

Plant Growth Regulators

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Plant growth regulators (PGRs) are used to control plant height and enhance flowering. Their main mode of action is to reduce stem growth (e.g. shorten internodes). Generally, they do not interfere with flower development, however late applications or too high of rates can delay flowering and affect flower size. Most PGRs inhibit the production of gibberellic acid within plants, which are involved in cellular elongation. Without gibberellins, cells do not elongate as much and plants do not grow as tall. Used properly, plants will be more compact, and will have deeper green foliage and an improved post harvest life. Applying PGRs at the incorrect rate or time can result in stunted plants, delayed flowering, or market unsuitability. This is especially true for the products that are effective at extremely low concentrations (e.g. Bonzi, Piccolo, and Sumagic).

The effectiveness of PGRs varies from cultivar to cultivar. Environmental and cultural factors will also influence the degree of height control obtained. Care should be taken when using PGRs for the first time or for the first time on a new cultivar. Always double check your calculations. When using a PGR for the first time, leave some untreated plants to evaluate its effectiveness. To improve subsequent years' height control, keep records of the effects of PGRs on each plant cultivar. Table 4.1 gives an overview of the PGRs labelled for specific crops.

For additional information, the [North Carolina State University](http://www.ncsu.edu) website contains numerous factsheets on how to control plant height with PGRs and by cultural practices.

Be sure to read labels and follow their recommendations carefully.

Crop	A-Rest	B-Nine & Dazide	Bonzi & Piccolo	Cycocel	Cycocel Extra	Sumagic
Asters		✓				
Azaleas		✓		✓		
Begonias			✓			
Celosia			✓			✓
Chrysanthemum	✓	✓				✓
Coleus			✓			✓
Cosmos		✓				
Geraniums			✓	✓	✓	✓
Hydrangea		✓				
Impatiens			✓			✓
Lilies, Easter	✓					✓
Marigolds		✓				✓
Pansy						✓
Petunia		✓	✓			
Poinsettias	✓	✓		✓	✓	✓
Salvia		✓	✓			✓
Snapdragon						✓
Vinca						✓
Viola						✓
Zinnias		✓				

Factors that Affect PGR Performance

Environmental Conditions

- Growing conditions directly affect the effectiveness and the amount of PGR needed.
- Rates may differ between winter and summer months for the same crops because of the differences in environmental conditions.
- Plants grown under high light conditions will need higher rates than those grown under low light conditions.
- Stem elongation increases under high temperature conditions, so plants will need more PGRs than those grown under cool conditions.
- Do not apply PGRs when temperatures exceed 22°C.

Production Practices

- Crops grown with tight spacing, high fertilizer levels, and optimum irrigation may require higher PGR application rates.
- Stressed, dry, or weak plants will be more susceptible to the effects of PGRs and more prone to damage.
- A well-watered plant is better able to translocate PGRs.
- A pine bark based media will reduce the efficacy of Bonzi, Piccolo, and Sumagic drenches.

Cultivar Differences

- Optimum rates vary with each plant species and even by cultivar.
- Generally, short, slow growing varieties require a lower rate than fast growing varieties.
- Most labels suggest that growers do small-scale tests using low-label rates on each cultivar to gain experience in using the product and to determine the optimum rate under their growing conditions.

- Keep records of cultivar response to PGR treatments to improve height control in subsequent years.

Timing

- Timing is critical; plants must be in the right stage of growth to achieve the desired effects. Generally, plants must have sufficient foliage to prevent excessive stunting.
- Drenches should only be applied to plants with well-developed root systems.
- Base the application time on the stage of plant growth, rather than its age. Labels give general timing recommendations, but it is plant size that ultimately determines when to apply a PGR.
- Applications late in the production cycle may result in reduced flower size or delayed flowering.

Application Techniques

- Uniformity and consistency are two key components of application technique. Use precise spray techniques when doing foliar applications. This is essential for success with products that are active at extremely low concentrations, such as Bonzi, Piccolo, and Sumagic.
- Double check application rate calculations - the correct rate is essential for success.
- Do not tank-mix PGRs with any fertilizers, insecticides, or fungicides.
- Sprayers should have a pressure gauge and pressure regulators for uniform spray distribution. A reliable output is crucial in delivering a uniform rate over the entire crop.
- Sprayer nozzle size affects droplet size and spray dispersal. For consistent results, always use the same nozzle size.

