Project title	Hardy Herbaceous Perennials: Workshop to explore the potential for crop scheduling and the effects of chemical plant growth regulators to optimise growth and habit.
Project number:	HNS 103b
Project leader:	Wayne Brough, ADAS
Report:	Final report, July 2010
Previous report	N/A
Key staff:	David Talbot, ADAS Chris Burgess, Consultant
Location of project:	Cuckoobridge Nursery, Somersham
Project coordinator:	Steve Carter, Farplants, Yapton Lane, Walberton, Arundel, W Sussex. Francis Mizuro, R.A. Meredith and Son, Cuckoobridge Nursery, Somersham, St Ives, Cambridgeshire
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Key words:	Herbaceous plants, growth regulators, plant growth control, plant habit manipulation, scheduling techniques, daminozide, chlormequat, paclobutrazol, prohexadione-calcium, Dazide Enhance, Bonzi, Fargo Chlormequat, Regalis

The information in this report is based on a simple demonstration trial conducted over a four month period. The conditions under which the trial was carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Signature ..... Date ....16 July 2010.....

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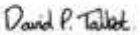
Signature .....  ..... Date ..28 September 2010 ...

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Grower Summary

Headline

Four chemical plant growth regulator treatments were applied to eighteen herbaceous plant species. The treatments gave variable control of plant height and habit and impacted to varying degrees on flowering times. No single treatment proved optimal across the range of plant species examined.

The effects of the chemical growth regulator treatments were variety specific, as well as species specific.

The drench applications examined tended to be more effective and more persistent than the spray applications, though they were more time consuming to apply.

Background and expected deliverables

The project was designed to explore the potential of scheduling herbaceous plant production and to examine the effects of chemical plant growth regulators on plant growth and habit on a selected number of herbaceous species. It was a combination of both knowledge transfer and demonstration research to show the possible benefits from such techniques.

The project was divided into three stages:

1. a literature review of chemical plant growth regulator use on herbaceous perennials (Annex II in the full report).

2. an unreplicated demonstration trial examining the use of paclobutrazol (Bonzi), daminozide (Dazide Enhance), chlormequat (Fargro chlormequat) and prohexadione-calcium (Regalis) on a range of herbaceous perennial species.

3. a workshop at the trial site to provide information about scheduling and chemical plant growth regulator use on herbaceous perennials (Annex I in the full report).

This Grower Summary highlights the key observations from the demonstration trial on the effect of the various chemical plant growth regulators on the herbaceous perennial species examined.

Summary of the project and main conclusions

1. Trial detail

Eighteen herbaceous plant species were selected for inclusion in the trial, which was hosted by a commercial nursery; selection was based on the potential to improve plant habit or control plant vigour via the application of chemical plant growth

regulators and species availability from stock on the host nursery. The species selected and the appropriate production detail for each are summarised in Table 1.

The plants were grown as a commercial crop under glass on mobile benching in 2 litre pots using a Bulrush growing media and watered overhead by hand. They were spaced as necessary and pesticides were applied to control aphid, whitefly and two spotted spider mites, according to commercial practice.

The plants were laid out by treatment on 11 May 2010, two treatments per bench.

Four plants of each of the eighteen species formed each treatment block (72 plants per treatment). There was no treatment replication as the trial was laid out for demonstration purposes only over seven benches. Two plants from each treatment per species were labelled and recorded throughout the trial period.

Table 1 herbaceous plant species selected and trial details

Species / variety	Seed	Cutting	Plug size	Sowing / sticking date	Potting on date	Pinch	Other comments
Achillea 'Moonshine'		x	60	Wk 6	Wk 16	No	
Campanula 'Blue waterfall'		x	60	Wk 6	Wk 14	11/05/10	
Catananche caerula 'Blue'	x		84	Bought in	Wk 16	26/04/10	
Centaurea 'Amethyst in Snow'		x	60	Wk 4	Wk 16	No	
Coreopsis 'Lime Rock Ruby'		x	60	Wk 8	Wk 12	11/05/10	
Diascia personata		x	60	Wk 6	Wk 16	No*	Very small plants initially
Erysimum 'Bowles Mauve'		x	60	Wk 6	Wk 14	No	
Gallardia 'St Clements'		x	84	Bought in	Wk 16	11/05/10	Small plants initially
Gaura neapolitanum 'Tutti Frutti'		x	60	Wk 6	Wk 14	26/04/10 11/05/10	
Lavatera 'Blushing Bride'		x	60	Wk 6	Wk 12	26/04/10	
Lavender 'Bella Rouge'		x	60	Wk 6	Wk 8	No	Well established plants
Leucanthemum 'Broadway Lights'		x	84	Bought in	Wk 17	No	
Monarda 'Beauty of Cobham'		x	84	Wk 6	Wk 14	No	Small plants initially
Penstemon 'Ice cream Sweet cherry'		x	84	Wk 6	Wk 12	26/04/10 11/05/10	
Phygelius 'Funfare Wine'		x	84	Wk 8	Wk 16	No	Small plants initially
Scabiosa 'Burgundy Bonnets'		x	60	Wk 6	Wk 12	No	Well established plants
Salvia 'Hot Lips'		x	60	Wk 8	Wk 12	11/05/10	
Verbena 'Seabrook Lavender'		x	60	Wk 8	Wk 12	26/04/10 11/05/10	

* except at cutting stage.

The chemical plant growth regulator treatments applied, the rate used, method of application and date of application are summarised in Table 2a. Product approvals status is provided in Table 2b.

