camellia, baby's breath (*Gypsophila*), and statice (*Limonium*). Gibberellic acid is also used to promote growth and increase stem length of other cut flowers like stock (*Matthiola*), *Delphinium*, and Sweet William (*Dianthus*). See product labels for specific uses and recommended rates.

Again, timing is critical because late applications or excessive rates may cause excessive plant stretching, resulting in weak, spindly stems. Chlormequat chloride (a plant growth retardant) used to control stem height of hibiscus and geranium also improves early flowering of these crops.

Removal of Flowers

Flower removal is especially desirable for stock plants maintained for cuttings of vegetatively propagated ornamentals, like *Verbena* or *Lantana*. Ethephon is the primary compound used for flower removal. Once ethephon is absorbed by the plant, it is converted to gaseous ethylene — a natural plant hormone effective in many plant processes. Ethylene is the primary hormone responsible for flower senescence and fruit ripening. It is the “postharvest” hormone. With proper rates and timing, it will remove unwanted flowers from stock plants, cuttings, or plugs/liners. Flower removal diverts more energy into vegetative growth, increases the number of laterals available for cuttings on stock plants, and promotes increased branching of plugs/liners and finished plants, which increases fullness in the container. Because initiation and development of flowers

require time, ethephon should not be used on crops within six to eight weeks of marketing.

Read the Label!

Plant growth regulators are classified as pesticides. Therefore, they are subject to all of the same U.S. Department of Agriculture (USDA) recordkeeping and Worker Protection Standard (WPS) rules as all of your other pesticides. Their use is governed by the manufacturer's label, as with other pesticides. The label not only contains information on restrictions, but it also has a great deal of information on how to use the product effectively. Before going to the time and expense of applying PGRs to your crop, answer these questions:

- Is the chemical labeled for the crop you wish to treat? Most PGR labels have undergone revisions that apply to a broad range of similar crops not specifically listed on the label, with the user taking responsibility for determining appropriate rates. This provides label permission to use the compound on these crops without the manufacturer accepting the responsibility for the rate selection.
- Is the chemical labeled for the area you wish to treat? Many PGRs are only labeled for use inside a greenhouse or other growing structure.
- Are there any potential side effects, such as phytotoxicity? Note that you may need to look elsewhere for this information for your specific crop.
- Are there label warnings regarding the PGR's effect on plant flowering? For example, many branching enhancers delay flowering. Ethephon causes flower bud abscission prior to enhancing branching; therefore, is not recommended within six to eight weeks of marketing. Side effects are frequently affected by the timing of the application, e.g., late applications of growth retardants may delay flowering.

Application Guidelines for Growth Regulators

Spray Application

Plants to be treated with PGRs should be healthy, turgid, and unstressed — never wilted. **The label will identify the target tissue for that PGR.** For example, daminozide is only effective as a foliar spray, whereas paclobutrazol and uniconazole sprays must reach the stems. When making spray applications, look at the growth and development of the plant to see that there is sufficient development to make the treatment effective and accomplish your goal. Generally, there should be sufficient foliage or stems to absorb the PGR.

Uptake and effectiveness of a PGR also depend on selecting the application technique that will ensure proper coverage of the target tissue. Daminozide is not soil-active. Therefore, a foliar spray application, wetting most of the foliage, is necessary to provide a uniform reduction in growth. Leaf surfaces should be dry for foliar applications, and the best uptake of PGRs from spray applications will occur under low-stress, low-drying conditions. This is more critical for daminozide and ethephon than for some of the newer chemistries, like the triazoles. Overhead irrigation after treatment with daminozide or ethephon should be delayed for 18 to 24 hours to avoid washing the material off of the leaves.

The triazoles — paclobutrazol and uniconazole — are absorbed primarily by stem tissue and then translocated upward in the plant. Therefore, consistent and complete coverage of the stems is necessary for uniform effects. In other words, if the stem of one lateral receives an inadequate amount of spray, it will grow faster than the others, resulting in a poorly shaped plant. Ancymidol and flurprimidol are taken up by both foliage and stems. In addition, all four of these compounds are very “soil-active,” which means they may be adsorbed to particles in the media and become available to the plant through root uptake. Therefore, drenching is a very effective application method for these chemicals in crops where it is economically feasible (see How to Apply Drenches).

The label will provide a recommended application volume for sprays, especially for chemicals that are soil-active. All foliar applications of PGRs should be applied on an area basis, i.e., uniformly spray the area where the plants are located with the recommended volume of solution. Do NOT spray individual plants or

spray to reach a subjective target, like “spray to glistening.” Every applicator will have a slightly different definition of these goals, so there is no way of recommending appropriate rates or obtaining predictable or consistent results.

For soil-active PGRs, dosage is dependent on both the concentration of the solution and the volume of that solution applied in the treated area. Therefore, to improve predictability, the label-recommended spray application rates are generally set at 2 quarts of finished spray per 100 square feet, which is sufficient to cover the plant and permit a small amount of runoff onto the medium. It is also considered to be a comfortable walking pace for applicators with hand-held sprayers. This is the same application volume recommended for daminozide, which is not soil-active.

With the soil-active PGRs, precautions should be taken to avoid overapplication with sprays. Spray applications require more attention to detail, because overspray material lands or drips onto the medium. The overspray from an application of 2 quarts per 100 square feet is part of the recommended dosage. However, if your application volume exceeds that recommendation, your application dosage also exceeds the recommendation (figure 3).

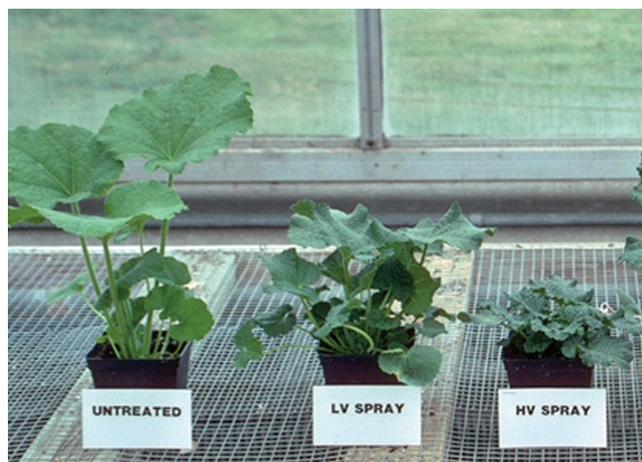


Figure 3. For the soil-active PGRs, spray application volume is critical. Hollyhock (*Alcea rosea*), left to right: untreated; treated with a foliar spray of 50 ppm paclobutrazol at the label-recommended volume of 2 quarts per 100 square feet; and treated at a high volume of 4 quarts per 100 square feet. Practice your technique to ensure a consistent application volume.

Recognizing that stem coverage is necessary for the triazoles, you may need to apply a higher-than-recommended volume to large or dense plants to obtain adequate coverage. In fact, the paclobutrazol label recommends 3 quarts per 100 square feet for “larger plants with a well-developed canopy.” Adjust the con-

centration you apply accordingly.

This suggests the importance of recordkeeping (see Recordkeeping). Always consider the rates presented in the appendix or from any other resource to be **guidelines** to assist you in developing your own rates based on your growing conditions and application methods.

The relationship of rate and volume can be exploited when treating multiple crops with different PGR needs. With a single solution of PGR in the spray tank, you can apply the label-recommended volume to attain your basic application dosage, or you can apply additional volume to crops that need additional growth regulation to attain a higher dosage. Application volume is another tool you can use to maximize your efforts and reduce time mixing or reloading higher concentrations of PGR solutions.

Spray Equipment

To assure proper spray volumes, your compressed air sprayer should be equipped with a pressure gauge and regulator, and you should consistently use the same nozzle for all PGR applications. Your sprayer should be calibrated by determining the output of the chemical with the selected nozzle at the selected pressure within a specified time period. Using this information, you can apply a known amount of material to a known area.

Spray droplet size also affects response, with smaller droplet sizes providing better coverage — but only up to a point. Mist- or fog-type applicators do NOT provide adequate volume for coverage of plant stems and the medium and, therefore, have not been effective when used with compounds like paclobutrazol and uniconazole. PGR applicators should be trained to uniformly apply a given amount of clear water in the greenhouse before they make PGR applications. Uniformity of the application is critical to the uniformity of the crop response (figure 4).



Figure 4. Uniformity of the spray application is critical to the quality of the crop. Both of these 'Forever and Ever' hydrangeas were treated with 10 ppm of uniconazole during the same spray application.

Applying Drenches

Although drench application has several advantages over sprays, traditional drenches are seldom used on perennials due to the higher application costs of handling individual pots. Drenches generally have less effect on flowering or flower size and tend to provide longer-lasting growth regulation than sprays. Drenches are easier to apply uniformly than sprays because the drench volume is easily measured; when applied to moist media, it is easy to obtain good distribution of the PGR in the media. Therefore, the resulting growth regulation is frequently more uniform.

The product label specifies the recommended volumes for drench applications to different size pots or types of media. In general, 4 fluid ounces of drench solution is applied to a 6-inch "azalea" pot, and that volume is adjusted up or down with pot size to obtain a volume where about 10 percent of the solution runs out of the bottom of the pot when the media is moist.

Remember that the amount of active ingredient applied to plants depends on both the concentration (ppm) of the solution and the volume applied. **Read the label.**

Alternative methods of applying PGRs directly to the media have been developed and are described on the label. For example, ancymidol, flurprimidol, and paclobutrazol are labeled for application through the irrigation system (chemigation). These are generally labeled for flood (subirrigation), drip irrigation, and overhead sprinkler systems. Again, rates vary with the volumes used and method of application. Paclobutrazol applied once by subirrigation requires 50 percent to 75 percent of the amount of paclobutrazol that is applied

in a typical drench application.

Pressure-compensated drippers are recommended for use with PGRs to more accurately regulate the volume of solution applied to each pot. Read and exactly follow the label for chemigation applications, especially with regard to safety of municipal water supplies.

Growers are using three other methods of providing a drench-type application of soil-active PGRs on a more economical scale: media surface application sprays, sprenches, and watering in.

Media surface application sprays are spray applications made to the surface of the media of filled flats or pots. The treatment is applied at normal-to-high spray volumes, but because it is applied to the media surface, it is activated by irrigation and is available to the plant in the root zone. Both paclobutrazol (Paczol only) and uniconazole are labeled for this method of application. Rates are lower than used for sprays but higher than used for drench applications.

Sprenches, the second method, is a high-volume foliar spray that results in additional runoff into the media, providing a drench effect. Rates are lower than those recommended for spray rates.