A-Rest (ancymidol) (0.0264% a.i. = 0.264 g a.i. per L)

Apply as a soil drench to control the height of greenhouse-grown potted chrysanthemums, lilies, and poinsettias. A short delay of two to five days in flower development may occur at the higher recommended treatment levels. Each 15 cm pot should be drenched with either 60 or 120 mL of the final solution. It is very important that the entire medium mass is uniformly drenched. Table 4.2

outlines application rates and timing. Refer to the label for the amount to drench per container. Rates will vary with plant species, cultivar, timing, type of treatment, and growing conditions. Do not add any wetting agents.

See the label for complete information on using this product.

Crop	Rate (Drench)*	Timing	Comments
Chrysanthemums	2 – 8 ppm Refer to label for drench rate.	Treat plants when 5 to 15 cm in height (approximately 2 weeks following pinch).	Some cultivars are more sensitive than others. Ensure the entire medium mass is uniformly drenched.
Lilies	2 – 8 ppm Refer to label for drench rate.	Plants may be treated from emergence to 30 cm in height. For optimum results, treatments should be made to plants 5 to 15 cm tall. Do not apply between January 23 and February 7; bud count may be reduced. If split application is used, then apply 2 nd dose 1 to 2 weeks later.	Split application is generally recommended to avoid palm-tree effect. Ensure the entire medium mass is uniformly drenched.
Poinsettias	2 – 8 ppm Refer to label for drench rate.	Apply at pinch to 4 weeks after pinch, or 8 to 12 weeks before finishing.	Some cultivars are more sensitive than others. Ensure the entire medium mass is uniformly drenched.

*Apply the drench to moist soil only.

B-Nine WSG or Dazide WSG (daminozide) (85% a.i. = 850 mg a.i. per gram)

Apply as a foliar spray to control the height and enhance flowering of select potted ornamentals. It is one of the easiest of the PGRs to use. It is very mobile in the plant, moving readily throughout the plant after application. Therefore, uniformity of spray application is not as critical as it is with some other PGRs. It is rapidly broken down in the media, so it is not effective as a drench. It provides a moderate level of height reduction and is often used in split applications. See Tables 4.3 and 4.4 for dilutions, application rates, and timing. Do not apply to wilted plants. Plants should be well watered and the foliage should be dry when application is made. Do not use a wetting agent. Apply it when conditions favour slow drying, such as high humidity with little air movement, overcast conditions, or in the early morning or late evening. Once it dries on the leaf, very little additional product gets into the plant. It is readily washed off by overhead irrigation within twenty-four hours of application.

Do not tank-mix or apply within 7 days of an application of a copper containing product such as Phyton-27. Burning of leaves may occur.

See the label for complete information on using this product.

Concentration		Dilution (g/L)
ppm	% active ingredient	
1,500	0.15	1.8
2,500	0.25	3.0
5,000	0.50	6.0
7,500	0.75	9.0
10,000	1.0	12.0

Crop	Purpose	Spray Rate (ppm)	Timing	Comments
Azaleas	Enhance flower development on plants grown for greenhouse forcing.	1,500 (apply twice at 1 week intervals) or 2,500 (1 application)	Apply following final shaping when new growth is 2-5 cm long.	May delay flowering of some cultivars.
Bedding Plants (asters, cosmos, marigolds, petunias, salvia, zinnias)	Height control	5,000	Apply when 4-5 cm of new growth has developed after transplanting or pinching (~2-3 weeks), or when plants start to stretch.	Petunias must have 3-5 leaves.
Chrysanthemums (potted, branched plants)	Height control	2,500	Spray to run-off 2 weeks after pinching, when shoots are 2.5-3 cm long. Repeat if necessary, in 3 weeks.	Some cultivars are more sensitive. Tall varieties in small pots may require more frequent applications at the higher rate.
Chrysanthemums (potted, single stemmed plants)	Height control	5,000	Spray to run-off 2 weeks after planting.	
Chrysanthemums (cut)	To retard neck stretching	2,500	Spray top 1/3 of the foliage to run-off 2 days after disbudding.	
Hydrangeas	Height control of spring forcing growth	5,000	Apply when new growth has just started to unfold and 4-5 pairs of leaves are visible.	Apply 2-4 weeks after the start of forcing, but not later.
Poinsettias (pinched)	Height control	5,000 or 7,500 See the label for complete details.	Apply when new growth is 7-10 cm long and reapply in 2 weeks, if necessary.	Rate and number of applications vary with date of pinching or propagation.
Poinsettias (single stem)	Height control	5,000 or 7,500 See the label for complete details.	Apply 1-2 weeks after rooting. See label for second application date.	