The spray treatments were applied in approximately 1,000 litres of water per hectare (to the point of run off from the foliage) by a small hand held sprayer. The drench treatments were applied at 150 ml of the final solution per 2 litre pot via a watering can and washed off with plain water. All applications were undertaken during late afternoon / early evening.

Table 2a *Treatments, rates used, method of application and timings*

Treatment	**Rate and application method**	**First application Date**	**Second application date**
Untreated control			
Bonzi	1 spray at 2.5 ml per litre	11/5/10	
Dazide Enhance	1 spray at 5.0 g per litre	11/5/10	
Fargro Chlormequat	1 spray at 6.0 ml per litre	11/5/10	
Regalis	1 spray at 2.5 g per litre	11/5/10	
Bonzi	2 sprays at 1.25 ml per litre	11/5/10	26/5/10
Dazide Enhance	2 sprays at 3.0g per litre	11/5/10	26/5/10
Fargro Chlormequat	2 sprays at 3.0 ml per litre	11/5/10	26/5/10
Regalis	2 sprays at 1.25 g per litre	11/5/10	26/5/10
Bonzi	Drench at 2.5 ml per litre	11/5/10	
Dazide Enhance	Drench at 5.0 g per litre	11/5/10	
Fargro Chlormequat	Drench at 6.0 ml per litre	11/5/10	
Regalis	Drench at 2.5 g per litre	11/5/10	

Most of the plants were of an appropriate size for treatment; however one species had insufficient growth (*Diascia*) whilst one or two others were too well developed (*Scabiosa* and *Lavandula*).

Table 2b *Approvals status for treatments (as of 20 October 2010)*

Product	MAPP	Active ingredient	%	Use	Crop	Approval status
Bonzi	13623	Paclobutrazol	0.4	Growth regulator	Ornamental plant production	On label
Dazide Enhance	14433	Daminozide	85	Growth regulator	Ornamental (protected)	On label
Fargro Chlormequat	02600	Chlormequat	46	Growth regulator	Ornamental plant production	On label
Regalis	12414	Prohexadione-calcium	10	Growth regulator	Ornamental (outdoor)*	Off label (2886/08)

*An experimental permit (COP 2101/00664) was obtained to use Regalis under protection and at the higher one off application rate.

The selected plants from each treatment were assessed on 11 May (at the start of the trial), on the 26 May 2010 and finally on 14 June 2010. Plant height / spread, growth score (0-5 score), time to flower and any phytotoxic damage symptoms were recorded.

The plants were moved outside under an open sided polythene tunnel on the 9 June 2010 to provide a cooler environment and minimise plant stress.

Two plants of each species per treatment were selected and moved onto separate benches on the 14 June 2010 prior to the demonstration workshop at R. A. Meredith and Son, Cuckoo Bridge Nursery (Somersham, Cambridgeshire).

Figure 1 *Stage of plant development at first application of chemical plant growth regulator (sprays and drench treatments) with a number of plant species*

Campanula

Diascia

Lavatera

Lavandula

Scabiosa

Verbena

(Plants in 2 litre pots).

2. Trial results

The effect of the 4 chemical plant growth regulators on each of the eighteen herbaceous plant species is described in Table 3 and is quantified in Table 4.

Growth control and habit manipulation were achieved in most cases (as described in Table 3) although no single chemical plant growth regulator treatment proved optimal for all the species examined.

Not all the plant species came into flower before the final recording, so comments on flower stem length control with these species is limited. A delay in flowering was noted with some species, however because records were made relatively infrequently it was not possible to measure the delay in days and only the more significant delays (a week or more) were noted.

Images of the most effective chemical growth regulator treatments are provided in Figure 2.

Some phytotoxic damage was noted in response to the higher rate chlormequat spray treatment (Figure 3); primarily this took the form of leaf chlorosis, but leaf crinkling was also noted in the case of *Lavatera*; flower petal bleach was noted in response to Regalis.

Some of the drench treatments gave rise to growth control that was too excessive (Figure 3) and lower chemical rates than those used the trial are suggested in these instances for commercial crops.