Watering in, the third technique, is a type of chemigation where the PGR is injected into the irrigation water and applied at each irrigation at very low rates of active ingredient. Only PGRs labeled for chemigation can be used for watering in.

All of these application methods use the relationship between rate and volume to provide the desired control. Again, you must develop techniques that fit your production methods and your growth management preferences.

Liner soaks or drenches are another specialized way to use soil-active growth retardants. Although many of the soil-active PGRs have been tested, only Paczol, Piccolo (paclobutrazols) and Concise (uniconazole) are labeled for this application (table 1). The root system of rooted liners or plugs is soaked into a solution of the PGR (or they may be thoroughly drenched in the plug tray). Extensive work has been conducted at the University of Florida on this application method:

- Liners should be dry, which is defined as the root ball being ready for irrigation but not under drought stress.

- Time in the solution is not critical; 30 seconds to two minutes is sufficient for saturation of the rootball.
- Liners may be planted immediately or held up to 10 days without loss of PGR effect.
- There is no loss of effectiveness of the dip solution during treatment.

Advantages of the liner soak include early control of very vigorous crops and flexibility of the treatment with respect to not having to handle plants during the restricted-entry interval. The liner soak is especially useful in combination plantings where the more vigorous plants can be treated prior to planting without reducing the growth of the slower plants in the group. The liner soak rates should be selected to provide early control of plant growth. Additional PGR applications can be made as necessary for longer-term crops (figure 5).

Be Aware of Bark

For many years, the adage in PGR drenches has been, “Bark ties up soil-active PGRs.” However, new research shows that this is not necessarily true. As long as the bark is properly aged before the media is mixed, it has little effect on the availability of these soil-active PGRs to the plant roots.

Growing Conditions

Look also for label recommendations on time of day or condition of the plant for optimum treatment response. Generally, a healthy, unstressed plant growing under low evaporative conditions, e.g., early in the morning or late in the afternoon, is most responsive to treatment.

To maximize uptake, the chemical must remain in contact with the leaf long enough to be absorbed. This time varies for the different PGRs, but generally, foliar uptake is enhanced with slower drying conditions, which in turn increases the effectiveness of the treatment. Plants treated with daminozide or ethephon should not be overhead irrigated for at least 18 to 24 hours after treatment, but plants treated with flurprimidol, paclobutrazol, or uniconazole may be irrigated one hour after treatment. Read the label for any warnings on how irrigation or environmental conditions will affect plant response to the PGR treatment.



Figure 5. Russian sage (*Perovskia atriplicifolia*) treated with paclobutrazol liner soaks (10 minutes in solution) at the time of planting. Top photo shows good baseline control of plant height at five weeks after treatment with, left to right: 0-, 2-, 4-, 6-, 8-, and 10-ppm paclobutrazol. Bottom photo shows the same plants at eight weeks after treatment; plants treated with 2-ppm paclobutrazol were comparable to controls, while those treated with 6 ppm were still well-controlled.

Specific Plant Growth Regulators

The following discussion of the effects of specific growth-retarding PGRs on perennials references the appendix, which summarizes the results of our research trials in Virginia and Georgia using PGRs on more than 100 perennial species/cultivars. Foliar spray applications are tested more often than drenches, presumably due to the higher labor costs involved in applying drenches in large-scale production areas. All of these research results are from the Mid-Atlantic and Southern U.S., which means they should be adjusted down for growers located farther north (see Summary).

Daminozide (B-Nine or Dazide; Restricted-Entry Interval [REI] = 24 hours) was one of the first PGRs labeled for use in the floriculture industry and is still widely used. In general, it is not phytotoxic and has a short-term effect that seldom results in overstunting of treated plants. The low activity of daminozide and its lack of soil activity make it easier to get consistent, predictable responses than with the newer, more-potent PGR chemistries. Plants should be well-irrigated prior to treatment, but foliage should be dry at the time of treatment. Do not irrigate overhead for 18 to 24 hours after treatment.

The low activity also means that daminozide must be applied more frequently to maintain control over vigorous crops. Nearly one-half of the perennial species tested have shown some response to multiple applications of daminozide (appendix). Generally, for

perennials in the Mid-Atlantic and Southern U.S., foliar sprays of 5,000 ppm are applied every 10 to 14 days as necessary. Daminozide is labeled for use on containerized or bed-grown crops in the greenhouse and on containerized plants grown outdoors under nursery conditions. Frequency of application may need to be increased to weekly for more vigorous cultivars grown outdoors.

Chlormequat chloride (Citadel or Cycocel; REI = 12 hours) is another PGR with a long history in floriculture. Note that the product-use labels for the chlormequat chloride products vary in application limits. See the label for your product for the specific rates and sites of application (table 1). Chlormequat chloride is generally applied as a foliar spray at 200 to 3,000 ppm with a maximum of three to six applications per crop cycle, depending on which product you use. Although rates above 1,500 ppm often cause chlorosis on young, treated leaves of other floricultural crops, we have seen few examples of phytotoxicity on perennials. However, chlormequat chloride alone has not been tested on a wide variety of perennials. Rose mallow (*Hibiscus moscheutos*), like the tropical *Hibiscus*, is responsive to chlormequat chloride, responding well to multiple applications of 500-ppm chlormequat chloride (appendix). Chlormequat chloride also promotes earlier flowering and greater flower numbers on *Hibiscus*. First application should be made when the laterals are 0.5 to 1.0 inch long.

Chlormequat chloride is also labeled for drench applications at rates of 2,000 to 4,000 ppm when applied inside a greenhouse, depending on the specific product label. Again, rose mallow was very responsive to a 2,000-ppm chlormequat chloride drench (4 fluid ounces per 6-inch pot). However, drench applications of chlormequat chloride are seldom cost-effective.

Only Cycocel is labeled for use on containerized plants in the outdoor nursery, where it may be applied at a maximum spray rate of 3,000 ppm up to three times in any crop production cycle. This limit includes any applications of Cycocel combined with daminozide. Drench applications of Cycocel are not permitted in the outdoor nursery, even on containerized plants. Read the pesticide label for your product: It is the law for application sites and rates. Chlormequat chloride is not labeled for application through the irrigation system.

A **daminozide/chlormequat chloride tank mix** has more PGR activity than either daminozide or chlormequat chloride alone and generally causes less phytotoxicity than chlormequat chloride applied by itself. Both the daminozide and chlormequat chloride labels have approved tank-mix instructions. This combination has been tested on a wide variety of perennials. For example, three-lobed coneflower (*Rudbeckia triloba*) was very responsive to daminozide applied twice at 5,000 ppm but was not responsive to chlormequat chloride at rates up to 4,000 ppm. However, a tank mix of 5,000-ppm daminozide with increasing rates of chlormequat chloride resulted in height control similar to the daminozide treatments — but with a single application. The high activity rate generally used for the tank mix is 5,000-ppm daminozide plus 1,500-ppm chlormequat chloride.

Although the rate of daminozide is usually adjusted to increase or decrease activity, changing the chlormequat chloride rate also affects activity. Shoot height of many of the perennials listed in the appendix was effectively controlled by this tank mix, including blanket flower (*Gaillardia grandiflora* 'Burgundy') and Russian sage (*Perovskia atriplicifolia*), along with two of the ornamental grasses, *Sorghastrum* 'Indian Steel' and *Calamagrostis* 'Karl Foerster' (figure 6). Single applications of the tank mix are frequently more effective than multiple applications of daminozide alone. In other crops where the tank mix is listed in the appendix as nonresponsive (NR) with one application, the effects may have been too short-term for the research evaluation. Multiple applications of the tank mix may provide

control of these species.



Figure 6. Blanket flower (*Gaillardia x grandiflora* 'Burgundy') was responsive to daminozide. Left to right: untreated control, two applications (at a two-week interval) of 5,000-ppm daminozide, and one application of a tank mix of 5,000-ppm daminozide and 1,500-ppm chlormequat chloride. Photo was taken at three weeks after treatment. Multiple applications of the tank mix were required for long-term control.

Ancymidol (Abide or A-Rest; REI = 12 hours) is a more active compound than daminozide or chlormequat chloride. Ancymidol is active as a spray or a drench, so application volume affects plant response. In addition, ancymidol is labeled for chemigation, i.e., distribution through the irrigation system via flood, sprinkler, or drip systems. Follow all label directions. Abide is not labeled for spray applications in shadehouses or nurseries, but drench applications can be made indoors and outdoors. A-Rest is labeled for use as a spray or drench on containerized plants in greenhouses, nurseries, shadehouses, and interiorscapes.

Although ancymidol has not been evaluated for effectiveness on a large number of perennial species, the labels specifically list foliar sprays on bleeding heart (*Dicentra*) and columbine (*Aquilegia*) at 65 to 132 ppm, gayfeather (*Liatris*) at 25 to 132 ppm, and hybrid bee delphinium (*Delphinium*) at 35 to 132 ppm. Ancymidol can also be applied as a drench at 2 to 4 ppm for these crops. For best results, treatments should be applied to well-rooted plants in active growth, prior to the initiation of flowering.

The higher rates necessary for foliar applications to some crops may not be economically feasible. The use of ancymidol as a treatment of plants in the plug stage is more economical than foliar applications on finished plants. In our studies on finished plants, we had excellent control of *Veronica* 'Icicle' and *Hemerocallis* 'Happy Returns' with 2-ppm drenches of ancymidol (2 fluid ounces per quart pot and 10 fluid ounces per trade gallon pot, respectively) and *Delphinium* 'Blue Bird' at



Figure 7. *Veronica* 'Icicle' treated with drenches of ancymidol, left to right: untreated, 2-, 4-, 6-, and 8-ppm drenches of ancymidol applied as 2 fluid ounces per quart pot. Higher rates caused excessive growth reductions and bronzing of the leaves. Photo was taken at six weeks after treatment.

4-ppm ancymidol (10 fluid ounces per trade gallon pot (appendix; figure 7).

Flurprimidol (Topflor; REI = 12 hours) is similar in chemistry to ancymidol but much more potent. Its activity is similar to that of the triazoles. Herbaceous perennials have proven very responsive to flurprimidol. With spray applications, Topflor rates are similar to those used with paclobutrazol. However, in soil applications, its activity is more similar to that of uniconazole. It is labeled for use as a spray or drench on containerized ornamental plants grown in nurseries, greenhouses, and shadehouses. Topflor is labeled for chemigation. Test spray rates around 15 to 40 ppm. We have not researched drench applications on perennials but reports on other bedding plants suggest drench rates of about 0.25 to 4 ppm.

