Cultural control of plant growth, and optimising the use of plant growth regulators to manage crop growth and development

Springfields Events and Conference Centre, Camel Gate, Spalding PE12 6ET

Wyeplants Nursery, Mallard Road, Spalding PE12 6ND

Contents

Agenda

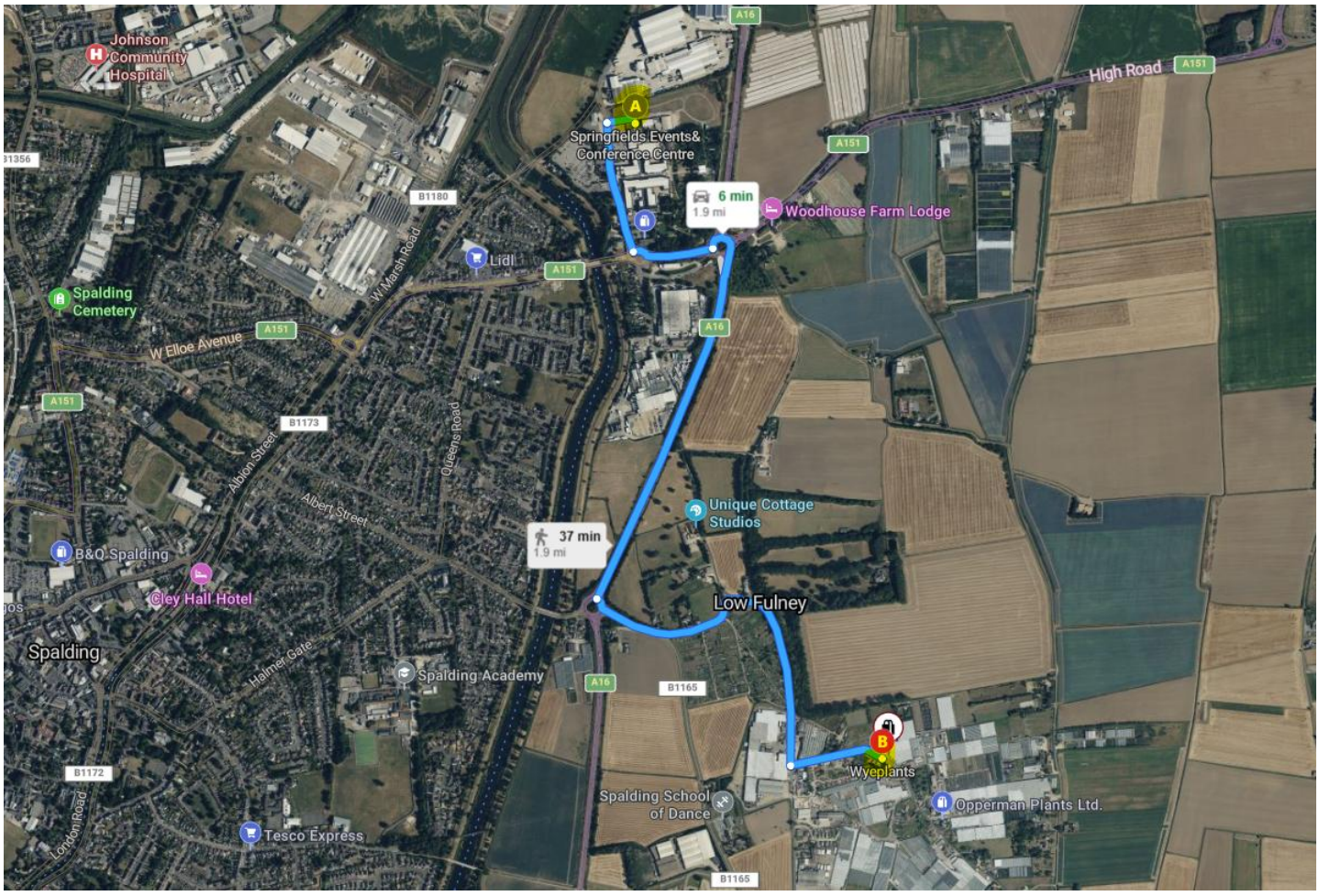
Time	Content	Speaker
Springfields Events and Conference Centre, Camel Gate, Spalding PE12 6ET		
09:00 – 09:30	*Coffee, tea, and refreshments*	
Presentations		
09:30 – 10:10	**Plant growth and physiology: growth control through mechanical and environmental manipulation**	Selchuk Kurtev, **Zest Sustainable ICM**
10:10 – 10:50	**Plant growth and physiology: growth control through nutrition and irrigation management**	Selchuk Kurtev, **Zest Sustainable ICM**
10:50 – 11:00	*Coffee, tea, and refreshments*	
11:00 – 11:40	**Getting the best from Bonzi: application methods, adjuvants, timing of applications, and rates**	Sean Loakes, **Syngenta UK**
11:40 – 12:30	**Plant growth regulators: available products and approvals, best practice and use, PGR mixtures, and integration into production programmes**	Selchuk Kurtev, **Zest Sustainable ICM**
12:30 – 13:30	*Lunch buffet*	
Wyeplants Nursery, Mallard Road, Spalding PE12 6ND		
14:00 – 14:15	Introduction to Wyeplants	Mark Yates, **Wyeplants**
14:15 – 15:45	Tour around the nursery and demonstration viewing: • Wyeplants herbaceous crop and discussion around PRGs • Small plot tests of various PGRs and combinations on Salvia 'Hot Lips' 1L	Mark Yates and Selchuk Kurtev
16:00	*Wrap up, networking and depart*	

BASIS and NRoSO continued professional development points will be available on the day of the workshop.

Location

Addresses and locations:

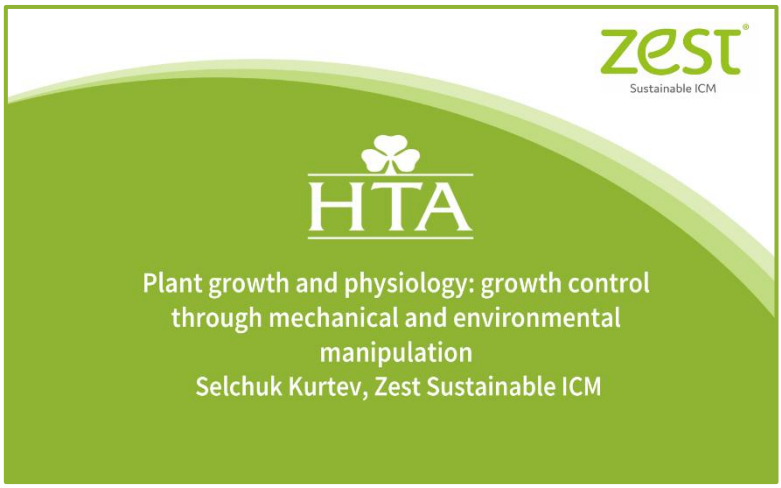
Springfields Events and Conference Centre, Camel Gate, Spalding PE12 6ET (highlighted in yellow and A on the map) *What3words: ///scrapping.decrease.paler*	**Wyeplants Nursery, Mallard Road, Spalding PE12 6ND** (highlighted in yellow and B on the map) *What3words: ///managers.bill.incurring*