Bonzi or Piccolo (paclobutrazol) (0.4% a.i. = 4 g a.i. per L)

Use as a soil drench or foliar spray to control the height of select greenhouse-grown ornamental bedding plants in containers. Thorough and uniform coverage of stems is essential when applied as a foliar spray. Uneven coverage will result in uneven height control. Spray volume is important in application effectiveness; sprays should thoroughly wet plant stems. It is generally recommended to use high volume application equipment. A light, misting spray on the leaves will not result in good height control. However, do not spray to the point of excessive run-off because product contacting the soil will be taken up by the roots, which will result in shorter than expected plants. Use lower rates and spray volumes in the early growth stages when leaves don't cover the media surface to prevent the

drench effect. Plants can be sprayed by area at a rate of 1-2 L/10 m², depending on the stage of growth, or sprayed by individual plants. Refer to Tables 4.5, 4.6, and 4.7 for information on dilution and application rates. It is not necessary to add wetting agents. Spray drift can be a problem if crops are grown closely together that have significantly different rates.

Paclobutrazol is readily absorbed by plant roots. The amount of chemical applied as a drench is more important than the volume of water used. The drench should be applied to moist potting media, and should deliver the desired milligrams of growth regulator per pot. Media containing pine bark will reduce the effectiveness of the product when it is applied as a drench.

Concentration (ppm)	Dilution (mL/L)
1	0.25
2	0.50
3	0.75
4	1.00
5	1.25
6	1.50
7	1.75
8	2.0
9	2.25
10	2.50
12	3.0
15	3.75
20	5.0
25	6.25
30	7.50
40	10.0
50	12.5
60	15.0

Paclobutrazol is extremely active at very low concentrations. Plant response to an application varies widely depending upon growing conditions and cultivar. Be sure of your calculations, volume measurements, and sprayer calibration. When in doubt recalculate! Frequent agitation of the spray mixture is essential. It is recommended to conduct a test spray to determine the optimum application rate for a given cultivar and growing conditions. Keep spray records to improve height control in subsequent years. High application rates may delay flowering of impatiens and petunias.

See the label for complete information on using this product.

Pot Diameter (cm)	Bonzi Drench Volume (mL)	Piccolo Drench Volume (mL)
10	60 - 80	60
15	120 - 140	120
20	180 - 200	300
25	-	740

Crop	Rate (ppm)*	Method	Application Volume
Begonia, cellpack	1 - 2	SPRAY	200 mL/m ²
Celosia, cellpack	20 - 40	SPRAY	200 mL/ m ²
Coleus, cellpack	20 - 40	SPRAY	200 mL/ m ²
Geranium, 10 cm pot	5 - 15	SPRAY	200 mL/ m ²
Impatiens, plugs	1 - 6	SPRAY	150 mL/ m ²
Impatiens, cellpack	6 - 12	SPRAY	150 mL/ m ²
Petunia, cellpack	30 - 60	SPRAY	200 mL/ m ²
Petunia, 10 cm pot	0.5 - 1.0	DRENCH	60 mL/pot
Salvia, cellpack	20 - 40	SPRAY	200 mL/ m ²

*One application at full label rate or two applications at half label rates, 7-10 days apart.

Cycocel (chlormequat chloride) (11.8 % a.i. = 118 g a.i. per L)

Use as a foliar spray or soil drench to control plant height and promote flowering in azaleas, geraniums, and poinsettias. Foliar sprays often result in phytotoxicity in the form of chlorotic spotting on leaves. Apply foliar spray to well watered, vigorously growing plants. Foliage should be dry at the time of application. Apply it when conditions

favour slow drying, such as high humidity with little air movement, overcast conditions, or in the early morning or late evening. See Tables 4.8, 4.9 and 4.10 for information on dilution, drench volumes, and application rates. Do not use Cycocel in combination with insecticides, acaricides, fungicides or fertilizers.