The triazole class of PGRs includes **paclobutrazol** (Bonzi, Downsize, Paczol, Piccolo, or Piccolo 10 XC; REI = 12 hours) and **uniconazole** (Concise or Sumagic; REI = 12 hours). These compounds are much more active than most of the previous compounds. Uniconazole is more potent than paclobutrazol.

As mentioned above, the activity of flurprimidol (Topflor) is between these two triazoles depending on application method. For perennials in the South and Mid-Atlantic, paclobutrazol is generally applied at spray rates of 30 to 100 ppm and uniconazole is applied at 15 to 45 ppm. These PGRs are rapidly absorbed by plant stems and petioles or through the roots. Excess spray dripping off of treated plants acts as a drench to

the substrate, increasing the activity of the treatment. For foliar sprays of triazoles, uniform application of a consistent volume per unit area is critical to uniform and consistent crop response.

Both compounds (see table 1) are labeled for application to the media surface prior to planting plugs. In this case, the PGR is applied as a spray to the surface of the medium in filled pots. The PGR moves into the medium with subsequent irrigations and effectively behaves as a drench. Effectiveness is also reduced by nonaged bark in the medium, as with drenches.

Neither paclobutrazol nor uniconazole has resulted in any specific phytotoxicity symptoms on perennials, but care must be taken with application on sensitive plants (figure 8). In some cases, excessive stunting can be very persistent, e.g., goldenrod (*Solidago sphecelata*) treated with higher rates of paclobutrazol (240 ppm) or uniconazole (60 ppm) did not recover normal size at five months after planting into the landscape. Growth of velvet sage (*Salvia leucantha*) was excessively reduced by 45- or 60-ppm uniconazole in the greenhouse. Furthermore, 60-ppm uniconazole caused a significant delay in landscape growth of the *Salvia*.

These compounds must be used carefully and appropriately. Especially when working with the triazoles, thoroughly test your application methods and rates on a small number of plants before treating your entire crop.

Avoid late applications of the triazoles. They should be applied prior to flower initiation when possible.



Figure 8. Larkspur (*Delphinium elatum* 'Blue Bird') at four weeks after treatment with paclobutrazol, left to right: untreated control, treated with paclobutrazol as a foliar spray at 30 ppm and at 60 ppm, and treated with paclobutrazol as a drench at 1 ppm and at 2 ppm. Overdose symptoms were evident on the plants treated with the 2-ppm drench. The triazole-type PGRs are actively taken up by the roots and are very effective in growth regulation.

The persistence of these compounds in plant stems and petioles can have significant effects on the flower display as well. As with many of the growth retardants, the triazoles inhibit gibberellin synthesis. Generally, the most rapidly elongating tissues have the highest production of gibberellins and, therefore, are most affected by reductions in gibberellin production. For example, PGR application affects the elongation of flowering stems of gaura (*Gaura lindheimeri*) much more than the leafy stems (figure 9). Usually this is acceptable because it keeps the flower height in better proportion to the plant height. However, differences in response vary, and in some yarrow (*Achillea*) cultivars, flower height has been excessively stunted at moderate application rates. We have also seen significant height suppression of flower stalks with drench applications of paclobutrazol or uniconazole on daylily (*Hemerocallis*). Nursery producers deemed these plants acceptable because of their improved ability to be shipped.

Paclobutrazol has a broad label for ornamentals that includes use on greenhouse or outdoor-grown, containerized crops. See table 1 for label restrictions for the different products. All of the paclobutrazol products are labeled for application through the irrigation system, including ebb/flow or flooded floor systems. Paclobutrazol has been tested on a wide variety of perennials, with species ranging from extremely sensitive to low rates to nonresponsive to very high rates.

To establish rates for plants not listed in the appendix or on the product label, treat a small number of plants with 30 to 100 ppm as a foliar spray or up to 10 ppm as a drench. In many cases, multiple treatments with lower rates have been more effective, with less chance of overstunting than a single application at a higher rate.

Uniconazole also has a broad label for ornamentals, but its use is limited to containerized plants grown in greenhouses, overwintering structures, shadehouses, or lath houses. It is not labeled for outdoor nursery use. Uniconazole also is not labeled for application through any irrigation system. It has been very effective on a large number of perennials, with spray rates in the 15- to 45-ppm range in the South and Mid-Atlantic areas. We have done less research on drench rates on perennials. However, we have found them to be very sensitive to uniconazole with good growth control using 0.5- to 2.0-ppm drenches. Because it is very potent, pay special attention to uniform application and proper volumes. Use caution in the higher rates or on more sensitive species because uniconazole effects can be very persistent in plants even after they have been transplanted into the landscape.

NOTE: Ancymidol, flurprimidol, paclobutrazol, and uniconazole are persistent on plastic surfaces and in soil. Do not reuse flats, pots, or soil from treated plants — especially for plug production of sensitive crops.



Figure 9. Elongation of flower inflorescence may be more affected by plant growth regulators than elongation of stem tissue is, as seen with white gaura (*Gaura lindheimeri* 'Siskiyou Pink') treated with increasing rates of uniconazole, left to right: 0, 15, 30, 45, and 60 ppm. Photo was taken at five weeks after treatment.

Ethephon Collate (Florel brand Growth Regulator; REI = 48 hours) is a compound that breaks down in plant tissue after application to release ethylene, a natural plant hormone. As with ethylene, its effects can vary depending on the species and the stage of growth at time of application. These products have a broad-use label for increasing lateral branching of floricultural crops.

Ethephon also inhibits internode elongation of many plants, but research with perennials has been limited (see appendix). It has controlled runner elongation of clump verbena (*Verbena* ‘Homestead Purple’) and increased inflorescence numbers of sage (*Salvia* ‘May Night’) and yarrow (*Achillea* ‘Coronation Gold’).

Ethephon should be applied to actively growing plants prior to flower development (figure 10). If flowers are present at the time of application, they are likely to abort. Ethephon may delay flowering by about one to two weeks, particularly if applied close to the time of flower initiation. Ethephon should not be applied to plants that are heat- or drought-stressed.



Figure 10. Young dianthus plants treated with ethephon to enhance branching and plant quality.

The pH of water used for the spray solution can be important. If the pH is too high, the ethephon will convert to ethylene before it gets to the plant and activity will be reduced. Ethephon contains sufficient acidifiers and buffers to maintain a pH of 5.0 or lower when mixed with most greenhouse water supplies. In general, water that has sufficient quality for irrigation of greenhouse crops (moderate pH and alkalinity) is suitable for mixing ethephon. However, if you are acidifying your water prior to irrigation, use the acidified water for mixing the ethephon as well. The solution should be applied within four hours of mixing.

Benzyladenine (Configure; REI = 12 hours) is a synthetic cytokinin (6-benzyladenine or 6-BA) — a plant hormone that stimulates lateral branching. It is a relatively inexpensive PGR and has been very effective in enhancing the branching of a wide variety of perennials. Configure stimulates — but does not cause — an increase in branching. Therefore, application timing is important. Treated plants must have sufficient lateral buds formed to respond to the treatment. BA has a short period of activity and has no residual in the plant, so multiple applications may be useful with many of the perennial crops. Furthermore, it is not translocated in the plant, so thorough coverage is required.

Initial work on herbaceous perennials focused on *Hosta* and *Echinacea*, both of which are very responsive to BA. In our trials, multiple cultivars of *Echinacea* have developed two to four times the number of basal branches versus untreated plants when treated about two weeks after potting. Other researchers have reported similar results with a number of other *Echinacea* cultivars. Further screening trials with other herbaceous perennials have identified a large number of crops that showed increased basal or lateral branching in response to a 600-ppm BA spray (see appendix) (figure 11).



Figure 11. Benzyladenine (Configure) improved branching and flowering of white gaura (*Gaura lindheimeri* ‘Siskiyou Pink’): untreated (left) and 600 ppm applied at two weeks after transplant (right). Photo taken at four weeks after final treatment.

We have found little incidence of phytotoxicity with Configure application. Successful use of Configure to increase the number of shoots on perennial plugs/liners has been reported by several growers. We found that Configure had little effect on root growth of plugs treated after the cuttings were moderately rooted, whereas branching was significantly increased for many crops.

Although the primary objective with Configure is to increase branching, it has resulted in growth reduction in some crops. However, if additional growth control is necessary, we have found that growth retardants may

be used following the Configure treatment without reducing the branching response.

Dikegulac sodium (Augeo; REI = 12 hours) is a compound that interferes with terminal growth by inhibiting cell-wall development, which is required for new growth. By primarily inhibiting terminals, apical dominance is reduced, which enhances the production of lateral branches. Dikegulac sodium usually causes leaf chlorosis that can be very persistent at higher rates (above 1,500 ppm).

Dikegulac sodium should be applied to actively growing plants with at least two nodes to provide sufficient lateral development. In addition to creating a fuller plant, enhancing the number of laterals in a pot generally reduces the overall height of the plant due to the greater distribution of resources. Responses are very species-specific, so test several rates under your growing conditions. Our research suggests that dikegulac sodium can increase branching of big-flowered hybrids of *Clematis*. Growers should apply the product early in production to allow time for plant growth to “cover” any chlorotic leaves.

Recordkeeping

Keeping notes on your application methods and the results of your PGR treatments will allow you to improve the consistency of your own application methods and establish rates and volumes appropriate for your production system. Note the concentration and the volume applied, the stage of development of the crop (number of leaves, approximate height, presence of flowers), and the environmental conditions under which the PGR was applied. It is always recommended to keep a few untreated plants for comparison, especially if you are new to using PGRs.

Summary

The degree of growth regulation by PGRs is impacted by all other phases of plant culture. Remember that you have to fit PGRs into your own production program. Plan ahead to achieve the best results from PGRs; do not use them as an afterthought when the plants are out of control. You cannot shrink an overgrown plant!

The multitude of variations possible in application methods, cultivar and species grown, and growing conditions make it impossible to recommend specific rates for all operations. The appendix provides a resource of research trial results in Georgia and Virginia using

PGRs on herbaceous perennials. In the Mid-Atlantic and the South, use these rates as suggested effective rates for starting your own trials. Growers in more northern or southern areas will need to adjust the rates as noted below.

There are two general rules for using rate recommendations from other sources:

1. Southern growers use higher rates and more frequent applications than northern growers. Rates for Virginia tend to be closer to the southern rates.
2. Outdoor applications usually require higher rates or more frequent applications than plants grown under cover.