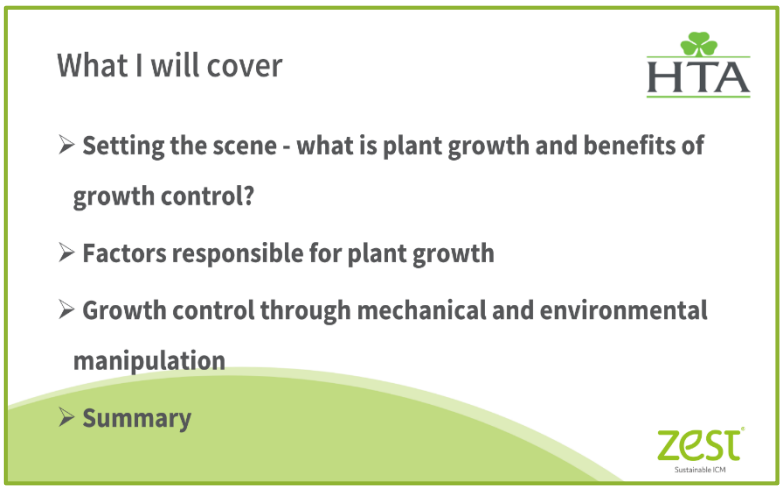


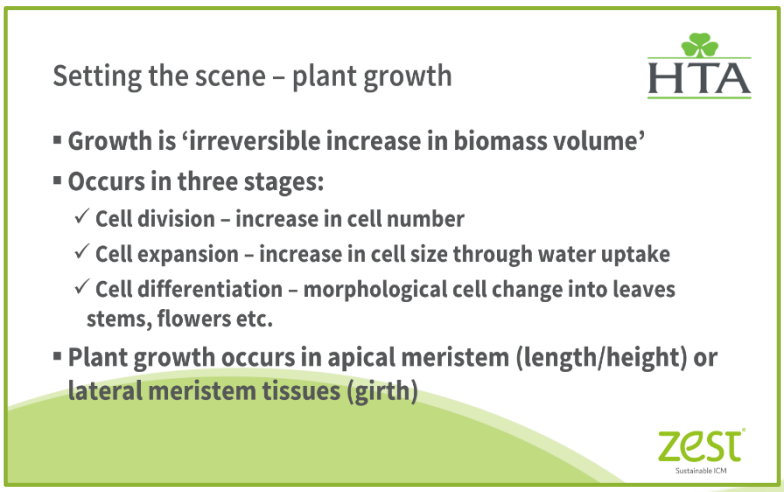
Plant growth and physiology: growth control through mechanical and environmental manipulation

Selchuk Kurtev, Zest ICM

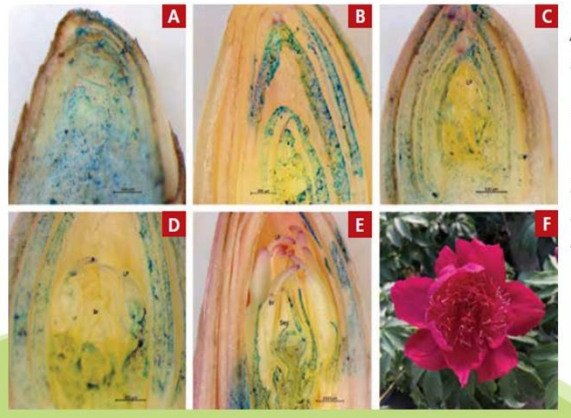
Notes







Setting the scene – plant growth

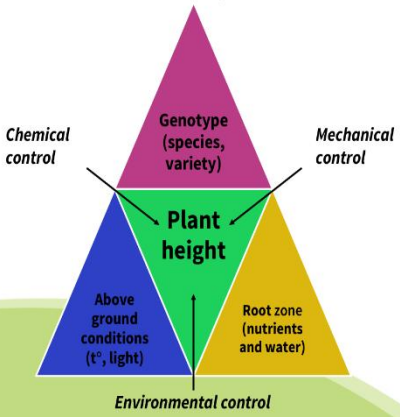


A. *Vegetative*
B. *Vegetative, formation of hollow*
C. *Transition between vegetative and reproductive*
D. *Reproductive*
E. *Flower formation*
F. *Flowering*

Benefits of growth control

- **Better plant quality**
- **More compact or balanced growth, reducing need to trim and leading to more plants per unit area or trolley**
- **Less wastage**
- **Reduced water demand (reduced stress)**
- **Customer requirements**
- **Improved shelf life**
- **Help with scheduling**
- **Other**

Factors responsible for plant growth



Notes

Mechanical growth control

Mechanical growth control

- Polythene or plastic netting/sheets
- Recommended 10-20 brushes per day for a minimum of five days

Mechanical growth control

- Leaf distortion possible
- Some shoot damage
- Could open wounds for secondary pathogens
- Very labour intensive unless automated
- Not all species respond in same way

Notes

Mechanical growth control – air brushing

- 5-11m/s (pulsed or non-pulsed)
- Effects visible above 8m/s
- Some species prone to damage (salvia, impatiens etc.) 6.5m/s+
- Difficult to create a uniform flow

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Environmental manipulation of growth - light

- **Light intensity**
  - Low light causes stretching
  - Light transmission through glass and polythene
  - Use of shading can cause stretching (higher light levels achieved via diffuse glass/polythene)
  - 400-700nm PAR
- **Light quality**
  - Increasing UV, Blue or Red can all reduce height
  - Use of LEDs or special lamps could be used (propagation)

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Environmental manipulation of growth - light

	Variety	Film and assessment											
		Luminance			Lumisol			SunSmart Blue (New)			SunSmart Blue- (Old)		
		H	Q	F	H	Q	F	H	Q	F	H	Q	F
Summer 2015	*Ageratum* 'Champion Blue'	↓	↓		↑	↓		↑	↓		↑	↑	
	Antirrhinum 'Liberty'	↓	↑		↓	↓		↓	↑		↓	↑	
	Dianthus 'Festival'	↑	↑		↑	↓		↑	↑	✓	↑	↓	
	French Marigold 'Durango'	↓	↔		↔	↔		↑	↔		↓	↓	
	Geranium 'Horizon'	↓	↔		↑	↓		↑	↓		↑	↔	
	Lobelia 'Regatta'	↓	↔		↑	↓		↓	↔		↓	↔	
	Pansy 'Matrix Spring Select'	↔	↑		↓	↔		↑	↑		↑	↓	
	Petunia 'Frenzy'	↓	↔		↑	↓		↑	↑		↑	↓	
	Salvia 'Vista'	↓	↔		↓	↓		↑	↔		↔	↓	
	Viola 'Sorbet XP Spring Select'	↑	↔	↔	↓	↔	↔	↑	↔	↔	↓	↓	↔
Autumn 2015	*Bellis* 'Medici'	↑	↔	✓	↔	↔		↑	↔		↑	↔	
	Cheiranthus 'Sugar Rush'	↔	↑	✓	↓	↔		↓	↑		↓	↑	
	Cineraria 'Silver Dust'	↔	↑		↓	↔		↔	↑		↔	↑	
	Cyclamen 'Metis'	↔	↓		↓	↓	✓	↔	↔	✓	↔	↔	✓
	Pansy 'Matrix Autumn Select'	↑	↔	✓	↔	↔	✓	↑	↑	✓	↑	↑	
	Polyanthus 'Piano'	↑	↑		↔	↑		↑	↔		↑	↔	
	Primrose 'Bonneli'	↑	↑	✓	↔	↑	✓	↑	↑	✓	↑	↔	✓
	Viola 'Sorbet XP Autumn Select'	↔	↔	↔	↓	↔	↔	↔	↑		↔	↑	↔

Key: Plant height (H), quality (Q) and flowering (F). ↑ - increased; ↓ - decreased; ↔ - no change. Treatments which increased plant quality and improved compactness are highlighted in red. Flowering: ✓ = flowering delayed compared with plants grown under glass; --indicates no difference in flowering time compared with glass.