Table 3 *Summary of treatment effects (as at 14 June 2010)*

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
Achillea **'Moonshine'**	Limited effect on plant height with spray treatments. No delay in flowering. No improvement in habit. Drench treatment led to plants which were very compact.	Slight height reduction with two spray treatment and possibly slight flower delay. No improvement in habit. Drench treatment reduced height by almost 50%.	Limited effect on plant height with spray treatments. Less reduction of side growth with this treatment. No delay in flowering. Drench treatment had little effect on height. Yellowing of older leaves still visible.	No effect with 1 x spray treatment, limited (varied) effect with 2 x sprays. No delay in flowering. Over 50% reduction in growth in response to drench treatment.	**Drenches had more impact on height, though lower rates will be needed commercially. Minimal improvement in habit, sprays targeted at flower stem may be better suited.**
Campanula **'Blue Waterfall'**	Limited effect of spray treatments. Possible slight delay in flowering, no habit improvement from sprays. Drench treatment very effective at reducing stem elongation and improving overall appearance of plant, growth regulation a little severe.	Limited effect of spray treatments. Possibly a slight improvement in habit where two foliar sprays were applied, no delay in flowering. Earlier application may improve results. Drench treatment less effective than Bonzi, but useful growth reduction achieved.	Limited effect of spray treatments. No delay in flowering. Maybe more shoot growth in crown of plant from 1 x spray treatment. Drench treatment slightly more effective than Dazide drench. Plants have smaller leaves / more open habit relative to other drench treatments. Leaf yellowing noted in response to drench and high rate spray treatment.	Limited effect of spray treatments. No delay in flowering. No improvement in habit. Flower petals slightly paler, especially in response to drench treatment. Drench treatment comparable to chlormequat treatment.	**Only drenches had a significant effect on plant growth. Bonzi drench treatment appears best in terms of growth reduction and habit improvement.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
Catananche caerula **'Blue'**	No effect of spray treatments (height control, flowering or plant habit improvement). Drench treatment improved habit and reduced flower stem length, also darkened foliage.	No effect with 1 x spray treatment, 2 x spray treatment gave significant growth reduction but may result in a delay in flowering. Drench treatment produced good balanced plants with sufficient flower stem reduction. Darkened foliage.	1 x spray treatment was ineffective (plants poorer quality than control plants). 2 x spray treatment gave no reduction in flower stem height but increased the number of flowering side shoots. Drench treatment effective, as for Dazide.	The 2 x spray treatment was more effective than the 1 x spray treatment, giving rise to more compact plants. Drench treatment least effective of all the drench treatments. Foliage darkened.	**Bonzi, Dazide and Chlormequat drenches all made the plants more compact, as did the Regalis and Dazide 2 x spray treatments. No flower before end of trial.**
Centaurea **'Amethyst Dream**'	Spray treatments of limited effect. No delay in flowering, no improvement in plant habit. Bonzi drench produced very compact plants, at least 60% height reduction allowing plants to remain upright.	Spray treatments as for Bonzi. Dazide drench treatment effective, less compact than in response to Bonzi drench, but better balance to plant habit.	No real improvement in habit or apparent reduction in height with any treatment.	No height reduction with 1 x spray treatment, some reduction with the 2 x spray treatment, but not commercially significant. Drench treatment produced compact plants, on par with the Bonzi drench treatment.	**Dazide drench treatment gave rise to best plant habit. Bonzi and Regalis drench treatments possibly gave rise to plants which were too compact. Spray treatments generally ineffective.**
Coreopsis **'Lime Rock Ruby'**	1 x spray treatment not effective, slight height reduction and habit improvement with 2 x spray treatment. Smallest plants in response to drench treatment, good compact plants.	1 x spray treatment of limited effect, visible height reduction and habit improvement in response to 2 x spray treatment. Drench treatment less severe than Bonzi drench treatment.	Spray treatments not effective, drench treatment comparable to Dazide.	As for Dazide.	**Drench treatments most effective giving rise to more compact plants of better habit.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
***Diascia* personata**	Sprays produced limited effect in terms of height control or habit improvement. Drench treatment produced compact plants with sturdy shoots.	2 x spray treatment more effective than 1 x spray treatment. Drench treatment as effective as Bonzi drench treatment.	Limited visible effect from all treatments.	Limited visible effect from all treatments.	**Smallest plants at treatment, plants probably too small to be treated. Bonzi and Dazide drenches most effective at controlling growth. No flower before end of trial.**
***Erysimum* 'Bowles Mauve'**	Some response to both spray treatments. Large (50% plus) reduction in height in response to the drench treatment (too compact) and delay in flowering (a week).	No response to the spray treatments, some response to the drench treatment.	Strong response to Chlormequat, even the sprays. Plants more compact (50% plus height reduction relative to control). Drench treatment darkens the foliage.	Limited effect on plant height in response to 1 x spray treatment, more growth control from other treatments. No real improvement in plant habit.	**Very responsive to the Chlormequat treatments and the drench treatments (with the exception of Dazide). Treatments can delay flowering by up to a week.**
***Gallardia* 'St Clements'**	Limited effect of spray treatments. No delay in flowering, no improvement in habit. Some height control but limited improvement in habit in response to drench treatment.	Some limited height reduction with the treatments, especially the 2 x spray and drench treatments. Increased number of flowering side shoots.	Limited effect from spray treatments. Drench treatment appears to increase the number of lower shoots and produces a plant of better habit.	Limited effect on plant height in response to spray or drench treatments. No real improvement in plant habit.	**Bonzi drench treatment most effective at controlling vigour, but didn't improve habit. Chlormequat drench produced best balanced plants.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
Gaura neapolitanum **'Tutti Frutti'**	Bonzi spray treatments of limited effect. Drench treatment very effective at reducing growth and flower stem length. Possibly too compact. Foliage darkened and leaf curling evident.	Limited effect from 1 x spray treatment, 2 x spray treatment more effective in terms of height control and habit improvement. Delay in flowering. Limited effect of drench treatment.	Limited effect from both spray treatments, drench treatment more effective.	Some impact on growth from both spray treatments. Drench treatment much more effective at controlling height, flower stem length and improving habit.	**Compact plants produced in response to the Bonzi, Chlormequat and Regalis drenches; generally drenches resulted in too severe an effect. Some effect from the 2 x sprays Dazide and Regalis treatments, resulting in improvements in plant habit.**
Lavatera **'Blushing Bride'**	Limited growth reduction in response to the spray treatments, but no improvement in plant habit. Drench treatment reduced growth excessively by at least 50%. Foliage darkened and crinkled in response to treatment.	No response to the 1 x spray treatment, some visible response to 2 x spray treatment, but habit still open. Limited response to the drench treatment.	Responsive to all treatments, sufficient growth check from 1 x spray treatment, this treatment gave the best result. Potential delay in flowering associated with 2 x sprays and drench treatments. Good reduction in height and improvement in habit. Foliage darkened, but also crinkled in response to treatments.	Limited response to all treatments, 2 x spray treatment produced best plants.	**Responsive to Chlormequat and Bonzi drench, with reductions of up to 50% in height. No flower before end of trial.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
***Lavender* 'Bella Rouge'**	Spray treatments produced limited visible effects. Drench treatment improved plant habit and darkened foliage.	Spray treatments produced limited effect. The drench treatment improved overall habit but didn't limit growth. Delay in flowering noted with spray treatment.	Limited effect in terms of height control and habit improvement with all treatments.	Limited effect in terms of height control and habit improvement with all treatments. Treatments reduced flower petal colour intensity.	**Dazide had the most effect in terms of improving habit, treatments applied too late to impact on plant habit.**
***Leucanthemum* 'Broadway Lights'**	Reduction in plant height in response to both spray treatments. Further reduction with drench treatment. Potential delay in flowering with drench treatment. All treatments had fewer flower spikes than those treated with Dazide Enhance / Regalis. Foliage darkened in response to all treatments.	Slight response to both spray treatments, more response to the drench treatment.	As per Dazide comments.	Limited response to 1 x spray treatment, slightly more response to the 2 x spray treatment. Response to drench similar to that noted for Bonzi.	**Drench treatments appeared more effective at controlling plant height. As plants didn't flower before the end of the trial any impact on flower stem length was not recorded.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
Monarda **'Beauty of Cobham'**	Very limited response to 1 x and 2 x spray treatments. Good response to the drench treatment, reducing height excessively by up to 60%. May delay flowering.	No apparent response to any of the treatments.	Some response in terms of height control to both spray treatments, but no improvement in habit. Good response to drench treatment height reduced by around 20-30%, this was perceived to be the best treatment.	Very limited response in terms of height control to both spray treatments, though the drench treatment produced the best response.	**Bonzi and Chlormequat drenches produced the greatest reductions in height, limited response to the spray treatments. No flower before end of trial.**
Penstemon **'Ice Cream – Sweet Cherry'**	Both spray treatments produced only limited effect. The drench treatment produced compact plants of good habit.	No real height control or habit improvement with the 1 x spray treatment. The 2 x spray and drench treatments improved habit without controlling plant height.	No real improvement in habit or any reduction height with all treatments.	As per Chlormequat comments.	**Bonzi drench produced an overly compact but balanced plant. Chlormequat drench and 1 spray of Dazide enhance resulted in subtle improvements.**
Phygelius **'Funfare – Wine'**	All the treatments reduced plant height and flower stem length. Compact plant in response to the drench treatment.	Slight response in terms of height control and habit improvement with both spray treatments. More response to the drench treatment, but less than Bonzi. Flower delay in response to treatments.	Limited effect of all treatments.	Very limited effect of all treatments.	**No real need for growth regulators with this variety, though Bonzi treatments could be useful in the production of plants for small pots / packs. Regalis drench looked promising.**