Concentration (ppm)	Dilution (mL/L)
1,000	8.5
1,500 (1:80)	12.7
2,000	17.0
2,500	21.2
3,000 (1:40)	25.4

See the label for complete information on using this product.

Pot Diameter (cm)	Drench Volume (mL)
6 to 8 *	55
10	85
13	110
15	170
20	220

*Two applications will be necessary to apply the recommended volume in 6 cm pots.

Crop	Purpose	Rate and Method	Timing	Comments
Azaleas	Early flower formation and shaping.	12 mL/L spray	When regrowth following pinching or shearing is 2-2.5 cm long. Repeat 1 week later.	May damage some cultivars (e.g. 'Dawn' or other Pericat varieties). Over-treatment may cause temporary leaf yellowing.
Azaleas, nursery stock	To prevent late season growth in nursery stock.	19 mL/L spray	When plants have reached desired size after final pinch/shear. Repeat 1 week later. If foliage becomes wet within 24 hours of treatment, repeat application.	May damage some cultivars. Over-treatment may cause temporary leaf yellowing and flower delay.
Geraniums, grown from seed in a greenhouse (Carefree only)	Height control	1 L/40 L (~3,000 ppm) applied as a soil drench	Apply 3 weeks after transplanting.	May cause chlorosis on leaf margins.
Poinsettias (red, pink, and white varieties)	Height control, stronger stems, and deeper foliage and bract colors.	1 L/40 L (~3,000 ppm) applied as a soil drench	Apply after plants have well established root systems and shoots are 2-4 cm long.	Most effective when applied during periods of active root growth. Do not apply after mid-October.

Cycocel Extra (chlormequat chloride) (46 % a.i. = 460 g a.i. per L)

A soil drench used to control plant height by reducing stem elongation in greenhouse grown geraniums and poinsettias. It controls height on all zonal-type geraniums, and also promotes branching and early flowering. For poinsettias, treated shoots or stems are more compact and stronger, and have deeper green foliage. Most effective response is obtained when Cycocel Extra is applied during the early period of active growth. Early application will produce more compact plants. Do not apply later than mid-October for poinsettias grown under

natural photoperiod as will result in crinkling and reduced size of bracts.

Apply the drench to established plants with healthy root systems. Apply only on moist growing medium and uniformly soak the medium with the drench. Foliage should be dry at the time of application. Do not apply this product if the crop is under stress. Environmental, cultural and genetic factors will affect application rates. Do not use Cycocel Extra in combination with insecticides, miticides, fungicides or fertilizers. Avoid applying to plants that are pot bound.

See the label for complete information on using this product.

Pot Diameter (cm)	Drench Volume (mL)
11	90
13	120
15	180
20	240
25	300

Crop	Purpose	Rate (Drench)	Timing
Geranium (zonal-type)	Height control, and promotes branching and early flowering.	325-650 mL/100 L	Apply 3 weeks after transplanting when well rooted or when stems begin to rapidly elongate.
Poinsettia	Height control, stronger stems, and deeper green foliage.	325-650 mL/100 L	Apply during early periods of active growth when plants are well rooted and established. Do not apply after mid-October on plants grown under natural photoperiod.

Sumagic (uniconazole-P) (0.055% a.i. = 0.5 g a.i. per L)

Use as a foliar spray for height control of certain ornamental greenhouse grown plants (e.g. bedding plants, chrysanthemum, Easter lily, geranium, and poinsettia). Thorough and uniform spray coverage is essential. It will not move from one lateral shoot to another, so plants will become uneven if each lateral shoot is not uniformly covered. It is most effective when applied to the stems, so foliar sprays should concentrate on uniform stem coverage. Ensure that adequate spray volumes are used and use high volume application equipment. Light, misting sprays over leaf tops will not result in good height control. Do not spray to the point of excessive run-off. Excess product will move into the soil and will be taken up by the roots, resulting in shorter than expected plants. Use lower rates and spray volumes in the early growth stages when leaves don't cover the media surface. See Tables 4.13 and 4.14 for more information on dilution and application rates. Apply uniformly at a rate of 2 litres of spray solution per 10 m² of bench area. Use only on well-watered, vigorously growing plants. It is recommended to apply during the morning or late afternoon. Do not tank-mix with pesticides, fertilizers, or adjuvants.