Luminance


SmartBlue

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Notes

Environmental manipulation of growth - temperature

- Knowledge of crop temperature requirement
- Mainly rely on DIF and DROP practices
  - DIF = day temp-night temp (can be positive, zero or negative)
  - DROP = temp drop just after sunrise (a drop of 6-8°C for 2 hours)
- Negative DIF is difficult to achieve and not always practical, also could result in damage with more temperate plants
- DROP tends to be more practical, in the spring it's easier to achieve and more effective than in the autumn

Environmental manipulation of growth - temperature

Example of height control in Chrysanthemum using DIF techniques

Table 1: The Effect of DIF on internode length of in "Bright Golden Anne" chrysanthemum grown at 18C average daily temperature. (From: Karlsson et al, 1989)

DIF (Day temp - Night temp)	Internode Length (mm)
-12	10.9
-8	12.8
-4	15.3
0	18.2
4	21.6
8	25.5
12	29.9

- Shorter internodes, increase in shoot and flower numbers
- Leaf necrosis and leaf drop can occur
- Not all plants are responsive – aster, dahlia, lavender, salvia etc. poor response

Summary

- Understanding plant growth is key to controlling it
- Each crop (species and variety) can respond differently to the mechanical and environmental treatments, need to be managed individually
- Mechanical intervention is often avoided, but brushing where applicable (if automated) could be a good solution
- Environmental control is perhaps the main option here, especially light and temperature
- Polythene and light quality is important, 'prevention is better than cure'!
- All the various manipulation methods carry a risk of damage to crops

Notes

Plant growth and physiology: growth control through nutrition and irrigation management

Selchuk Kurtev, Zest ICM

Notes

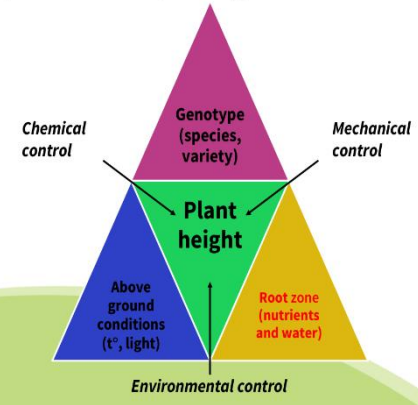
Plant growth and physiology: growth control through nutrition and irrigation management

Selchuk Kurtev, Zest Sustainable ICM

What I will cover

- Growth control through irrigation and RDI (regulated deficit irrigation)
- Growth control through nutrition
- Example nutritional products
- Summary

Factors responsible for plant growth



Growth control with irrigation (RDI)

- **Water stress and RDI**
  - Reduces speed of growth and increases root production
  - Requires careful monitoring
  - Growing media selection is important
  - High humidities cause stretching
  - Uniform starting material is crucial
  - Target moisture levels depend on species and growing media but generally around 12-15%

Growth control with irrigation (RDI)

- Risk of crop damage and loss
- Impact on immobile nutrients – Ca, B, Fe, Mn, Cu, Zn
- Reduces root pathogen infections
- Reduces sciarid flies and other soil dwelling pests
- Useful for holding crops back
- Needs uniform irrigation
- Challenges with suitability of production beds – highs and lows, drainage etc

Growth control with irrigation (RDI)

- Scheduling of crop must be considered with RDI
- Possible permanent change to plant habit, colour and growth
- Combination with RDI and environmental manipulation works well
- Caution on using combination of RDI and nutritional intervention
- It requires meticulous monitoring and skilled staff to implement it
- Irrigation system suitability and maintenance is very important

Notes

Growth control with nutrition - nitrogen

- NH_4 vs NO_3 – do we know the difference???
- Antagonism with potassium – good thing!
- In excess in peat-free growing media
- Use less NH_4 in winter
- Substitute with potassium nitrate or calcium nitrate
- Ideally remove nitrogen from base fertiliser for pot and bedding, but supplementary liquid feeding required
- Not influenced by pH of growing media

Growth control with nutrition - phosphorus

- Involved in the energy transfer of plants
- Insoluble in water and often difficult to maintain low levels of phosphorus without deficiency
- Caution when using Previcur Energy and phosphonate-based fertilisers
- Excess or deficiency leads to imbalance in 'root vs shoot'
- Lower phosphorus improves shelf life
- Influenced by pH of growing media

Low P High P PGRs

Impact of P buffer – Compalox (aluminium oxide absorbs excess P)

Growth control with nutrition - potassium

- Responsible for generative production and control of water movement within plants through 'potassium pump'
- Mobile within plants and can help with hardening off cells and growth
- Antagonistic with nitrogen, calcium and magnesium
- Not influenced by pH of growing media

Notes

Growth control with nutrition

- CRF not necessarily 'controlled' !
- Low base fertiliser is better than high rate of base fertiliser, especially where the media is high in coir
- Avoid ammonium nitrate fertiliser input
- Using phosphonate and low pH can trigger more growth, especially in temperatures above 15°C
- Use of high potassium fertiliser as foliar feed with plant protection products help with hardening off and counteracting nitrogen uptake
- High bark content in growing media absorbs nutrients and can lead to less effective growth regulator applications

Example nutritional products

- **Omex K50**
  - KCO_3 potassium carbonate based biostimulant
  - Type of salt highly biologically active
  - Mainly through foliar applications
  - Improves the plant tolerance to drought
  - Very strong hardening off effect
  - Phytotoxicity seen, even in trees where high doses used
  - Improves shelf life
  - Max dose 2L/ha in 600L/ha water
  - Minimum 10 days interval

Example nutritional products

- **High K soluble feeds – Peters 9-9-36, Kristalon Orange or Scarlet, Universol Violet and others**
  - Compound soluble feeds for liquid or foliar feeds
  - Helps with increasing potassium levels whilst adding nitrogen and phosphorus
  - Much slower results over longer period
  - Works well in combination with RDI and PGRs
  - Also provides some tolerance to Botrytis infections in autumn and winter
  - No more than 3g/L foliar and 5g/L liquid feeding

Notes

Example nutritional products

- **CalMax Ultra**
  - Compound liquid fertiliser with low nitrogen and high concentration of immobile nutrients
  - It has a formulation technology called AXN acting as 'pump primer'
  - Mainly used as calcium booster
  - Works well in combination with RDI
  - Improves product shelf life
  - No more than 1ml/L foliar with 10-day spray interval

Summary

- RDI is an effective way of growth control, however it requires skilled staff and meticulous crop monitoring
- Growing media type, production beds, irrigation system type are all key factors in implementing such growth control strategies
- Nutritional choice for growing media - incorporated fertilisers, liquid and foliar feeds, can supplement RDI or other growth control strategies but not sole strategy
- Timing of nutrient input is equally important