Species	Bonzi	Dazide Enhance	Fargro Chlormequat	Regalis	Overall comments
***Salvia* 'Hot Lips'**	Limited response to spray treatments. Drench treatment reduced height by 30% plus. Flower delay and foliage darkened in response to drench treatment.	Limited response to all treatments. Drench treatment darkened foliage and delayed flowering.	As per Dazide comments.	As per Dazide comments.	**Responsive to the Bonzi drench treatment, limited response to the spray treatments.**
***Scabiosa* 'Burgundy Bonnets'**	Limited response to both spray treatments. Drench treatment produced a compact plant. Potential flower delay and foliage darkened in response to drench treatment.	No response to the 1 x spray treatment, slight reduction in plant height in response to the 2 x spray and drench treatments.	Limited response in terms of height control with both spray treatments, but side shoot development encouraged. Drench treatment reduced plant height.	Some response to the 1 x spray treatment, even more to the 2 x spray treatment. Drench treatment equivalent to Chlormequat drench treatment. Drench treatment darkened the foliage.	**Clear differences in height and habit in response to the 1 x and 2 x spray treatments and between sprays and drenches. Drench treatments most effective. No flower before end of trial.**
***Verbena* 'Seabrook Lavender'**	Limited effect of both spray treatments. Slight response to the drench treatment. Drench treatments appear to slightly darken the foliage.	As per Bonzi comments.	As per Bonzi comments.	As per Bonzi comments. Some paleness in flower petal colour.	**Limited growth control with most treatments. Some control in response to the drench treatments.**

Table 4 *Growth and flowering data from the trial based on two plants per treatment (as at 14 June 2010)*

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Achillea	Untreated	42	33		25	9
	Bonzi x 1 spray	44	35	-	25	9
	Dazide Enhance x 1 spray	44	37	-	25	9
	Fargro Chlormequat x 1 spray	49	37	-	25	9
	Regalis x 1 spray	44	36	-	25	9
	Bonzi x 2 sprays	42	34	-	25	9
	Dazide Enhance x 2 sprays	34	28	15	25	9
	Fargro Chlormequat x 2 sprays	45	37	-	25	9
	Regalis x 2 sprays	30	22	33	25	9
	Bonzi drench	8	1	97	25	9
	Dazide Enhance drench	25	18	45	25	9
	Fargro Chlormequat drench	42	35	-	25	9
	Regalis drench	20	11	67	25	9

Species	Treatment	Average final width (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Campanula	Untreated	77	70		24	10
	Bonzi x 1 spray	68	62	11	24	10
	Dazide Enhance x 1 spray	74	67	4	24	10
	Fargro Chlormequat x 1 spray	75	68	3	24	10
	Regalis x 1 spray	70	63	10	24	10
	Bonzi x 2 sprays	80	73	-	24	10
	Dazide Enhance x 2 sprays	70	61	13	24	10
	Fargro Chlormequat x 2 sprays	73	65	7	24	10
	Regalis x 2 sprays	67	60	14	24	10
	Bonzi drench	57	49	30	24	10
	Dazide Enhance drench	69	61	13	24	10
	Fargro Chlormequat drench	55	47	33	24	10
	Regalis drench	65	57	19	24	10