Always consider any rate recommendation as a starting point for your own trials and keep records of your successes and failures with PGRs. Whenever you treat your crop, hold back a few untreated plants so that you can judge the effectiveness of your treatment. Remember that methods of application have significant effects on results. Develop your own program, then test and refine it. Watch for PGR compounds new to the floriculture market and for expanded labeling of current products as we develop more guidelines for their use on perennials.

Recommended Resources

PGR Calculator

For a ready resource on preparing PGR solutions for both spray and drench applications, use the online PGRMix Master app, a plant growth regulator calculator developed by floriculture specialists from North Carolina State University and the University of New Hampshire: <http://e-gro.org/mixmaster/>

OHP PGR Calculator

OHP, Inc. also has a PGR mixing app for iPhone, iPad or iPod. The PGR calculator app is available for free from the Apple App Store. Product information bulletins and other publications are also available with this app. See www.ohp.com for more information.

General Resources

Latimer, Joyce, and Brian Whipker, eds. 2010. *Configure: Product Information and University Trial Results*. Walnut Creek, Calif.: <http://fine-americas.com/lit/usa/configure/Brochures/Configure%20University%20Trial%20Results.pdf>

Michigan State University Plant Growth Regulator Research website: <http://flor.hrt.msu.edu/PGRs/>

N.C. State University Commercial Floriculture website: <https://horticulture.ces.ncsu.edu/horticulture-ornamentals/floriculture/>

Pilon, Paul. 2006. *Perennial Solutions: A Grower's Guide to Perennial Production*. West Chicago, Ill.: Ball Publishing.

Virginia Tech Floriculture website: <http://www.hort.vt.edu/floriculture/>

Disclaimer

Commercial products are named in this publication for informational purposes only. Virginia Cooperative Extension does not endorse these products and does not intend discrimination against other products which also may be suitable.

Appendix. Growth Regulators for Containerized Herbaceous Perennial Plants

This table lists results of research trials on herbaceous perennials at Virginia Tech (VT) and the University of Georgia (UGA). Spray rates listed were applied at the label-recommended volume of 0.5 gallon per 100 square feet, unless otherwise stated. Use the rates listed as starting points for your own plant growth regulator (PGR) trials. “NR” means that the plants were not responsive to the rates tested.

Note: Not all uses are listed on the label; always check the product label before using. Consult product labels for a complete listing of precautions and recommended-use rates. When using any PGR for the first time, always test the rate on a few plants and compare the results to untreated plants before treating an entire crop. Keep in mind that these rates are applicable to Sun Belt growers. Northern growers should test lower rates.