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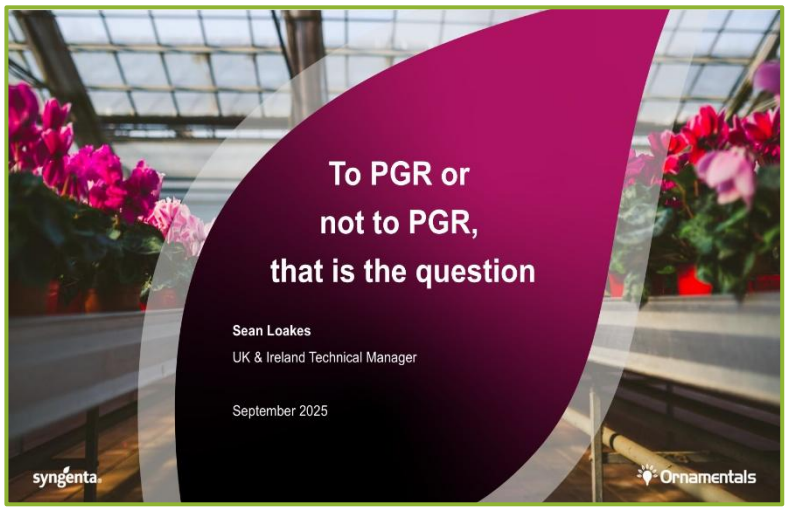
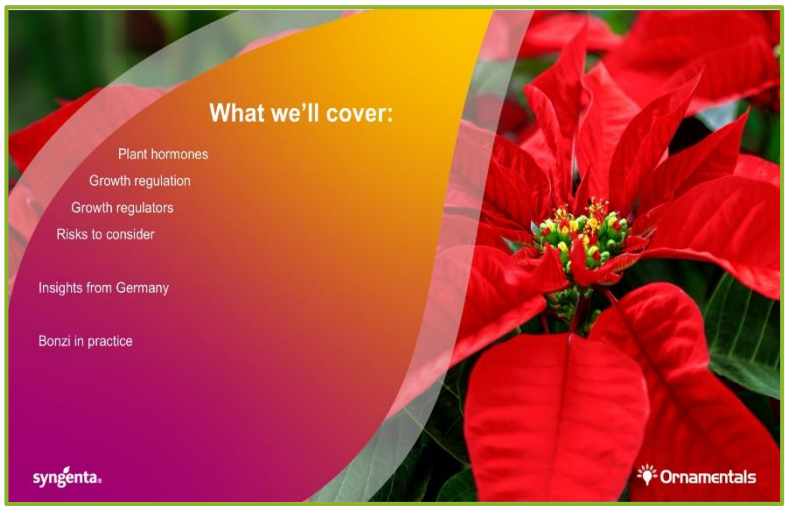
Notes

Getting the best from Bonzi: application methods, adjuvants, timing of applications, and rates

Sean Loakes, Syngenta UK





Notes

How does a plant grow??

Growth by

- Cell division
- Cell elongation
- Formation of tissues and plant parts

Influenced by

- Climate (air and soil)
- Water
- Nutrients
- Plant variety (genetics)
- Plant density
- (Chemical) growth regulators

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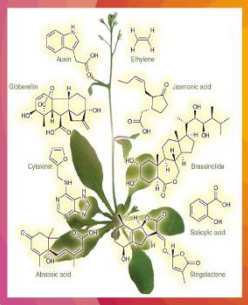
Hormones

- Internal and external signals that regulate plant growth are mediated, at least in part, by plant growth-regulating substances, or hormones
- The effect on plant physiology is dependent on the amount of hormone present and tissue sensitivity
- Hormones are substances produced in small quantities by a plant, and then actively transported elsewhere
- There are at least five major plant hormones or plant growth regulators



Greek: *hormaein* means "*to excite*").

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The five major plant growth regulating hormone types

- **Auxins** (cell elongation)
- **Gibberellins** (cell elongation + cell division - translated into growth)
- **Cytokinins** (cell division + inhibits senescence)
- **Abscisic acid** (abscission of leaves and fruits + dormancy induction of buds and seeds)
- **Ethylene** (promotes senescence, epinasty, and fruit ripening)

Our focus today

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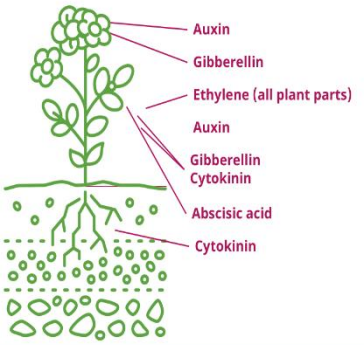
Notes

Where are plant hormones?



Sink/Source:

Plant hormones are formed in various areas in the plant (production site or source) and need to be transported to the effect site (sink)

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Gibberellins

Synthesis

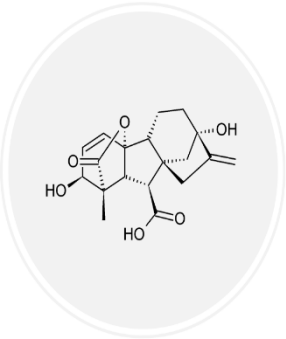
- Synthesis occurs in shoot apex, embryos, fruit, and roots

Function

- Wide spectrum of phytohormonal effects
- Regulate growth through **cell elongation** and cell division
- Induce hydrolytic enzymes

Compounds

- Natural
  - More than 70 naturally occurring gibberillins
- Synthetic
  - Many (Gibberellic Acid-3 "GA-3" is most commonly used commercially)



Did you know

Gibberellins are named after the fungus Gibberella fujikuroi which causes rice plants to grow abnormally tall.

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GA has been described as "an inhibitor of an inhibitor"

A car doesn't roll down a hill when the brake is on to inhibit it. Releasing the brake "inhibits the inhibitor", allowing another force (gravity) to move it

GA doesn't promote growth on its own, but instead inhibits growth inhibitors (i.e. releases the brakes)

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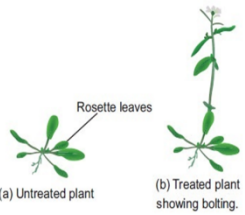
Notes

Effects of gibberellins

Cell elongation

- GA induces cellular division and cellular elongation; auxin induces cellular elongation alone.
- GA-stimulated elongation does not involve the cell wall acidification characteristic of auxin-induced elongation.
- Breaking of dormancy in buds and seeds.
- Seed germination - especially in cereal grasses, like barley. Not necessarily as critical in dicot seeds.



Promotion of flowering

- Transport is non-polar, bidirectional producing general responses.

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Growth regulation

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Options for growth regulation

Biological
Genetics

Physical
Pot size
Timing
Limit watering
Nutrition
Movement (e.g. wind)
Light intensity and period
Temperature

Chemical
PGR's

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Notes

Plant growth regulators (PGR)

- Internal and external signals that regulate plant growth.
- Effect depends on hormone present, sensitivity of the tissue.
- Small quantities are naturally produced and transported.
- Have the capacity to stimulate and/or inhibit physiological processes.

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When to use what?

- Regulate shoot growth of the plant, resulting in a sturdier, more compact plant with improved colour
  → **Growth regulator**
- Increase plant branching for enhanced cutting production or for a bushier potted plant or hanging basket
  → **Branching agent**
- Remove flowers from stock plants to increase the number of vegetative cuttings
  → **Ethylene-generating compound**

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Why do growers use PGR's?

Improved plant appearance by maintaining plant size and shape in proportion with the pot

Increased shipping capacity with smaller plants

Increased shelf life

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Notes

Why do growers use PGR's?

Growth regulators **do not** reduce plant size. They limit the plant's growth rate. You must apply the growth retardant **prior** to the "stretch."

Use PGR just prior to rapid shoot growth. This is generally one to two weeks after transplanting a plug, after the roots are established, and as the plant resumes active growth.