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Catananche	Untreated	40	32		-	-
	Bonzi x 1 spray	39	32	-	-	-
	Dazide Enhance x 1 spray	40	35	-	-	-
	Fargro Chlormequat x 1 spray	39	33	-	-	-
	Regalis x 1 spray	44	41	-	-	-
	Bonzi x 2 sprays	49	42	-	-	-
	Dazide Enhance x 2 sprays	24	18	43	-	-
	Fargro Chlormequat x 2 sprays	62	53	-	-	-
	Regalis x 2 sprays	30	24	25	-	-
	Bonzi drench	33	26	19	-	-
	Dazide Enhance drench	30	25	22	-	-
	Fargro Chlormequat drench	30	24	25	-	-
	Regalis drench	47	41	-	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Centaurea	Untreated	41	32		24	8
	Bonzi x 1 spray	39	27	16	24	8
	Dazide Enhance x 1 spray	34	21	34	24	8
	Fargro Chlormequat x 1 spray	40	28	12	24	8
	Regalis x 1 spray	47	37	-	24	8
	Bonzi x 2 sprays	38	28	12	24	8
	Dazide Enhance x 2 sprays	32	30	6	24	8
	Fargro Chlormequat x 2 sprays	39	25	22	24	8
	Regalis x 2 sprays	35	24	25	24	8
	Bonzi drench	17	5	84	24	8
	Dazide Enhance drench	31	20	37	24	8
	Fargro Chlormequat drench	39	29	9	24	8
	Regalis drench	18	5	84	24	8

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Coreopsis	Untreated	41	32		-	-
	Bonzi x 1 spray	44	33	-	-	-
	Dazide Enhance x 1 spray	37	26	19	-	-
	Fargro Chlormequat x 1 spray	46	36	-	-	-
	Regalis x 1 spray	39	29	9	-	-
	Bonzi x 2 sprays	37	28	12	-	-
	Dazide Enhance x 2 sprays	34	24	25	-	-
	Fargro Chlormequat x 2 sprays	45	36	-	-	-
	Regalis x 2 sprays	31	20	37	-	-
	Bonzi drench	23	14	56	-	-
	Dazide Enhance drench	31	20	37	-	-
	Fargro Chlormequat drench	31	23	28	-	-
	Regalis drench	27	16	50	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Diascia	Untreated	27	25		-	-
	Bonzi x 1 spray	20	17	32	-	-
	Dazide Enhance x 1 spray	19	17	32	-	-
	Fargro Chlormequat x 1 spray	17	14	44	-	-
	Regalis x 1 spray	19	16	36	-	-
	Bonzi x 2 sprays	27	24	4	-	-
	Dazide Enhance x 2 sprays	17	14	44	-	-
	Fargro Chlormequat x 2 sprays	17	14	44	-	-
	Regalis x 2 sprays	23	20	20	-	-
	Bonzi drench	11	9	64	-	-
	Dazide Enhance drench	12	10	60	-	-
	Fargro Chlormequat drench	23	20	20	-	-
	Regalis drench	18	14	44	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Erysimum	Untreated	46	34		24	10
	Bonzi x 1 spray	31	19	44	24	10
	Dazide Enhance x 1 spray	45	32	6	24	10
	Fargro Chlormequat x 1 spray	22	9	74	25	11
	Regalis x 1 spray	47	34	-	24	10
	Bonzi x 2 sprays	48	35	-	24	10
	Dazide Enhance x 2 sprays	45	31	9	24	10
	Fargro Chlormequat x 2 sprays	19	6	82	24	10
	Regalis x 2 sprays	25	13	62	24	10
	Bonzi drench	15	2	94	25	11
	Dazide Enhance drench	41	29	15	24	10
	Fargro Chlormequat drench	15	2	94	25	11
	Regalis drench	33	20	41	24	10

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Gallardia	Untreated	38	30		25	9
	Bonzi x 1 spray	32	21	30	25	9
	Dazide Enhance x 1 spray	35	22	27	24	8
	Fargro Chlormequat x 1 spray	37	25	17	24	8
	Regalis x 1 spray	34	23	23	25	9
	Bonzi x 2 sprays	37	26	13	24	8
	Dazide Enhance x 2 sprays	32	20	33	25	9
	Fargro Chlormequat x 2 sprays	39	29	3	24	8
	Regalis x 2 sprays	32	22	27	25	9
	Bonzi drench	23	15	50	25	9
	Dazide Enhance drench	33	20	33	25	9
	Fargro Chlormequat drench	35	15	50	25	9
	Regalis drench	36	25	17	25	9

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Gaura	Untreated	58	45		24	10
	Bonzi x 1 spray	47	36	20	24	10
	Dazide Enhance x 1 spray	50	35	22	24	10
	Fargro Chlormequat x 1 spray	55	44	2	24	10
	Regalis x 1 spray	46	34	24	24	10
	Bonzi x 2 sprays	56	45	-	24	10
	Dazide Enhance x 2 sprays	39	28	38	25	11
	Fargro Chlormequat x 2 sprays	50	37	18	24	10
	Regalis x 2 sprays	43	31	31	24	10
	Bonzi drench	28	17	62	24	10
	Dazide Enhance drench	57	44	2	24	10
	Fargro Chlormequat drench	39	26	42	24	10
	Regalis drench	34	21	53	24	10