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Achillea millefolium</i> Common yarrow	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Good control of ‘Red Beauty’ and ‘Paprika’ with 2 applications, 2 weeks apart, but ‘Moonshine’ was NR ³ @ 5,000 ppm x 2 (UGA and VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control on ‘Paprika’ (UGA).
		Citadel, Cycocel	NR @ 5,000 ppm spray x 1	‘Coronation Gold’ NR (UGA).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	100-120 ppm spray x 1	Good control on ‘Summer Pastels’ with 120 ppm spray (VT).
		Concise, Sumagic	10-15 ppm spray x 1	Excellent response with ‘Paprika’ and ‘Coronation Gold’; however, ‘Red Beauty’ and ‘Moonshine’ were NR @ 60 ppm spray x 1 (UGA and VT).
	To increase lateral or basal branching	Augeo	800 ppm spray x 2	70% increase in branching when applied to ‘Moonshine’ as plug (21 days after sticking) and again at 5 days after transplanting; some leaf yellowing still visible at 7 weeks after treatment; single application not effective and no effect at 400 ppm x 2 (VT).
		Configure	600 ppm spray x 2	60% increase in branching when applied to ‘Moonshine’ as plug (21 days after sticking) and again at 5 days after transplanting; no phytotoxicity (VT).
<i>Agastache hybrids</i> Anise hyssop	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 3	Based on research results with ‘Blue Fortune’ (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Based on research results with ‘Blue Fortune’ (UGA).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Agastache hybrids Anise hyssop (cont.)		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	60-80 ppm x 1; much less than 5 ppm drench x 1	'Tutti Frutti' responsive; test 1-2 ppm drenches; 2 fl oz/quart pot; volume and mg a.i. ⁴ vary with pot size (VT).
		Concise, Sumagic	10 ppm spray x 1	Based on research results with 'Blue Fortune,' which is very sensitive to uniconazole (UGA).
	To enhance lateral branching of liners	Configure	300 ppm spray x 1 on liners	'Purple Haze' treated ~4 days after liners were removed from mist increased lateral branching. Multiple applications during liner production or higher rates decreased root growth (VT).
Alchemilla mollis Lady's mantle	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	NR in VT trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Multiple applications at 10-14 day intervals may be necessary (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 200 ppm spray x 1	NR in VT nursery trials.
		Concise, Sumagic	NR @ 90 ppm spray x 1	NR in VT nursery trials.
Aquilegia x hybrida Hybrid columbine	To control plant growth, apply as flower stalks get above foliage	B-Nine, Dazide	5,000 ppm spray x 2	Effective on 'McKana Giants' (UGA).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 240 ppm spray x 1	'McKana Giants' was NR to a single spray application of 240 ppm (UGA).
		Concise, Sumagic	NR @ 120 ppm spray x 1	'McKana Giants' was NR to a single spray application of 120 ppm (UGA).
Aquilegia vulgaris Columbine	To induce lateral or basal branching	Configure	NR @ 600 ppm spray x 1	No effect with our screening rate on 'Winky Purple White' in VT research. Test multiple applications or higher rates.
Artemisia schmidtiana Wormwood, white sage	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate control of 'Silver Mound' with multiple applications in VT research.
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Silver Mound' in VT research; multiple applications may be required.
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	200 ppm spray x 1	Moderate control of 'Silver Mound' with 200 ppm sprays in VT research; may require multiple applications.
		Concise, Sumagic	30-60 ppm spray x 1	Moderate control of 'Silver Mound' with 45 ppm spray; the hybrid 'Oriental Limelight' was more sensitive — use 30 ppm sprays. The hybrid 'Powis Castle' was less responsive — test 60 ppm sprays; multiple applications may be necessary (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Asclepias tuberosa</i> Butterfly weed	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 3	NR in UGA trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	NR in UGA trials.
	To induce lateral branching	Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	NR @ 50 ppm spray x 1; NR @ 2 ppm drench x 1	No effect on plant height but reduced width of 'Hello Yellow' by 10-18%. Drenches applied at 2 fl oz/quart pot; volume and mg a.i. vary with pot size (VT).
		Concise, Sumagic	45 ppm spray x 1	Good control in UGA trials.
		Configure	NR @ 600 ppm spray x 1	No effect with our screening rate in VT research. Higher rates or multiple applications may be effective.
<i>Aster dumosus</i> Bushy aster <i>Aster x frikartii</i> Frikart's aster <i>Aster novae-angliae</i> New England aster	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Apply first application after pinching when new shoots are ~1-inch long. <i>Aster x frikartii</i> cvs. 'Monarch' and 'Monch' were responsive to 2 spray applications of daminozide, but <i>A. dumosus</i> 'Sapphire' was NR to this rate in VT research trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	<i>A. dumosus</i> 'Sapphire' was NR to this rate in VT research trials.
	To induce lateral branching	Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	80 ppm spray x 1; 2-16 ppm drench x 1	80 ppm spray controlled width of <i>A. dumosus</i> 'Sapphire' but had little effect on height. <i>A. x frikartii</i> 'Monarch' and 'Monch' were NR to 1 spray application of 240 ppm but were responsive to a drench application. Drench applied at 2 fl oz/quart pot; volume and mg a.i. vary with pot size (VT, UGA).
		Concise, Sumagic	30 ppm spray x 1	Moderate width control of <i>A. dumosus</i> 'Sapphire' but little effect on height. <i>A. x frikartii</i> 'Alpine Mix,' 'Monarch,' and 'Monch' were NR to 1 spray application of 60 ppm or a drench of 4 ppm. Drench applied at 2 fl oz/quart pot; volume and mg a.i. vary with pot size (VT, UGA).
		Topflor	NR @ 60 ppm spray x 1	No response in fall trial with <i>A. dumosus</i> 'Sapphire' (VT).
	To induce lateral branching	Configure	Phytotoxic	Significant phytotoxic response at a single spray of 600 ppm applied to liners (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Astilbe x arendsii</i> False spirea	To control plant growth	B-Nine, Dazide	Less than 5,000 ppm spray x 2	Excessive height reduction of <i>A. chinensis</i> 'Purpurkerze' in VT trials; use lower rate and/or fewer applications. However, <i>A. x arendsii</i> 'Elizabeth Bloom' was NR to these rates in VT trials.
<i>Astilbe chinensis</i> Chinese astilbe		B-Nine, Dazide + Citadel, Cycocel tank mix	Less than 5,000 ppm + 1,500 ppm spray x 1	Excessive height reduction of <i>A. chinensis</i> 'Purpurkerze' in VT trials; reduced both daminozide and chlormequat rates.
<i>Astilbe thunbergii</i> False spirea		Citadel, Cycocel	1,500 ppm spray x 1	Moderate control of <i>A. chinensis</i> 'Purpurkerze' in VT trials.
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	40-80 ppm spray x 1-2	40 ppm x 1 resulted in good control of <i>A. chinensis</i> 'Purpurkerze' in VT trials. However, 80 ppm x 1 resulted in only short-term height control of <i>A. x arendsii</i> 'Elizabeth Bloom'; plan on multiple applications (VT).
		Concise, Sumagic	25-35 ppm spray x 1-2	Good control of <i>A. chinensis</i> 'Purpurkerze' in VT trials. Short-term response on <i>A. x arendsii</i> 'Elizabeth Bloom'; plan on multiple applications (VT).
<i>Buddleia davidii</i> Butterfly bush	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate control of 'Royal Red'; apply at 10-14 day intervals (UGA). This rate resulted in no control of 'Pink Delight' in VT trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	No height control of 'Royal Red' or 'Pink Delight' in UGA or VT trials.
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1; NR @ 10 ppm drench x 1	No height control of 'Royal Red' in VT trials. Drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size.
			10 mg a.i. ⁴ drench x 1	Excellent control of 'Dubonnet' under nursery conditions with drench (100 ml/2.8 L pot); drench volume and mg a.i. vary with pot size (UGA).
		Concise, Sumagic	60 ppm spray x 1; 0.025 ppm drench x 1	Moderate control of 'Royal Red'; multiple applications may be required. Drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
<i>Buddleia fallowiana</i> 'Lochinch' butterfly bush	To control plant growth	Concise, Sumagic	60 ppm spray x 1; 1.5 ppm drench x 1	Short-term height control with sprays and drenches. Multiple applications required. Drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
<i>Buddleia weyeriana</i> 'Honeycomb' butterfly bush	To control plant growth	Bonzi, Paczol, Piccolo	4 ppm liner soak x 1	Good control (VT).
		Concise	2 ppm liner soak x 1	Moderate control (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Caryopteris x clandonensis</i> 'Dark Knight' bluebeard	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm x 2	Not responsive in VT trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm x 1	Not responsive in VT trials.
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm x 1	Not responsive in VT trials.
		Concise, Sumagic	30 ppm x 1	Moderate control (VT).
<i>Chrysanthemum parthenium</i> Feverfew	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC,	Much less than 40 ppm x 1	Very sensitive to paclobutrazol. Test rates much less than 40 ppm (UGA).
		Concise, Sumagic	Much less than 15 ppm x 1	Very sensitive to uniconazole. Test rates much less than 15 ppm (UGA).
<i>Coreopsis grandiflora</i> Tickseed	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Good control of 'Sunray' with multiple applications at 10-14 day intervals under nursery conditions (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Sunray'; multiple applications may be required (UGA, VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	80-100 ppm spray x 1; 5-10 ppm drench x 1	'Sunray' and 'Baby Sun' responsive to sprays or drench. Drenches applied at 2 fl oz/quart pot; volume and mg a.i. vary with pot size (VT).
		Concise, Sumagic	40 ppm spray x 1; 15 ppm spray x 2	May delay flowering of 'Sunray' (UGA, VT).
<i>Coreopsis rosea</i> Pink coreopsis	To control plant growth	Bonzi, Paczol, Piccolo	4-8 ppm liner soak x 1	Moderate response to lower rate with 'Sweet Dreams'; rates up to 8 ppm resulted in good control (VT).
		Concise	0.5 ppm liner soak x 1	Good growth control of 'Sweet Dreams' (VT).
<i>Coreopsis verticillata</i> Thread leaf coreopsis	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2-3	Good control but slight flower delay with 'Moonbeam' and overwintered 'Golden Gain'; apply at 10-14 day intervals (UGA and VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Effective on overwintered 'Golden Gain' (VT).
		Citadel, Cycocel	NR @ 1,500 ppm spray x 1	Overwintered 'Golden Gain' NR (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Coreopsis verticillata Thread leaf coreopsis (cont.)		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	Spray application not effective on 'Moonbeam' (UGA) or overwintered 'Golden Gain' (VT).
		Concise, Sumagic	15-20 ppm spray x 1; less than 1 ppm drench x 1	Good control of 'Moonbeam' with spray application but excessive growth reduction at 1 ppm drench; test rates ~0.5 ppm; drench applied as 2 fl oz/quart pot; volume and mg a.i. vary with pot size. Growth of overwintered 'Golden Gain' was moderately responsive at 45 ppm spray x 1; multiple applications necessary (VT).
Coreopsis Tickseed	To induce lateral or basal branching on liners or finished plants	Configure	300-600 ppm spray x 1	Various cultivars including 'American Dreams,' 'Sweet Dreams,' 'Moonbeam,' 'Rum Punch,' and 'Zagreb' are responsive to a single foliar application to increase lateral and basal branching in liners and finished plants; multiple applications may improve response (Virginia grower, VT).
Delosperma cooperi Ice plant	To enhance lateral branching	Configure	NR @ 600 ppm spray x 2	NR to our screening rate; higher rates may be effective (VT).
Delphinium x elatum Larkspur, hybrid bee delphinium	To control plant growth	Abide, A-Rest	4 ppm drench x 1	Apply as flower stalks start to elongate. Good control of 'Blue Bird'; drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
		B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Astolat' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	'Astolat' NR (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	40-100 ppm spray x 1	Moderate control of 'Astolat' at lower rates and of 'Black Knight' at higher rates; multiple applications may be necessary. 'Blue Bird' height NR to 60 ppm spray x 1; slight reduction in width (VT).
			Less than 2 ppm drench x 1	'Blue Bird' was very sensitive to drenches; drench applied at 10 fl oz/quart pot; volume and mg a.i. vary with pot size (VT).
		Concise, Sumagic	30-45 ppm spray x 1	Multiple applications may be required for 'Astolat' (VT).
			1 ppm drench x 1	Very short-term response with 'Blue Bird'; multiple applications or higher rate required; drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
	Topflor	15 ppm spray x 1	Good control of 'Blue Bird' (VT).	
	To increase branching	Configure	NR @ 600 ppm spray x 1	'Galahad' NR to our screening rate; higher rates may be effective (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Digitalis purpurea</i> Foxglove	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 4	'Foxy' NR to multiple applications (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	'Foxy' NR (UGA).
		Concise, Sumagic	30 ppm spray x 1	Excellent height control of 'Foxy'; moderate width reductions (UGA).
<i>Echinacea purpurea</i> <i>Echinacea hybrids</i> Purple coneflower	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Apply at 10-14 day intervals for control of 'Bravado', 'Magnus' (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 + 1,500 ppm spray x 1-2	Good control of 'Magnus'; may require multiple applications at 10-14 day intervals (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	120 ppm spray x 1; 15 ppm spray x 3-4	Moderate control of 'Doubledecker'; multiple applications required (VT). First spray before budding; evaluate weekly to determine need for additional control (Virginia grower).
		Concise, Sumagic	30 ppm spray x 1-2	Multiple applications may be required for 'Ruby Star'; 'Bravado' sensitive, test rates less than 30 ppm (VT).
		Topflor	45 ppm spray x 1; 22 ppm spray x 2	Short-term control of 'Ruby Star'; multiple applications may be required (VT).
	To increase basal branching	Augeo	800 ppm spray x 1 on finished plants	Increased lateral branching of 'Sombrero Hot Pink'. This rate did not increase branching when applied to 'Sundown' or 'White Swan' liners (VT).
		Configure	300-600 ppm spray x 1-2 on liners or finished plants	Increases basal branching; multiple applications may be required. No significant effect on plant height (VT).
<i>Erysimum linifolium</i> Wallflower	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Multiple applications at 10-14 day intervals (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	May require multiple applications (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80-120 ppm spray x 1	Moderate control (VT).
		Concise, Sumagic	15 ppm spray x 1	Good control (VT).
		Topflor	30 ppm spray x 1	Good control (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Eupatorium coelestinum Hardy ageratum	To control plant growth	B-Nine	NR @ 5,000 ppm x 2	Not responsive in VT trials.
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	NR @ 240 ppm spray x 1; 8-10 ppm drench x 1	Drenches applied at 2 fl oz/quart pot (UGA).
		Concise, Sumagic	60 ppm spray x 1; NR @ 1 ppm drench x 1	Drench applied at 4 fl oz/quart pot (UGA).
Eupatorium rugosum 'Chocolate' chocolate boneset, white snakeroot	To control plant growth	Concise, Sumagic	60 ppm spray x 1; 4 ppm drench x 1; 2 ppm liner soak x 1	Moderate growth control. Multiple applications may be required. Drench applied at 2 fl oz/quart pot (VT).
Euphorbia dulcis Purple spurge	To increase branching	Configure	600 ppm spray x 1	This rate was our screening rate on 'Chameleon.' Lower rates may be effective (VT).
Euphorbia hybrid Wood spurge	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 3	'Efanthia' and 'Despina' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 2	'Efanthia' and 'Despina' NR (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80 ppm spray x 1	Moderate control of 'Efanthia' and 'Despina' (VT).
		Concise, Sumagic	30 ppm spray x 1	Moderate control of 'Efanthia' and 'Despina' (VT).
		Topflor	30 ppm spray x 1	Moderate control of 'Efanthia' and 'Despina' (VT).
Gaillardia x grandiflora Blanket flower	To control plant growth; begin weekly applications when stems are rapidly elongating and before flower buds appear	B-Nine, Dazide	5,000 ppm spray x 3	'Burgundy' responsive; apply at 10-14 day intervals; 'Goblin' ('Gold Kobold') NR @ 5,000 ppm spray x 2 (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	'Burgundy' responsive to a single application; 'Goblin' ('Gold Kobold') NR (UGA).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1; NR @ 5 ppm drench x 1	'Goblin' ('Gold Kobold') NR @ 160 ppm spray x 1, or 5 ppm drench applied at 4 fl oz/quart pot; drench volume and mg a.i. vary with pot size (UGA).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Gaillardia x grandiflora Blanket flower (cont.)		Concise, Sumagic	60 ppm spray x 1 NR @ 60 ppm spray x 1; NR @ 2 ppm drench x 1	Moderate control of 'Burgundy'; may require multiple applications. 'Goblin' ('Gold Kobold') NR to uni-conazole applied as a 60 ppm spray, a 5 ppm liner dip, or a 2 ppm drench applied at 4 fl oz/quart pot. Drench volume and mg a.i. vary with pot size (UGA, VT).
	To increase branching	Augeo	400 ppm spray x 1 on liners or finished plants	For finished plants: increased lateral branching on 'Gallo Yellow.' For liners: single 400 ppm spray at 21 days after sticking increased branching of finished plants (VT).
		Configure	600 ppm spray x 1-2 on liners or finished plants	Very effective at increasing branching but delays flowering up to 4 weeks (VT).
Gaura lindheimeri White gaura, wand flower, whirling butterflies	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Effective on 'Siskiyou Pink' and 'Whirling Butterflies'; apply at 10-14 day intervals (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control of 'Corrie's Gold'; moderate control of 'Whirling Butterflies'; multiple applications may be required (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	80-100 ppm spray x 1; 15 ppm drench x 1; 2-4 ppm liner soak x 1	80 ppm resulted in good growth control on 'Corrie's Gold' but 100 ppm gave only moderate growth control of 'Siskiyou Pink'; test multiple applications or higher rate. Drench applied at 2 fl oz/quart pot; volume and mg a.i. vary with pot size. Good control of 'Pink Fountain' with liner soaks for 4 weeks (VT).
		Concise, Sumagic	15-60 ppm spray x 1	Significant cultivar differences in response: height of 'Whirling Butterflies' was excessively reduced by 15 ppm, but 30 ppm gave short-term growth regulation of 'Corrie's Gold'; 'Dauphin' was only moderately controlled by 60 ppm, and 'Siskiyou Pink' was NR to a 60 ppm spray (VT).
	To increase branching	Configure	600 ppm spray x 1; 300 ppm spray x 1-2 on liners	Increased branches and shoots. Increased number of flower stalks. This was our screening rate; lower rates may be effective. For liners, single or multiple foliar sprays applied ~27 days after sticking (plants moderately rooted) increased lateral and basal branching with no adverse effects on rooting (VT).
Geranium 'Rozanne' cranesbill, perennial geranium	To increase basal branching	Configure	NR @ 600 ppm spray x 1	This rate was our screening rate. Higher rates or multiple applications may be effective (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Heliopsis helianthoides False sunflower, sunflower heliopsis	To control plant growth	B-Nine, Dazide	Less than 5,000 ppm spray x 2	'Summer Sun' was very sensitive to daminozide under nursery conditions; test at lower rates (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Persistent control of 'Summer Sun' under nursery conditions; test lower rates (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	'Summer Sun' was NR under nursery conditions (VT).
		Concise, Sumagic	NR @ 60 ppm spray x 1	'Summer Sun' was NR under nursery conditions (VT).
Hemerocallis Daylily	To control plant growth	Abide, A-Rest	2 ppm drench x 1	Moderate control of height of 'Happy Returns' but significant reduction of flower stalk height; use care with higher rate; applied at 10 fl oz/trade gallon pots; volume and mg a.i. will vary with pot size (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	160-180 ppm spray x 1; 2 ppm drench x 1	Spray applications gave moderate height control of 'Mary Todd' and 'Hyperion' but no control on 'Black-Eyed Stella' or 'Prairie Blue Eyes.' Drench application gave moderate control of height of 'Happy Returns,' 'Hyperion,' and 'Prairie Blue Eyes' but significantly reduced flower stalk height; use care with higher rates; applied at 10 fl oz/trade gallon pots; volume and mg a.i. will vary with pot size (VT).
		Concise, Sumagic	0.1-0.5 ppm drench x 1	Moderate control of height of 'Butter Pat,' 'Sammy Russell,' 'Happy Returns,' and 'Frankly Scarlet' but significant reduction of flower stalk height; use care with higher rate; applied at 10 fl oz/trade gallon pots; volume and mg a.i. will vary with pot size (VT).
			NR @ 60 ppm spray x 1; NR @ 1 ppm drench x 1; NR @ 2 ppm liner soak x 1	Bare root liners of 'Pink Song' NR to uniconazole; drench applied at 2 fl oz/quart pot; drench volume and mg a.i. will vary with pot size (VT).
	To increase basal branching	Configure	NR @ 600 ppm spray x 1	'Strutters Ball' was NR to our screening rate of 600 ppm; higher rates or multiple applications may be effective (VT).
Heuchera hybrids Coral bells	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 120 ppm spray x 1	'Silver Lode' NR (VT).
	To increase basal branching	Configure	600 ppm spray x 1	'Raspberry Ice' and 'Silver Lode' increased basal branching at our screening rate; lower rates may be effective (VT).
Hibiscus moscheutos Hardy hibiscus, rose mallow	To control plant growth	Citadel, Cycocel	500 ppm spray x 2;	Good control of 'Lord Baltimore' with spray applications but excessive growth reduction with 2,000 ppm drenches applied at 4 fl oz/6-inch pot; reduce drench rate; volume and mg a.i. vary with pot size (VT).
			less than 2,000 ppm drench x 1	