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Plant growth regulators (PGR)

Most plant growth regulators interfere with GA synthesis

Blocking early steps of GA synthesis:

- Chlormequat: positively charged compounds are bound to enzymes, the enzymes can no longer work, are pH sensitive.
- Paclobutrazol (Bonzi): replaces half-products in the synthesis, prohibiting the forming of GA.

Blocking late steps in GA synthesis:

- Daminozide (B-nine): mimics enzymes in late steps of GA production, inactivate precursors. Because of its structural form, it is easily absorbed in leaves.

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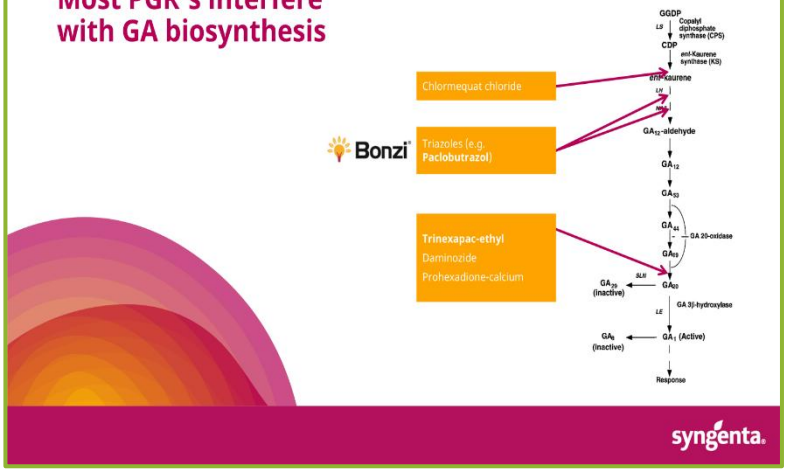
Notes

Most PGR's interfere with GA biosynthesis



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Risks of PGR application – application technique

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Bonzi and water volumes

The effect of Bonzi is not only determined by the dose rate but also by water volume.

More water can increase the efficacy (root absorption).

Diascia 'Piccadilly Denim Blue'

Same dose per ha, different water volume

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Notes

Effects of overdosing PGR

Some PGR's (like paclobutrazol) are very persistent and remain for a long time (months) in soils and on (concrete) floors.

This can have an unwanted effect in the next cycle.

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Make the crop ready for the PGR

- Make sure the plants have been watered the previous day;
  - No turgor → no plant activity → no absorption of PGR
  - Dry media binds the chemical
- Correct temperature of the crop (too cold/hot → inactive crop → no absorption of PGR)
- Climate, irrigation and humidity controlled (Daminozide and Bonzi → late afternoon)
- Difference of 4°C before sunset or day temp 2-3°C colder, can lead to growth deformation
- Spray in time – all PGR's reaction is delayed
- Spray open crops – otherwise only growing tips are hit

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Key information for some PGR's

	Daminozid	Chlormequat	Paclobutrazol
leaf	+	+	+
stem	+/-	+	+
root	-	+	+
reaction time	++	++	+
systemic	-	+	++
temp range	6 - 25 °C	6 - 30 °C	10 - 25 °C
reduced activity above	30°C	35°C	30°C

note: Daminozid and Chlormequat will react slow below 10°C

source: internal and Frank Korting

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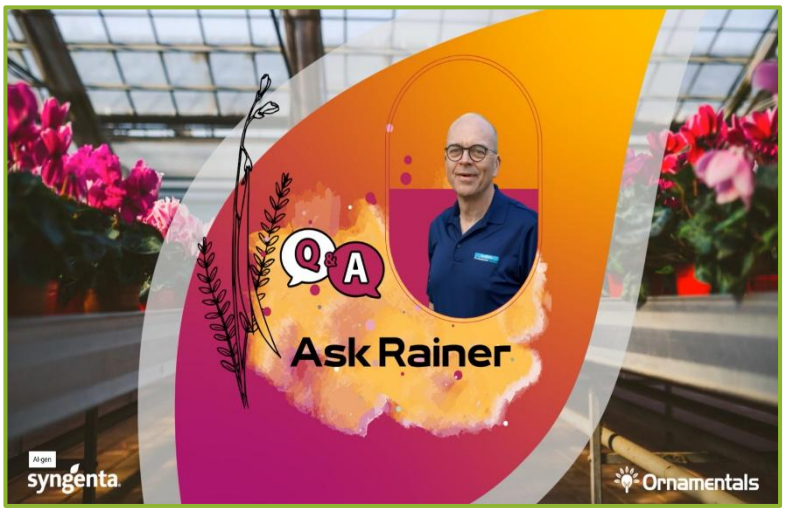
Notes

Notes


Q&A
Ask Rainer
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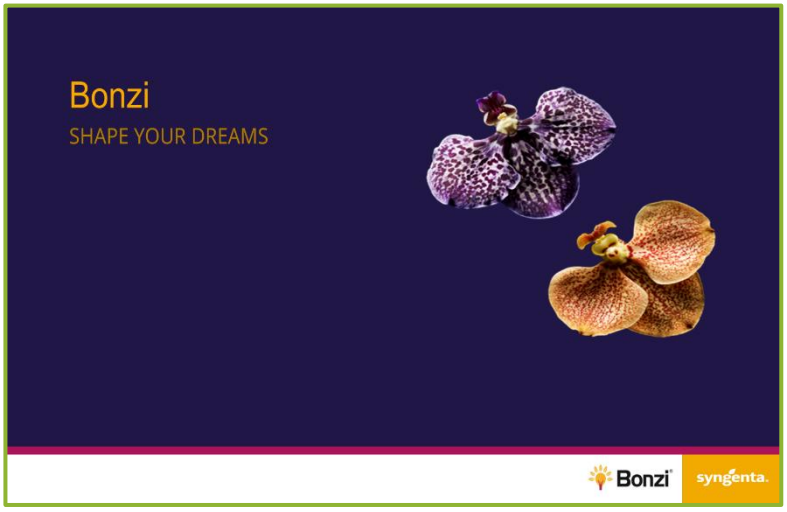
Bonzi
SHAPE YOUR DREAMS
Bonzi
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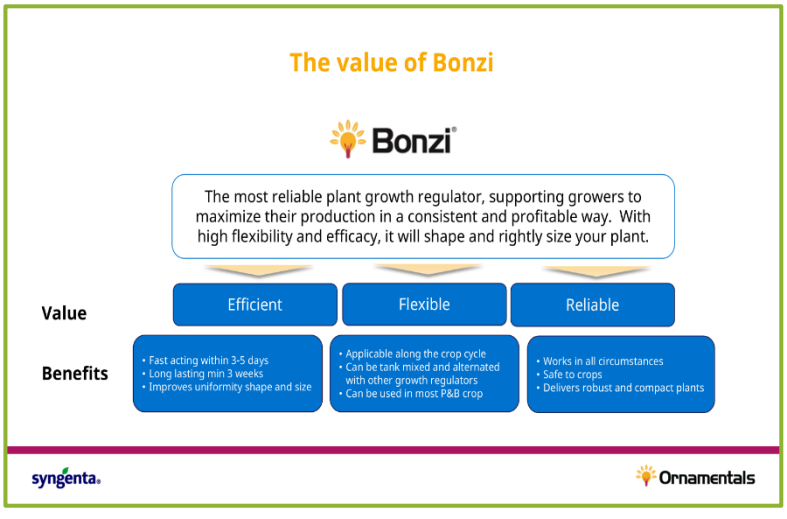
The value of Bonzi
Bonzi
The most reliable plant growth regulator, supporting growers to maximize their production in a consistent and profitable way. With high flexibility and efficacy, it will shape and rightly size your plant.
Value
Efficient
Flexible
Reliable
Benefits
• Fast acting within 3-5 days
• Long lasting min 3 weeks
• Improves uniformity shape and size
• Applicable along the crop cycle
• Can be tank mixed and alternated with other growth regulators
• Can be used in most P&B crop
• Works in all circumstances
• Safe to crops
• Delivers robust and compact plants
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Ornamentals

UPTAKE AND TRANSLOCATION

- BONZI can easily be taken up by the plant through leaves, roots and stems.
- It is transported upwards to the growing points through the xylem.
- The distribution is limited within the leaf therefore an equal coverage of the leaves is critical.