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Lavatera	Untreated	62	49		-	-
	Bonzi x 1 spray	44	32	35	-	-
	Dazide Enhance x 1 spray	62	53	-	-	-
	Fargro Chlormequat x 1 spray	26	14	72	-	-
	Regalis x 1 spray	57	42	14	-	-
	Bonzi x 2 sprays	55	42	14	-	-
	Dazide Enhance x 2 sprays	37	24	51	-	-
	Fargro Chlormequat x 2 sprays	21	6	88	-	-
	Regalis x 2 sprays	47	31	37	-	-
	Bonzi drench	27	13	73	-	-
	Dazide Enhance drench	60	47	4	-	-
	Fargro Chlormequat drench	22	10	80	-	-
	Regalis drench	58	46	6	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Lavandula	Untreated	23	10		21	13
	Bonzi x 1 spray	23	8	20	21	13
	Dazide Enhance x 1 spray	21	9	10	24	16
	Fargro Chlormequat x 1 spray	19	5	50	21	13
	Regalis x 1 spray	23	11	-	21	13
	Bonzi x 2 sprays	21	6	40	21	13
	Dazide Enhance x 2 sprays	21	8	20	21	13
	Fargro Chlormequat x 2 sprays	22	8	20	21	13
	Regalis x 2 sprays	22	8	20	21	13
	Bonzi drench	20	5	50	21	13
	Dazide Enhance drench	22	8	20	21	13
	Fargro Chlormequat drench	22	9	10	21	13
	Regalis drench	20	7	30	21	13

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Leucanthemum	Untreated	25	18		-	-
	Bonzi x 1 spray	19	11	39	-	-
	Dazide Enhance x 1 spray	24	14	22	-	-
	Fargro Chlormequat x 1 spray	26	17	6	-	-
	Regalis x 1 spray	26	16	11	-	-
	Bonzi x 2 sprays	21	13	28	-	-
	Dazide Enhance x 2 sprays	25	17	6	-	-
	Fargro Chlormequat x 2 sprays	30	21	-	-	-
	Regalis x 2 sprays	26	16	11	-	-
	Bonzi drench	16	7	61	-	-
	Dazide Enhance drench	21	13	28	-	-
	Fargro Chlormequat drench	23	15	17	-	-
	Regalis drench	19	10	44	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Monarda	Untreated	33	30		-	-
	Bonzi x 1 spray	39	35	-	-	-
	Dazide Enhance x 1 spray	28	25	17	-	-
	Fargro Chlormequat x 1 spray	27	24	20	-	-
	Regalis x 1 spray	35	30	-	-	-
	Bonzi x 2 sprays	32	27	10	-	-
	Dazide Enhance x 2 sprays	49	45	-	-	-
	Fargro Chlormequat x 2 sprays	24	20	33	-	-
	Regalis x 2 sprays	32	27	10	-	-
	Bonzi drench	16	11	63	-	-
	Dazide Enhance drench	45	41	-	-	-
	Fargro Chlormequat drench	26	23	23	-	-
	Regalis drench	44	30	-	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Penstemon	Untreated	33	20		-	-
	Bonzi x 1 spray	30	15	25	-	-
	Dazide Enhance x 1 spray	34	22	-	-	-
	Fargro Chlormequat x 1 spray	40	29	-	-	-
	Regalis x 1 spray	47	35	-	-	-
	Bonzi x 2 sprays	35	25	-	-	-
	Dazide Enhance x 2 sprays	42	26	-	25	13
	Fargro Chlormequat x 2 sprays	39	29	-	-	-
	Regalis x 2 sprays	42	29	-	-	-
	Bonzi drench	28	16	20	25	13
	Dazide Enhance drench	37	26	-	25	13
	Fargro Chlormequat drench	22	9	55	-	-
	Regalis drench	35	21	-	-	-

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Phygelius	Untreated	40	29		24	8
	Bonzi x 1 spray	25	16	45	24	8
	Dazide Enhance x 1 spray	31	20	31	25	9
	Fargro Chlormequat x 1 spray	37	26	10	24	8
	Regalis x 1 spray	47	37	-	24	8
	Bonzi x 2 sprays	28	18	38	24	8
	Dazide Enhance x 2 sprays	40	31	-	25	9
	Fargro Chlormequat x 2 sprays	44	35	-	24	8
	Regalis x 2 sprays	42	33	-	25	9
	Bonzi drench	24	14	52	24	8
	Dazide Enhance drench	33	23	21	24	8
	Fargro Chlormequat drench	35	24	17	25	9
	Regalis drench	42	32	-	25	9

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Salvia	Untreated	63	52		25	13
	Bonzi x 1 spray	59	45	13	25	13
	Dazide Enhance x 1 spray	56	39	25	24	12
	Fargro Chlormequat x 1 spray	60	45	13	24	12
	Regalis x 1 spray	61	45	13	24	12
	Bonzi x 2 sprays	58	42	19	25	13
	Dazide Enhance x 2 sprays	60	47	10	25	13
	Fargro Chlormequat x 2 sprays	52	37	29	24	12
	Regalis x 2 sprays	61	48	8	24	12
	Bonzi drench	39	23	56	24	12
	Dazide Enhance drench	54	40	23	24	12
	Fargro Chlormequat drench	50	37	29	24	12
	Regalis drench	55	39	25	25	13