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Hibiscus moscheutos</i> Hardy hibiscus, rose mallow (cont.)		Concise, Sumagic	10-20 ppm spray x 1; 0.5 ppm drench x 1	Good control of 'Grenache' with 20 ppm spray; sensitive to uniconazole drenches; drench applied at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
<i>Hosta</i> Plantain lily	To increase basal branching	Configure	500-3,000 ppm spray x 1-2	See Configure product information guide for detailed application instructions and cultivar responses (Latimer and Whipker 2010).
<i>Hypericum calycinum</i> Aaron's beard, St. John's wort	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	NR in nursery trials (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Slight control under greenhouse conditions; NR in nursery trials (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	160 ppm spray x 1; less than 4 ppm drench x 1	Good response in greenhouse trials but NR to sprays in nursery trials. Excessive growth reduction with 4 ppm drench at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
		Concise, Sumagic	30 ppm spray x 1; 1 ppm drench x 1	Good response to spray in greenhouse and nursery trials; moderate control with drench in greenhouse at 10 fl oz/trade gallon pot; volume and mg a.i. vary with pot size (VT).
<i>Iris siberica</i> Siberian iris	To control plant growth	Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	90 ppm spray x 1; less than 2-4 ppm drench x 1	A single spray controlled growth of 'Caesar's Brother,' but 180 ppm spray x 1 did not control 'Chilled Wine.' Use lower drench rates on 'Caesar's Brother' and higher rates on 'Chilled Wine'; drench applied at 10 fl oz/trade gallon pot; drench volume and mg a.i. vary with pot size (VT).
<i>Kniphofia uvaria</i> Red hot poker, torchlily	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Bressingham Comet' NR in VT trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm x 1	'Bressingham Comet' NR in VT trials.
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	'Bressingham Comet' NR in VT trials.
		Cycocel	NR @ 4,000 ppm spray x 1	'Bressingham Comet' NR in VT trials.
		Concise, Sumagic	45 ppm spray x 1	'Bressingham Comet' good control (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Lamium galeobdolon</i> Yellow archangel, golden dead nettle	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Excellent control of runners 'Hermann's Pride'. Apply at 10-14 day intervals (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	2,500 + 1,500 ppm spray x 1	Excellent control of 'Hermann's Pride' runners (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80 ppm spray x 1	Moderate width control of 'Hermann's Pride' (VT).
		Concise, Sumagic	15 ppm spray x 1	Moderate width control of 'Hermann's Pride' (VT).
		Topflor	45 ppm spray x 1	Moderate width control of 'Hermann's Pride'. May need multiple applications (VT).
<i>Lamium maculatum</i> Spotted dead nettle	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Begin applications when canopy starts to close. Moderate control of 'Pink Pewter' but no control of 'Beacon Silver' under nursery conditions (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Pink Pewter'; multiple applications may be required. No control of 'Beacon Silver' under nursery conditions (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	40 ppm spray x 1	Good control of 'Pink Pewter' but multiple applications may be necessary. No control of 'Beacon Silver' with 160 ppm spray x 1 under nursery conditions (VT).
		Concise, Sumagic	30 ppm spray x 1	Moderate control of 'Pink Pewter'; multiple applications may be required. No control of 'Beacon Silver' with 60 ppm x 1 under nursery conditions (VT).
<i>Lavandula x intermedia</i> Lavandin	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Good control of 'Silver Edge' ('Walvera'); apply at 10-14 day intervals (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control of 'Silver Edge' ('Walvera'; VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	'Silver Edge' ('Walvera') NR (VT).
		Concise, Sumagic	NR @ 60 ppm spray x 1	'Silver Edge' ('Walvera') NR to 60 ppm spray x 1 (VT).
	To increase lateral branching of liners	Configure	300 ppm spray x 2 for liners	Two foliar sprays applied to 'Provence', first at ~34 days after sticking and again 2 weeks later; increased lateral and basal branching with slight reduction in root growth; apply after liners are well-rooted (VT).
<i>Leucanthemum x superbum</i> Shasta daisy	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Alaska' and 'Becky' NR (UGA).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Leucanthemum x superbum</i> Shasta daisy (cont.)		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 1	'Becky' NR; test increased daminozide rate (UGA).
		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	'Becky' NR (UGA).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	Less than 40 ppm spray x 1	'Alaska' is sensitive to paclobutrazol; test rates below 40 ppm (UGA). 'Becky' had a moderate, short-term response to 120 ppm spray x 1; multiple applications or higher rates required (VT).
		Concise, Sumagic	Less than 15 ppm spray x 1	'Alaska' is sensitive to uniconazole; test rates less than 15 ppm (UGA). 'Becky' was NR to 60 ppm spray x 1; multiple applications or higher rates required (VT).
	To increase basal branching	Configure	300 ppm spray x 1-2 for liners; 600 ppm spray x 1-2 on fin- ished plants	Single or multiple foliar sprays applied ~27 days after sticking (plants moderately rooted) increased basal branching of 'Snowcap' but slightly reduced root growth; apply after liners are well-rooted. Applied to finish plants, Configure increased branching of 'Becky' and 'Alaska' short-term but doubled the number of flowers of 'Alaska'; 600 ppm was our screening rate; higher rates or multiple applications may be more effective (VT).
<i>Liatris spicata</i> Spike gayfeather	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	'Floristan Violet' NR (VT).
		Concise, Sumagic	NR @ 60 ppm spray x 1	'Floristan Violet' NR (VT).
<i>Lilium x aurelianense</i> Trumpet lily	To control plant growth	Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	NR @ 40 ppm x 1 (drench); NR @ 40 ppm x 1 (bulb dip)	'Pink Perfection': drenches applied at 10 fl oz/trade gallon pot. Bulbs dipped for 15 minutes the day before potting (VT).
		Concise, Sumagic	8 ppm x 1 (drench); 16 ppm x 1 (bulb dip)	'Pink Perfection': dips or drenches at 4 or 8 ppm reduced height at 6 weeks after planting, but control did not persist through flowering. Drenches applied at 10 fl oz/trade gallon pot. Bulb dipped for 1 minute the day before potting resulted in ~50% height reduction at flowering (VT).
<i>Lilium lancifolium</i> Tiger lily	To control plant growth	Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	10 ppm x 1 (drench); 20 ppm x 1 (bulb dip)	Bulbs dipped for 15 minutes the day before potting. Drenches applied at 10 fl oz/trade gallon pot. Growth control: ~25% height reduction at flowering (VT).
		Concise, Sumagic	8 ppm x 1 (drench); 4 ppm x 1 (bulb dip)	Drenches applied at 10 fl oz/trade gallon pot. Bulbs dipped for 1 minute the day before potting. Growth control of 'Red Twinkle': ~40% height reduction at flowering (VT).