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BONZI IS A PRECISION TOOL

Tool	Effect
Plant spacing	More plants per sqm promotes stem elongation
Temperature	Higher temperatures promotes growth
Light	High light levels promotes stronger and stockier growth
Humidity	High humidity promotes more vigorous growth
Water	More water will stimulate growth
Nutrition	Higher EC results in more compact plants

Bonzi compliments cultivation measures for growth control

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Bonzi in practice

- Apply on a **dry crop** but be sure that the crop has enough water
- Apply the appropriate dosage to **avoid overdosing**
- After applying Bonzi wait for the crop to **dry before overhead watering**
- Ensure the optimum water volume to prevent Bonzi on the ground
- Do not re-use growing media which are used with treated plants
- Bonzi has no negative effects on flowers and flower development
- Earlier flowering after application of Bonzi has been observed in dianthus, fuchsia, petunia, and verbena
- With poinsettia, Bonzi should be applied before the first week of floral initiation to prevent effect on the bract size

syngenta Ornamentals

Notes

Bonzi is flexible

"Pansies can be produced year round under all kinds of circumstances"

"It is safe for beneficial insects and can be used in integrated growth systems"

- Start using BONZI just after pinching
- Apply 1 – 2 times per week
- Dose:
  - Less strong growing varieties: 25 – 50 ml / 100 litre
  - Vigorous crops: 50 - 125 ml / 100 litre

BONZI is flexible to use in combination with other growth regulators

- To produce ideal plants for your market
- To produce the right shaped and sized plant during the whole year
- Use solo, or tank mixed with other growth regulators

Source trials: Botany NL

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Bonzi is efficient

"With poinsettia, Bonzi can be used during the complete crop cycle"

"Last application in the first week of floral initation to prevent effect on the bract size and colour"

- Start using BONZI just after pinching
- Apply 1 – 2 times per week

Dose:

- Less strong growing varieties: 25 – 50 ml / 100 litre
- Vigorous crops: 50 - 125 ml / 100 litre

BONZI is a very efficient growth regulator

- To improve shape
- To improve size
- To improve homogeneity of plants

Source trials: DLR Rheinpfalz

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Bonzi is reliable

"BONZI can be safely used for growth control in crops such as pelargonium with a positive effect on bud formation and flowering time (earlier flowering)"

- Start using BONZI shortly after potting
- Weekly applications
- Dose: 30 – 100 ml/100 litre
- Water volume: 750 – 1000 litre per ha

BONZI has a reliable performance under all kinds of circumstances.

- To produce robust and compact plants
- Safe to use

syngenta Ornamentals

Notes

Bonzi and water volumes

The effect of Bonzi is not only determined by the dose rate, but also by water volume. More water can increase the efficacy

Same dose per ha, different water volume

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Ornamentals

Use and recommendations

Crop group	Crop	Dose per 100 litre
Pot and bedding plants	Begonia	30 – 100 ml
	Kalanchoë	25 - 100 ml
	Oxalis	2.5 ml
	Pelargonium	30 – 100 ml
	Poinsettia	25 - 50 ml
Trees, shrubs and perennials	Azalea	2.25 – 2.75 l
	Forsythia	125 ml
	Fuchsia	30 - 100 ml
	Hibiscus	30 – 150 ml
	Rhododendron	2 – 3 l

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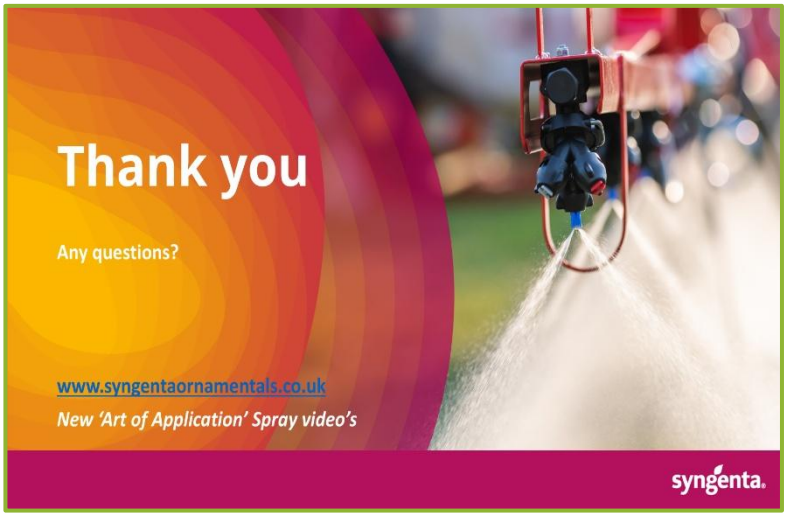
Ornamentals

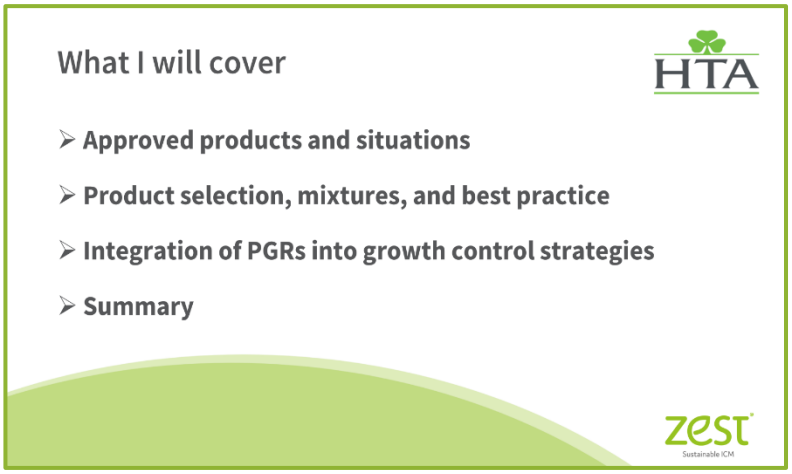


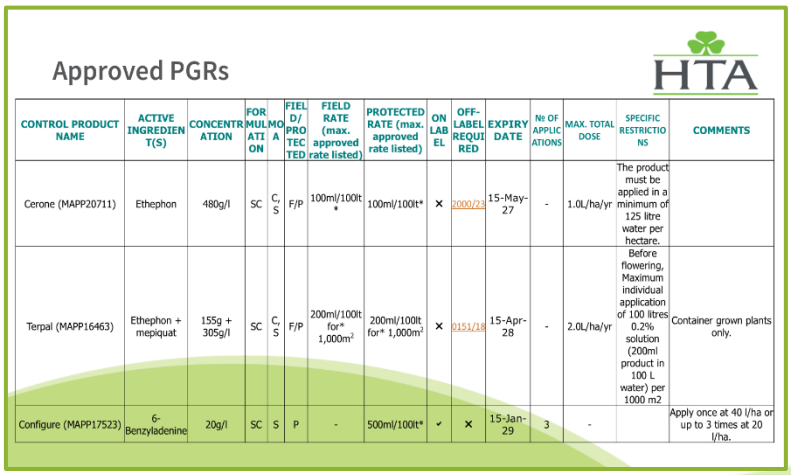
Notes

Plant growth regulators: available products and approvals, best practice and use, PGR mixtures, and integration into production programmes