Species	Treatment	Average final height (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Scabiosa	Untreated	41	26		-	-
	Bonzi x 1 spray	34	18	31	-	-
	Dazide Enhance x 1 spray	45	29	-	-	-
	Fargro Chlormequat x 1 spray	37	20	23	-	-
	Regalis x 1 spray	30	13	50	-	-
	Bonzi x 2 sprays	32	17	35	-	-
	Dazide Enhance x 2 sprays	35	17	35	-	-
	Fargro Chlormequat x 2 sprays	41	24	8	-	-
	Regalis x 2 sprays	18	1	96	-	-
	Bonzi drench	13	1	96	-	-
	Dazide Enhance drench	23	11	58	-	-
	Fargro Chlormequat drench	23	13	50	-	-
	Regalis drench	28	14	46	-	-

Species	Treatment	Average final width (cm)	Average increase from potting (cm)	Percentage reduction relative to control	Date to first flower (week number)	Weeks from potting to flowering
Verbena	Untreated	98	90		24	12
	Bonzi x 1 spray	106	100	-	24	12
	Dazide Enhance x 1 spray	106	97	-	24	12
	Fargro Chlormequat x 1 spray	77	72	20	24	12
	Regalis x 1 spray	106	97	-	24	12
	Bonzi x 2 sprays	91	85	5	24	12
	Dazide Enhance x 2 sprays	88	70	22	24	12
	Fargro Chlormequat x 2 sprays	92	86	4	24	12
	Regalis x 2 sprays	115	109	-	24	12
	Bonzi drench	84	76	16	24	12
	Dazide Enhance drench	72	64	29	24	12
	Fargro Chlormequat drench	96	90	-	24	12
	Regalis drench	82	75	17	24	12

Figure 2 *Comparative images of untreated plants alongside the more effective chemical growth regulator treatment for each plant species examined (control plants on the left hand side of images)*

Control v Fargro Chlormequat (2 sprays) - *Achillea*.

Control v Bonzi drench – *Campanula*

Control v Fargro Chlormequat (2 sprays) – *Catananche*

Control v Dazide Enhance drench – *Centaurea*

Control v Bonzi drench - *Coreopsis*

Control v Bonzi drench - *Diascia*

Control v Regalis drench - *Erysimum*

Control v Fargro Chlormequat drench – *Gallardia*

Control v Regalis drench - *Gaura*

Control v Fargro Chlormequat (2 sprays) – *Lavatera*

Control v Dazide Enhance drench – *Lavandula*

Control v Bonzi drench - *Leucanthemum*

Control v Bonzi drench - *Monarda*

Control v Bonzi drench - *Penstemon*

Control v Bonzi (2 sprays) - *Phygelius*

Control v Bonzi drench - *Salvia*

Control v Dazide Enhance drench – *Scabiosa*

Control v Bonzi drench - *Verbena*

Figure 3 *Various phytotoxic symptoms noted*

Leaf yellowing with the high rate chlormequat spray treatment on *Campanula*

Leaf yellowing with the high rate chlormequat spray treatment on *Campanula*

Petal bleach with the high rate Regalis spray treatment on *Lavandula*

Excessive growth control with the Bonzi drench treatment – *Achillea, Lavatera* and *Phygelius*

3. Conclusions

Chemical plant growth regulator treatments can be useful for controlling the height, manipulating the habit and to a lesser extent influencing the flowering times of herbaceous perennial species, in particular for those crops grown under protection. However, no one chemical plant growth regulator treatment appeared to give universal growth control and habit improvement across all plant species.

It is not safe to assume that a plant growth regulator that is effective on one species will be effective on another species. It is also generally not safe to assume that all varieties within a species respond in the same way to a given plant growth regulator, the effects observed may be variety specific, not just species specific.

In terms of application method, the drench applications examined tended to be more effective and persistent than the spray applications, though they were more time consuming to apply and on occasion they caused too much growth restriction. Two lower rate application spray treatments applied on separate occasions were sometimes more effective than a single higher rate application.

Higher rates of chlormequat applied as a spray sometimes gave rise to foliage chlorosis (especially yellowing around the leaf edge) and leaf crinkling, whilst higher spray rates or drench applications of prohexadione-calcium (Regalis) sometimes bleached the colour from the flower petals turning dark colours into paler ones (especially purple / blue flowers).

The stage of plant growth at the point of chemical plant growth regulator application was important as it determined what the effect of the treatment would be (for example control of vegetative growth or flower stem height) and the intensity of the effect. It is worth highlighting that *Diascia* had made insufficient growth at the time of application; had this been a commercial crop, plants would have been allowed to have grown on prior to plant growth regulation application. Conversely, chemical growth regulator applications would have been applied a little earlier to the *Scabiosa* and *Lavandula* whilst the plants were smaller and less developed.

Some herbaceous plant species such as *Lavandula* and *Verbena* appeared to show little response to the chemical plant growth regulators at the rates examined.

Financial benefits

Plant scheduling techniques can provide growers with the ability to target markets at specific time periods with flowering product, so that delivery dates can be achieved, over production minimised or new markets exploited, potentially increasing market size whilst reducing plant wastage.

Not all scheduling techniques have to be high energy or high input cost; measures such as sequential planting, slightly higher growing temperatures, night-break lighting and chemical plant growth regulator applications can be used to achieve some level of manipulation. A summary of scheduling techniques was presented at the HDC 'Optimising plant growth and habit of herbaceous plants' workshop (25 June 2010). The PowerPoint slides from this workshop are contained within the Science Section of the full Final Report.