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Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Lobelia cardinalis Cardinal flower	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 4,000 ppm spray x 1	NR (VT).
	To increase lateral branching	Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 60 ppm spray x 1	NR (VT).
		Concise, Sumagic	30 ppm spray x 1	Good control (VT).
Lobelia x speciosa Hybrid lobelia	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC	120 ppm spray x 1	'Fan Deep Rose' had moderate response; multiple applications required (VT).
	To increase lateral branching	Configure	600 ppm spray x 1	Increased number of shoots, not branches, on 'Fan Deep Rose'; moderate response. This rate was our screening rate. Higher rates may be more effective (VT).
Lysimachia Loosestrife	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate control of 'Snow Candles.' Apply at 10-14 day intervals (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	2,500 + 1,500 ppm spray x 1	Moderate control of height and width of 'Snow Candles' (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	120 ppm spray x 1	Moderate height and width control of 'Snow Candles' (VT).
		Topflor	30 ppm spray x 1	Moderate height and width control (VT).
Malva alcea Hollyhock malva	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	(UGA)
		Cycocel	750-1,500 ppm spray x 1	(UGA)
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	Much less than 40 ppm spray x 1	Very sensitive to paclobutrazol. Test rates ~10-20 ppm (UGA).
		Concise, Sumagic	Much less than 15 ppm spray x 1	Very sensitive to uniconazole. Test rates ~2-5 ppm (UGA).
Miscanthus sinensis Maiden grass	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Gracillimus' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	NR @ 5,000 ppm + 1,500 ppm spray x 2	'Gracillimus' NR (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Miscanthus sinensis Maiden grass (cont.)		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1	'Gracillimus' NR (VT).
		Concise, Sumagic	NR @ 60 ppm spray x 1; 2 ppm liner dip x 1	'Gracillimus' NR to spray, but liner dip gave more than 12 weeks of control (VT).
		Topflor	NR @ 120 ppm spray x 1	'Gracillimus' NR (VT).
Monarda didyma Bee balm	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2-3	Good control of 'Mahogany,' 'Marshall's Delight,' and 'Raspberry Wine' but no control of 'Blue Stocking' (VT, UGA).
		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	'Blue Stocking' NR (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control of 'Mahogany' and 'Marshall's Delight'; multiple applications may be required (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	100 ppm spray x 1; 6 ppm drench x 1; 16 ppm liner dip x 1	Good control of 'Raspberry Wine' but no control of 'Blue Stocking,' 'Jacob Kline,' or 'Mahogany' with 160 ppm spray x 1 (VT, UGA). Good control of 'Raspberry Wine' with 6 ppm drench x 1 applied as 2 fl oz/quart pot, but 'Jacob Kline' was NR to 10 ppm drench x 1 applied as 10 fl oz/trade gallon pot; drench volume and mg a.i. vary with pot size. Liner dip gave good control of 'Raspberry Wine' for 4 weeks (VT).
		Concise, Sumagic	15-30 ppm spray x 1; 1 ppm drench x 1	Good control of 'Mahogany,' 'Marshall's Delight,' 'Blue Stocking,' and 'Jacob Cline'; drench applied to 'Jacob Cline' at 4 fl oz/quart pot; drench volume and mg a.i. vary with pot size (VT, UGA).
		Topflor	Less than 37 ppm spray x 1	Excessive control of 'Jacob Cline' (VT).
	To increase lateral branching	Augeo	NR @ 1,600 ppm spray x 1	Limited height control of 'Beauty of Cobham' under nursery conditions with no increase in branching (VT).
Nepeta x faassenii Catmint	To control plant growth	B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control of 'Six Hills Giant'; multiple applications may be required (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	15 ppm spray x 1	For 'Walker's Low,' a single application at 3 weeks after planting gave good control (Virginia grower).
	To increase lateral branching	Augeo	1,600 ppm spray x 2 on liners	For 'Walker's Low,' 1 application at 5 days after transplanting increased branching without reducing plant growth; higher rates or multiple applications stunted plants (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Nepeta x faassenii</i> Catmint (cont.)		Configure	600 ppm spray x 1-2 on liners	Applied once at 5 days after transplant, or twice at liner stage (7 days after sticking) and 5 days after transplant; increased number of lateral branches (75%); slight reduction in plant growth (VT).
<i>Panicum virgatum</i> Switchgrass	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Shenandoah' NR in VT trials.
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 2	'Shenandoah' moderate response (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80 ppm spray x 1	'Shenandoah' moderate response (VT).
		Concise, Sumagic	NR @ 60 ppm spray x 1	'Shenandoah' NR in VT trials.
		Topflor	60 ppm spray x 1	'Shenandoah' moderate response (VT).
<i>Papaver orientale</i> Oriental poppy	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC	160 ppm spray x 1	Growth reduction of 'Royal Wedding' was moderate and short-term; 'Princess Victoria' was NR under nursery conditions (VT).
		Concise, Sumagic	30-45 ppm spray x 1	Growth reduction of 'Royal Wedding' and 'Princess Victoria' was moderate under nursery conditions (VT).
<i>Penstemon digitalis</i> Smooth white penstemon	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 3	'Husker Red' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Husker Red'; multiple applications may be necessary (VT).
		Bonzi, Downsize (drenches only), Paczol, Piccolo, Piccolo 10 XC	40-80 ppm spray x 1; 15 ppm drench x 1	Moderate control of 'Husker Red'; multiple spray applications may be necessary. Drench applied at 2 fl oz/quart pot (VT).
		Concise, Sumagic	10 ppm spray x 1; 0.5 ppm drench x 1; 1 ppm liner soak x 1	Moderate control of 'Husker Red'. Drench applied at 2 fl oz/quart pot (VT).
	To increase lat- eral branching	Configure	600 ppm spray x 1	Small increase in number of laterals of 'Huskers Red' but increased pot fill. This rate was our screening rate; lower rates may be effective (VT).
<i>Penstemon hybrids</i> Beard-tongue	To control plant growth	Bonzi, Paczol, Piccolo, Piccolo 10 XC	More than 16 ppm liner soak x 1	Slight (15%) reduction in height and width of 'Laura' (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Perovskia atriplicifolia</i> Russian sage	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Apply at 10-14 day intervals; slight delay in flowering (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control; multiple applications may be necessary (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	30-40 ppm spray x 1; 2 ppm liner soak x 1	'Longin' required higher rate of 80 ppm spray; may require multiple applications (VT).
		Concise, Sumagic	15-30 ppm spray x 1; 1 ppm liner soak x 1	Good control; multiple spray applications may be necessary (VT).
		Topflor	35-45 ppm spray x 1; less than 2 ppm liner soak x 1	This liner dip rate gave excessive early height reduction, but plants grew out by 7 weeks after treatment (VT).
<i>Persicaria microcephala</i> Knotweed, fleece flower	To control plant growth	Concise, Sumagic	45 ppm spray x 1; 0.5 ppm drench x 1	Good control of 'Red Dragon' in VT trials. Drench applied as 10 fl oz/trade gallon pot.
<i>Phlox paniculata</i> Garden phlox	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate response with 'Blue Boy,' 'Bright Eyes, and 'David,' but 'Charles Curtis' was NR; apply at 10-14 day intervals (VT).
		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	'Blue Boy' and 'Charles Curtis' were NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 4,000 ppm spray x 1	Good control of 'Blue Boy' and 'Charles Curtis'; multiple applications required. 'David' was NR (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	NR @ 160 ppm spray x 1; 4 ppm liner soak x 1	'Blue Boy' NR to spray, but moderate growth control of 'Blue Boy' and 'Bright Eyes' with liner dip (VT).
		Concise, Sumagic	60 ppm spray x 1; 2 ppm liner soak x 1	Moderate control of 'David,' but 'Blue Boy' and 'Charles Curtis' were NR to sprays. 'Blue Boy,' 'Bright Eyes,' and 'David' had moderate growth control with liner dips (VT).
		Topflor	75 ppm spray x 1	Moderate growth control of 'David'; multiple applications may be required (VT).
		Configure	600 ppm spray x 1-2 on liners and finished plants	Single sprays on finished plants: 'Franz Schubert' had an increased number of shoots; 'David' and 'Laura' were NR. This rate was our screening rate; higher rates or multiple applications may be effective. On liners: 'Bright Eyes' treated twice (26 days after sticking and 5 days after transplant) had increased lateral branches with no reduction in growth or flowering (VT).
		<i>Phlox paniculata</i> Garden phlox (cont.)		

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Phlox subulata Thrift, moss pink, creeping phlox	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Apple Blossom' NR (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	120 ppm spray x 1	Moderate control of 'Apple Blossom'; multiple applications may be required (VT).
		Concise, Sumagic	15 ppm spray x 1	Good control of 'Apple Blossom' (VT).
		Topflor	30 ppm spray x 1	Good control of 'Apple Blossom' (VT).
Rosmarinus officinalis Rosemary	To increase- lateral or basal branching	Configure	300 ppm spray x 2 on liners	Applied ~28 days after sticking; moderately rooted; increased numbers of shoots and branches and shoot growth of liners (VT).
Rosa 'Knock Out' knock out rose	To control plant growth	Concise, Sumagic	45-60 ppm spray x 1; 0.25 ppm drench x 1	Short-term response to sprays; multiple spray applications required. Drench controlled growth through 6 weeks after treatment, reduced height 35% without reducing width; drench applied at 10 fl oz/trade gallon pot; drench volume and mg a.i. will vary with pot size (VT).
Rudbeckia fulgida var. sullivantii 'Goldsturm' orange coneflower, black-eyed Susan	To control plant growth; begin applica- tions as flower stalks near leaf canopy because they bolt rapidly	Citadel, Cycocel	NR @ 4,000 ppm spray x 1	NR (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80-120 ppm spray x 1	Multiple applications may be necessary (VT).
		Concise, Sumagic	30 ppm spray x 1; 1 ppm liner dip x 1; 2 ppm drench x 1	Good control; drench applied as 2 fl oz/quart pot; drench volume and mg a.i. will vary with pot size (VT).
	Induce lateral or basal branching on liners	Configure	300 ppm spray x 1	Single foliar spray increased basal branching with significant early phytotoxicity (Virginia grower).
Rudbeckia hirta Black-eyed Susan	To control plant growth; apply PGRs just after bloom initia- tion but before bud has formed to reduce flower delay	Citadel, Cycocel	Phyto @ 1,500 ppm spray x 1	Excessive phytotoxicity on 'Indian Summer' (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	Phyto @ 5,000 ppm + 1,500 ppm spray x 1	Excessive phytotoxicity on 'Indian Summer' (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	160 ppm spray x 1	Little control of 'Indian Summer'; multiple applica- tions or higher rates required (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Salvia leucantha Velvet sage, Mexican sage	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 3	Apply at 10-14 day intervals (UGA).
		Citadel, Cycocel	2,250 ppm spray x 1	(UGA)
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	(UGA)
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	60 ppm spray x 1	(UGA, VT)
		Concise, Sumagic	30 ppm spray x 1	No landscape persistence at 30 ppm (UGA).
		Topflor	30 ppm spray x 1	(VT)
Salvia x sylvestris Salvia nemorosa Salvia hybrids meadow sage	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	'Indigo Spires' NR; this rate stunted and delayed flowering of 'Blue Queen' but controlled growth and increased flower number of 'May Night' (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80 ppm spray x 1	Cultivar differences. Good control of 'Blue Queen' with single spray at 80 ppm. 'Indigo Spires' NR @ 60 ppm; 'Blue Hill' and 'May Night' NR @ 160 ppm x 1 (VT).
	To increase lateral branching	Concise, Sumagic	15-60 ppm spray x 1	'Indigo Spires' very responsive at 15 ppm but may require multiple applications. Good control of 'Blue Queen' with a single 60 ppm spray. 'May Night' NR to a single 20 ppm spray (VT).
		Configure	300 ppm spray x 1-2 on liners	Single or multiple foliar sprays applied to 'May Night' ~34 days after sticking increased basal branching; apply after liners are well-rooted (VT).
Scabiosa columbaria Pincushion flower	To control plant growth; apply PGRs as flower stalk starts to elongate or if rosette appears to be elongating with flowers	B-Nine, Dazide	5,000 ppm spray x 3-4	Good growth control of 'Butterfly Blue' (UGA) and moderate control of overwintered 'Pink Mist' (VT).
		Citadel, Cycocel	NR @ 1,500 ppm spray x 1	'Pink Mist' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Butterfly Blue' but little control of overwintered 'Pink Mist'; test multiple applications (VT).
Scabiosa columbaria Pincushion flower (cont.)				