Selchuk Kurtev, Zest ICM

Notes





Approved PGRs

HTA

CONTROL PRODUCT NAME	ACTIVE INGREDIENT(S)	CONCENTRATION	FORMULATION		FIELD/ PROTECTED	FIELD RATE (max. approved rate listed)	PROTECTED RATE (max. approved rate listed)	ON LABEL	OFF-LABEL REQUIRED	EXPIRY DATE	№ OF APPLICATIONS	MAX. TOTAL DOSE	SPECIFIC RESTRICTIONS	COMMENTS
Cerone (MAPP20711)	Ethephon	480g/l	SC	C, S	F/P	100ml/100lt*	100ml/100lt*	×	2000/23	15-May-27	-	1.0L/ha/yr	The product must be applied in a minimum of 125 litre water per hectare.	
Terpal (MAPP16463)	Ethephon + mepiquat	155g + 305g/l	SC	C, S	F/P	200ml/100lt for* 1,000m²	200ml/100lt for* 1,000m²	×	0151/18	15-Apr-28	-	2.0L/ha/yr	Before flowering, Maximum individual application of 100 litres 0.2% solution (200ml product in 100 L water) per 1000 m2	Container grown plants only.
Configure (MAPP17523)	6-Benzyladenine	20g/l	SC	S	P	-	500ml/100lt*	✓	×	15-Jan-29	3	-		Apply once at 40 l/ha or up to 3 times at 20 l/ha.

Approved PGRs

CONTROL PRODUCT NAME	ACTIVE INGREDIENT (S)	CONCENTRATION	FORMULATION	MOA	FIELD/ PROTECTED	FIELD RATE (max. approved rate listed)	PROTECTED RATE (max. approved rate listed)	ON LABEL	OFF-LABEL REQUIRED	EXPIRY DATE	№ OF APPLICATIONS	MAX. TOTAL DOSE	SPECIFIC RESTRICTIONS	COMMENTS
Stabilan 750 (MAPP09303)	Chlormequat	750g/l	SC	C, S	P	-	50ml/100lt*	×	1416/17	31-Aug-29	2	-	Workers must wear SRSU gloves for handling the crops 48 days after treatment.	
B-Nine (MAPP19611)	Daminozide	850g/kg	SG	C	P	-	500g/100lt*	✓	×	15-Mar-28	5	15kg/ha/yr		Plants should not be watered for 24hrs.
Dazide Enhance (MAPP16092)	Daminozide	850g/kg	SG	C	P	-	600g/100lt*	✓	×	15-Mar-28	5	-		
Bonzi (MAPP17576)	Paclobutrazol	4g/l	SC	S	P	-	25ml/100lt	✓	×	30-Nov-28	10	-	Workers must wear SRSU for handling the crops after treatment	The maximum concentration must not exceed 25 ml product per litre water

Approved PGRs

CONTROL PRODUCT NAME	ACTIVE INGREDIENT(S)	CONCENTRATION	FORMULATION	MOA	FIELD/ PROTECTED	FIELD RATE (max. approved rate listed)	PROTECTED RATE (max. approved rate listed)	ON LABEL	OFF-LABEL REQUIRED	EXPIRY DATE	№ OF APPLICATIONS	MAX. TOTAL DOSE	SPECIFIC RESTRICTIONS	COMMENTS
Pirouette (MAPP17203)	Paclobutrazol	4g/l	SC	S	P	-	30ml/100lt (250ml/100lt)	✓	1269/17	30-Nov-28	4 (1)	-	Workers must wear SRSU for handling the crops after treatment	
Regalis Plus (MAPP16485)	Prohexadione	100g/l	SG	S	F/P	416g/100lt	416g/100lt	×	0175/15	30-Jun-28	-	(2.5kg/ha/crop)		requires EAMU 2153/19 for indoor use
Moddus (MAPP15151)	Trinexapac-ethyl	250g/l	EC	S	F/P	60ml/100lt	60ml/100lt	×	3062/10	15-Jun-27	1	-		

ATTRIBUTES	PLANT GROWTH REGULATOR				
Active ingredient	*Chlormequat*	*Daminozide*	*Daminozide + Chlormequat*	*Ethephon*	*Paclobutrazol*
Activity level	+	+	++	+	+++
Multiple application needed	+++	+++	++	++	+
Application type	YES	YES	YES	YES	YES[1]
Foliar spray	YES	NO	NO	NO	YES
Drench	plugs/liners	cuttings	-	-	bulbs,plugs/liners
Dips/soaks					
Chemical absorption	+	+	+	++	+++
Ease of absorption	4h	18-24h	18-24h	12-16h	0.5-1.0h
Time (hours)					
Factors improving absorption	high humidity, limited air movement, cloudy days, early morning or late afternoon applications				
Translocation within plant	+++	+++	+++	-	+
Absorption site	+++	+++	+++	+++	++
Leaves	+	-	+	-	++
Stems	+	-	-	+	+++
Roots					
Typical concentrations Foliar sprays (mg/L)	0.6	2.5-5.0	1.5-3.0; 0.4-0.8	0.1 -0.5	1-200
Drench (mg active ingredient per pot)	0.1-0.2	-	-	0.01-0.1	0.01-8.0
Other factors	-	-	-	-	++
Does pine bark substrates affect drenches?					
Phytotoxicity potential	+++	+	+	++ (do not apply to stressed plants)	+
Overdose potential	+	++	++	++	+++
Optimum water pH	3.0-7.0	5.0-9.0	-	<5.0	4.0-9.0
Shelf life	<2	<2	-	indefinite	<4
In the bottle	<24h	<24h	<24h	<4h	<1 week
Mixed solution					

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Notes

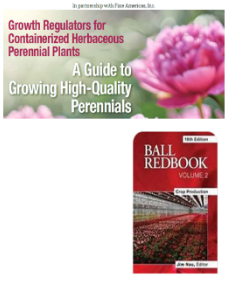
Key areas for getting the best of PGRs

- Scheduling and production strategy
- 'Strength' of active substance
- Timing of applications
- Product choice and dose rate
- Weather conditions at, before, during and after applications (also irrigation)
- Drench v spray
- Spray quality and droplet size
- Coverage and water volume
- Use of adjuvants and foliar fertilisers

Some examples

Varietal response

- Every species or variety responds differently
- Generally, the choice is based on grower experience
- Some PGRs delay flowering
- Behaviour of PGR under different conditions needs to be considered
- Results are dependent on factors mentioned previously
- Lots of data from the US and literature (note US gallon)



Notes

PGR mixtures

- Most common mixture daminozide* + chlormequat (3g + 0.8ml)
- Usually used as first treatment followed by daminozide
- Second most common paclobutrazol + daminozide*(1.5ml + 3ml) as spray
- Trinexapac-ethyl and prohexadione, mainly used for trees and shrubs (trinexapac on conifers or grasses)
- Ethephon tends to be used on herbaceous perennials often with daminozide (not on fuchsia)
- Caution with ethephon as it can abort flowers!
- *(label states not to mix daminozide)