Sumagic is extremely active at very low concentrations. Therefore, extreme caution must be exercised when measuring, diluting, and applying

this growth regulator. If in doubt, recalculate! Excessive doses, either too high or too often, will result in severe growth retardation and possible adverse affects on flowering, plant appearance, and marketability. Avoid spray drift onto non-target crops. Do not use in greenhouses with soil floors consisting of sand or sandy loam. Plant response varies widely depending upon growing conditions, species, and cultivar. It is very important to do small-scale trials on every cultivar using the low rate before any large-scale applications are made.

See the label for information on using this product.

Concentration (ppm)	Dilution (mL/L)
1	2
2.5	5
5	10
10	20
12.5	25
15	30
20	40

Crop	Rate*	Timing	Comments
Chrysanthemums	5–10 ppm (10–20 mL/L)	Apply 7–14 days after pinching when the breaks are 3.8–5.0 cm long. A single repeat application can be made 7–21 days later.	Cultivars vary in their response. Test on a few plants. Avoid late season applications. Ensure uniform coverage of all lateral shoots for an even plant. Two applications may have more effect than the same amount of product used in a single treatment.
Easter Lilies	3–30 ppm (6–60 mL/L)	Apply when shoots are 7.5 cm tall. A single repeat application of 3–5 ppm (6-10 mL/L) can be made if the rate of the initial application did not exceed 5 ppm.	Avoid late season applications. Treated plants may need less water. Use with caution if you are controlling plant height with DIF.
Poinsettias	2–8 ppm (4–16 mL/L)	When breaks are 3.5–5.0 cm in length (e.g. about 10–14 days after pinching). Up to 2 repeat applications can be made at 7 day intervals.	Bract size may be reduced and days to flowering may be delayed. DO NOT APPLY AFTER THE INITIATION OF SHORT DAYS. Some cultivars are very sensitive.
Bedding Plants: <i>Celosia plumosa</i>	2.5–10 ppm	5-10 cm height	Do not apply more than 2 applications.
<i>Coleus spp.</i>	5–10 ppm	2-5 cm height	Do not apply more than once.
<i>Impatiens walleriana</i> or <i>I. balsamina</i>	2.5–10 ppm	3-10 cm height	Do not apply more than 2 applications.
Marigold (<i>Calendula officinalis</i> , <i>Tagetes erectus</i> , <i>T. patula</i> , and <i>T. signata</i>)	5–15 ppm	5-10 cm height	Do not apply more than 2 applications.
Pansy (<i>Viola wittrockiana</i>)	1–6 ppm	3-5 cm height	One application if >3 ppm applied; two applications if both are 1-3 ppm.
Periwinkle (<i>Vinca minor</i>)	1–3 ppm	5-10 cm height	Do not apply more than 2 applications.
<i>Petunia hybrida</i>	10–30 ppm	2-5 cm height	Do not apply more than once.
<i>Salvia splendens</i> , <i>S. horminum</i> , <i>S. farinacea</i> , <i>S. coccinea</i> , and <i>S. sclarea</i>	1–10 ppm	3-10 cm height	Do not apply more than 2 applications.
Snapdragon (<i>Antirrhinum majus</i>)	10–30 ppm	5-10 cm height	One application if >15 ppm applied; two applications if both are 10-15 ppm.
<i>Viola tricolor</i> , <i>V. cornuta</i> , and <i>V. williamsii</i>	1–5 ppm	2-5 cm height	Do not apply more than once.
Ivy and Zonal Geraniums (<i>Pelargonium hortorum</i> , <i>P. peltatum</i>)	Seed grown: 2–4 ppm Vegetative cuttings: 2–8 ppm	Seed grown: apply when plants are 5-16 cm tall. Vegetative cuttings: apply once rooting is established.	Do not apply more than 2 applications.
*Apply 2 litres of solution per 10 m ² of bench area.			