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	60 ppm spray x 1	Moderate control of 'Pink Mist' (VT).
		Concise, Sumagic	20-30 ppm spray x 1	Good growth regulation of 'Butterfly Blue' with 20 ppm (UGA), but higher rates or multiple applications necessary for 'Pink Mist' (VT).
		Topflor	30-45 ppm spray x 1	Moderate control of 'Pink Mist'; test multiple applications as necessary; high rates (60-75 ppm) reduced flowering (VT).
Sedum x hybrids	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate control of 'Autumn Joy'; apply at 10-14 day intervals (UGA, VT).
Sedum		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	'Autumn Joy' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate control of 'Autumn Joy'; multiple applications may be required (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80-160 ppm spray x 1-2	Good control of 'Autumn Joy' with a single 80 ppm spray, but 'Matrona' requires multiple applications at higher rates (VT).
		Concise, Sumagic	15-45 ppm spray x 1	Rates higher than 30 ppm on 'Autumn Joy' caused persistent reductions in plant growth in the landscape (UGA). 'Matrona' requires higher rates and/or multiple applications (VT).
		Topflor	37-60 ppm spray x 1	Good control of 'Autumn Joy' with a single 37 ppm spray; may require multiple applications. 'Matrona' height was not reduced with a single 120 ppm spray, but width was reduced with a single 60 ppm spray (VT).
	To increase lateral branching	Configure	600 ppm spray x 2 on liners	On liners: 'Autumn Joy' treated twice (18 days after sticking and 5 days after transplant) had double the number of shoots and 3 times as many lateral branches with no reduction in growth (VT).
Solidago sphacelata	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	'Golden Fleece': apply at 10-14 day intervals (UGA).
Golden rod		Bonzi, Paczol, Piccolo, Piccolo 10 XC	80-100 ppm spray x 1	'Golden Fleece': persistent reductions in plant growth continue in the landscape with rates more than 100 ppm (UGA).
Golden rod (cont.)		Concise, Sumagic	Less than 30 ppm spray x 1	'Golden Fleece': persistent reductions in plant growth continue in the landscape with 30 ppm (UGA).
Sorghastrum nutans	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate response with 'Indian Steel' in VT trials.
Indiangrass		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 2	Good response with 'Indian Steel' in VT trials.

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	160 ppm spray x 1	Moderate response with 'Indian Steel' in VT trials.
		Concise, Sumagic	45 ppm spray x 1	Moderate response with 'Indian Steel' in VT trials; may require multiple applications.
		Topflor	NR @ 120 ppm spray x 1	NR with 'Indian Steel' in VT trials.
<i>Stokesia laevis</i> Stoke's aster	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	'Purple Parasols' and 'Klaus Jelitto' responsive; apply at 10-14 day intervals (UGA, VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500-2,250 ppm spray x 1	'Purple Parasols' and 'Klaus Jelitto' responsive; may require multiple applications (UGA, VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	40-80 ppm spray x 1	Good control of 'Purple Parasols' but 'Klaus Jelitto' NR at 80 ppm spray x 1; also NR at 2 ppm drench x 1 applied at 2 fl oz/quart pot. (UGA, VT).
		Concise, Sumagic	Less than 60 ppm spray x 1	Excessive control of 'Silver Moon' at 60 ppm, but 'Purple Parasols' and 'Klaus Jelitto' were NR at this rate (UGA, VT).
	To increase lat- eral branching	Configure	NR @ 600 ppm x 1	'Sliver Moon': this was our screening rate; higher rates may be effective (VT).
<i>Tradescantia virginiana</i> Virginia spiderwort	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Moderate growth control of 'Red Cloud' and 'Blue Stone'; multiple applications necessary (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 2	Moderate growth control of 'Red Cloud'; multiple applications necessary. 'Blue Stone' NR at 5,000 ppm + 1,500 ppm spray x 1 (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	40-80 ppm spray x 1	Use higher rate for 'Red Cloud' (VT).
		Concise, Sumagic	15-30 ppm spray x 1	Use higher rate for 'Red Cloud' (VT).
		Topflor	15-45 ppm spray x 1	'Red Cloud' responsive to low rate. Use higher rate for 'Blue Stone' (VT).
<i>Verbena bonariensis</i> South American verbena, tall verbena	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Apply at 10-14 day intervals (UGA).
		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	(UGA)
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	120-160 ppm spray x 1	(UGA)
		Sumagic	Less than 30 ppm spray x 1	Persistent reductions in plant growth continued in the landscape with 30 ppm (UGA).
	To increase lat- eral branching	Configure	300 ppm spray x 2	Increased branching of 'Lolipop' liners (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
<i>Verbena canadensis</i> Clump verbena	To control plant growth	B-Nine, Dazide	NR @ 5,000 ppm spray x 2	'Homestead Purple' NR (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control of 'Homestead Purple'; may require multiple applications (VT).
	Induce lateral or basal branching	Concise, Sumagic	15-60 ppm spray x 1; 8 ppm drench x 1; 2 ppm liner soak x 1	A 15 ppm spray application had very short-term effect on 'Homestead Purple'; multiple applications required. A 60 ppm spray application gave moder- ate control of 'Homestead Red Carpet'; two applica- tions of 60 ppm caused excessive growth reduction. An 8 ppm drench or 2 ppm liner soak gave moderate control of 'Homestead Red Carpet'; test higher rates; drench applied at 10 fl oz/trade gallon pot; drench volume and mg a.i. will vary with pot size (VT).
<i>Verbena rigida</i>	Induce lateral or basal branching	Configure	250-1,000 ppm spray x 1	Single foliar sprays immediately after pinching increased lateral branching; 1,000 ppm controlled shoot elongation by 19% (VT).
		Florel	600 ppm spray x 1	Increased number of shoots and branching (VT).
<i>Veronica spicata</i> Spike speedwell	To control plant growth	Configure	600 ppm spray x 1	Increased number of shoots and branching (VT).
		Florel	NR @ 500 ppm spray x 2	Higher rates reduced height slightly but there was no increased branching (VT).
		B-Nine, Dazide	5,000 ppm spray x 2	Good control of 'Red Fox' (UGA).
		Citadel, Cycocel	NR @ 4,000 ppm spray x 1	'Red Fox' NR (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm sprays x 2	'Red Fox' responsive (UGA).
	Bonzi, Paczol, Piccolo, Piccolo 10 XC	Less than 40 ppm spray x 1	'Red Fox' sensitive; test lower rates (UGA).	
	Concise, Sumagic	10 ppm spray x 1	'Red Fox' very sensitive (UGA).	
	To increase lat- eral branching	Configure	300 ppm spray x 2 on liners	'Goodness Grows' treated twice (~28 days after sticking and 2 weeks later) had 4 times the number of lateral branches; shoot height was slightly reduced on liners; no effect on finished plants (VT).

Using Plant Growth Regulators on Containerized Herbaceous Perennials

Crop (Scientific name/ Common name)	Purpose	Trade name	Application rate (ppm ¹) x number of applications ²	Precautions or remarks
Veronica x 'Sunny Border Blue' Hybrid speedwell	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Multiple applications required; apply at 10-14 day intervals (UGA, VT).
		Citadel, Cycocel	750-1,000 ppm spray x 1	Higher rates cause persistent delay of growth in the landscape (UGA).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Good control; multiple applications may be required (UGA, VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	20 ppm spray x 1	Very sensitive (UGA).
		Concise, Sumagic	10 ppm spray x 1 Less than 1 ppm drench x 1	Very sensitive; persistent reductions in plant growth continue in the landscape at 15 ppm. Drench applied at 4 fl oz/quart pot; drench volume and mg a.i. will vary with pot size (UGA).
		Topflor	30 ppm spray x 1	Moderate control; multiple applications may be required (VT).
Vinca minor Lesser periwinkle	To control plant growth	B-Nine, Dazide	5,000 ppm spray x 2	Excessive reductions under nursery conditions; reduce rate or frequency (VT).
		B-Nine, Dazide + Citadel, Cycocel tank mix	5,000 ppm + 1,500 ppm spray x 1	Moderate reductions under nursery conditions; may require multiple applications (VT).
		Bonzi, Paczol, Piccolo, Piccolo 10 XC	40 ppm spray x 1	Moderate effect under nursery conditions; may require multiple applications (VT).
		Concise, Sumagic	15 ppm spray x 1	Moderate effect under nursery conditions; may require multiple applications (VT).
	To increase lat- eral branching	Configure	NR @ 1,200 ppm spray x 1	'Sterling Silver' was NR (VT).

Notes:

1. ppm = parts per million
2. Spray rates given are for spray applications at label-recommended volumes unless stated otherwise. Not all uses listed are on the label. Check product label before using.
3. NR = Nonresponsive at rates listed
4. a.i. = active ingredient



PUBLICATION 430-103 (HORT-281)

www.ext.vt.edu

Produced by Virginia Cooperative Extension, Virginia Tech, 2018

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VT/0218/430-103(HORT-281)