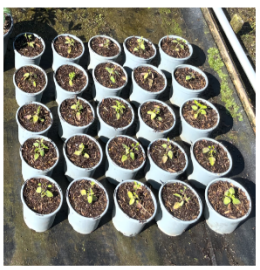
Integration of PGRs in strategies

Considerations:

- ✓ Crop family and genera
- ✓ Situation (outdoor, polythene, glasshouse)
- ✓ Weather conditions
- ✓ Crop specification (height, branching, number of flowers etc.)
- ✓ Growing media (bark content, coir content, CEC etc)
- ✓ Production beds (ebb and flow benches, MyPex over soil, capillary matting and MyPex etc.) (Potential to absorb or recycle PGR drench applications)
- ✓ Age (or stage) of the crop – plugs/liners vs finished crop
- ✓ Any mechanical, nutritional or environmental interventions
- ✓ Pest and disease pressure
- ✓ Stress…

Test plot trial – Salvia 'Hot Lips' 1L

- 104 plug potted and grown on outdoor bed, week 29 (14th July) into 1L
- Peat-free mix 4.0kg CRF + 0.8kg base
- 25 plants per plot
- 12 treatments including 'UNTREATED'
- MyPex over sand
- Overhead irrigation (no specific regime)
- All plots had single pinch on 29th August at 8cm height above pot



Notes

Test plot trial – Salvia ‘Hot Lips’ 1L

TREATMENT	CONCENTRATION / L	WATER VOLUME/ ha	WATER VOLUME / PLOT	11/08/2025	15/08/2025	22/08/2025
1. Untreated	N/A	N/A	N/A			
2. B-Nine	3g	600	60ml	✓	✓	✓
3. B-Nine + Cycocel	3g + 0.8ml	600	60ml	✓	✓	
4. B-Nine + High K	3g +3g	600	60ml	✓	✓	✓
5. B-Nine + Bonzi	3g + 2.5ml	600	60ml	✓	✓	✓
6. Bonzi (spray)	5ml	600	60ml	✓	✓	✓
7. Bonzi (spray) + Elasto	5ml + 2.5ml	600	60ml	✓	✓	✓
8. Bonzi (drench)	5ml	2,000	200ml	✓		✓
9. Bonzi + Cycocel	2.5ml + 0.8ml	600	60ml	✓	✓	
10. High K	3g	600	60ml	✓	✓	✓
11. Brushing	N/A	N/A	N/A	✓	✓	✓
12. Regulated deficit irrigation (RDI)	N/A	N/A	N/A	✓	✓	✓

Test plot trial – Salvia ‘Hot Lips’ 1L

Test plot trial – Salvia ‘Hot Lips’ 1L

Notes

Test plot trial – Salvia 'Hot Lips' 1L

Bonzi lead *Cultural lead* *B-Nine lead*

Summary

- If you think you should apply PGRs = YOU ARE TOO LATE!
- The product choice and application method is crucial for each species/variety
- Coverage and application techniques are crucial
- Daminozide, paclobutrazol and chlormequat remain key actives
- BUT, some adjustment to fertilisers both foliar and liquid feeding could be beneficial
- Brushing carries some risk depending on plant species but perhaps needs to be done early before shoot extension and more gently
- Finally, it's a combination of activities that form a strategy and not relying on PGRs alone

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Notes

Appendix

HDC/AHDB reports/factsheets/projects and online sources/articles/magazines

General PGR literature

1. GrowerTalks articles - https://www.growertalks.com/Article/?articleid=25336
2. GrowerTalks magazine covering PGRs on herbaceous plants - https://www.growertalks.com/pdf/Perennials_PGR_Guide_2024-2025.pdf
3. GrowerTalks magazine covering PGRs on annuals - https://www.growertalks.com/pdf/PGR_Guide_2025-26_Annuals.pdf
4. Hardy herbaceous perennials: a review of techniques for manipulating growth and flowering HNS 103, 2000 - HNS 103 final report
5. Hardy herbaceous perennials: validation of a screening protocol for factors that manipulate flowering – Annual report
6. Hardy herbaceous perennials: workshop to explore the potential for crop scheduling and the effects of chemical plant growth regulators to optimise growth and habit | AHDB
7. Collaborative research programme in partnership with Saxon State Institute for Agriculture, Pillnitz, Germany for the development of 'new' ornamental plants for early season sales - HDC project self assessment and report form
8. Collaborative research programme in partnership with Saxon State Institute for Agriculture, Pillnitz, Germany for the development of 'new' ornamental plants for early season sales. Part II: scheduled production and quality improvement - Project report
9. Herbaceous perennials: a guide to the production of container grown plants - Herbaceous perennials a guide to the production of container grown plants.pdf

Protected ornamentals related literature

10. Factsheet 04/13 Ornamental plant production: the use of chemical plant growth regulators on protected crops - https://projectbluearchive.blob.core.windows.net/media/Default/Imported%20Publication%20Docs/AHDB%20Horticulture%20/11881%20PGR%20FS%20aw%20low.pdf
11. HDC Factsheet 01/02 Growth regulation of ornamental plants by reduced phosphorus availability - https://projectblue.blob.core.windows.net/media/Default/Horticulture/Publications/Growth%20regulation%20of%20ornamental%20plants%20by%20reduced%20phosphorous%20availability.pdf
12. Growth control in protected ornamentals - https://potatoes.ahdb.org.uk/growth-control-in-protected-ornamentals
13. The use of chemical plant growth regulators on protected ornamental crops - https://potatoes.ahdb.org.uk/knowledge-library/the-use-of-chemical-plant-growth-regulators-on-protected-ornamental-crops
14. New plant growth regulators for use on poinsettia - https://potatoes.ahdb.org.uk/knowledge-library/new-plant-growth-regulators-for-use-on-poinsettia

15. Non-chemical growth control in protected pot plants - https://potatoes.ahdb.org.uk/non-chemical-growth-control-in-protected-pot-plants
16. HDC Grower summary PO 004: assessment of a number of new plant growth regulator products to control growth on commercial crops of bedding plants - https://projectbluearchive.blob.core.windows.net/media/Default/Research%20Papers/Horticulture/PO%20004%20Final%20psg.pdf
17. The use of spectral filter polythene in bedding plant production - https://archive.ahdb.org.uk/knowledge-library/the-use-of-spectral-filter-polythene-in-bedding-plant-production#:~:text=Plants%20respond%20differently%20to%20light,film%20compared%20with%20the%20Lumisol
18. HDC Grower summary CP 19: Horticulture crops: a demonstration of potential benefits of modified plastic crop covers - https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Horticulture/CP/CP%20019%20Spectral%20filters%202006.pdf

Hardy nursery stock related literature

19. HNS 108 Growth of a range of nursery stock subjects under different coloured and spectral filter plastic films - https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Horticulture/hns/HNS%20108%20HNS%20Spectral%20filters%202003.pdf
20. HNS 39b An examination of the use of plant growth regulators as a management tool in the production of liners of container grown nursery stock - https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Horticulture/hns/HNS%20039b%20Liners%20growth%20regulators%201998.pdf
21. HNS 039/ 039a The use of growth regulators on container grown hardy nursery stock - https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Horticulture/hns/HNS%20039%20&%20039a%20Container%20growth%20regulation%201996.pdf

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