In terms of chemical growth regulator product cost and cost per litre of final solution, Dazide Enhance is the most expensive growth regulator within this trial. Regalis is comparable to Bonzi whilst Fargro chlormequat is much less expensive (Table 5). Compared to pinching or cutting back over grown stock even the most expensive growth regulators may be warranted where the growth regulatory effects meet customer requirements.

Table 5 *The relative costs* of growth regulator treatments examined in the trial (2010)*

Product	Average cost of product	Cost per litre of solution at rate trialled
Fargro Chlormequat	1.8p per ml of product	10.8p per litre at 6ml/l rate
Dazide Enhance	14.0p per gram of product	70p per litre at 5g/l rate
Bonzi	6.9p per ml of product	17.25p per litre at 2.5ml/l rate
Regalis	8.2p per gram of product	20.5p per litre at 2.5g/l rate

*Average costs not taking into account discounts etc.

The summary of chemical plant growth regulator effects contained within the report will aid selection of the most appropriate product, rate and method of application to achieve the desired effect for a particular species. It is envisaged that chemical plant growth regulators will be used to:

- manipulate plant growth and habit to provide height control at the point of flowering so more plants can be placed onto each trolley
- obtain a better balance between shoot growth and flower production and potentially increase the number of side shoots thus improving plant quality and overall appearance
- help maintain product shelf life once plants have left the nursery.

Action points for growers

Consider the use of chemical plant growth regulators to control the growth or improve the habit of more vigorous herbaceous species. Undertake small scale nursery trials to assess the potential use of chemical growth regulator products.

Avoid run off into the growing media when applying plant growth regulators as a foliar spray as this can enhance and increase the persistence of some chemical growth regulators; particular care should be taken with paclobutrazol (Bonzi), chlormequat (Fargro Chlormequat), 2-chloroethylphosphonic acid (Cerone) and prohexadione calcium (Regalis).

Avoid high volume sprays to small plants which have yet to achieve pot cover as plant growth regulators are likely to be absorbed by the growing media and may result in a strong, undesirable and persistent response.

Ensure that sufficient irrigation has been applied prior to treatment to minimise the risk of washing the plant growth regulator off the leaves and into the growing media.

Apply products containing chlormequat, daminozide and prohexadione-calcium at the end of the day to ensure adequate leaf absorption.

Bear in mind that spray applications tend to have less impact on plant growth (depending upon the product and rate applied) and so often need to be applied on several occasions to have the desired effect. Drench applications are generally more effective, although they are more costly to apply in terms of application time and there may be issues with product build up (in capillary matting etc) beneath the crop.

Remember that different growing media mixes can alter the effectiveness of treatments. For example, bark can reduce the effectiveness of drench applied plant growth regulators.

Take account of the growth regulatory effect of triazole fungicides used in fungicide programmes when planning a chemical growth regulator programme.

Bear in mind that a range of cultural techniques can be employed to reduce reliance on plant growth regulators such as:

- Ensuring stock is sufficiently spaced to minimise competition for light.
- Maintaining dry regimes where possible to prevent excessive growth.
- Making sure that protected structures are clear of algae to maximise light transmission to help prevent plants stretching.
- Managing temperatures and ventilation, to optimise the desired growth.
- Limiting the amount of ammonium nitrogen in liquid feeds; use less than 50% ammonium nitrogen when liquid feeding by utilising potassium and calcium nitrates.

Science Section

The Science Section contains information that was provided within the handout at the 'Optimising plant growth and habit of herbaceous plants' workshop at R. A. Meredith and Son, Cuckoo Bridge Nursery (25 June 2010).

Annex I contains the PowerPoint slides and Annex II contains a literature review of plant growth regulator use on herbaceous perennials.

All other details relating to the HNS 103b are presented within the Grower Summary section.

Annex I

This section contains the PowerPoint slides from the HDC HNS 103b 'Optimising plant growth and habit of herbaceous plants' workshop (25 June 2010).

The content of the slides are primarily based on the outputs of work funded by the HDC. The reports are available from the HDC.

- HNS 103: Hardy herbaceous perennials: Value of a screening protocol for factors that manipulate flowering (2002).

- PC 246: Garden plants: Development of new marketing opportunities based on controlled flowering of herbaceous perennials for early spring and late summer sales (2009).

- PC 247: Collaborative research programme in partnership with Saxon State Institute for Agriculture, Pillnitz, Germany for the development of 'new' ornamental plants for early season sales (2007).

The presentation titles are listed below.

- Presentation 1: 'Needs of the grower! A grower's perspective'.

- Presentation 2: Manipulating herbaceous perennial flowering – a screening protocol for growers.

- Presentation 3: Scheduling Perennials – Summary of recent HDC protects and related work (including PC246 and PC247).

- Presentation 4: Optimising the plant growth and habit of herbaceous perennials.

- Presentation 5: Scheduling perennials – plant growth regulator trial (HNS103b).

Presentation 1: 'Needs of the grower! A grower's perspective'

Steve Carter, Farplants

The Needs of the grower!

A growers perspective

Steve Carter, Farplants

Farplants

What are the needs of the grower?

- Higher price
- No wastage
- Good Weather
- No Supply problems

Farplants

What are the needs of the grower?

- Guaranteed Quality
- Customer to take product when its ready
- Customer to take what they've booked!

- But,

»In the real world…..

Farplants

In Reality…..

- **Every season is different**
  - Customers change their minds
  - Supply problems
  - Weather
  - Plants don't always do what you expect them to

Farplants

Useful tools / techniques

- The point of today is to highlight some of these tools

»Scheduling

»Growth Control

Farplants

Benefits

- Improved Quality
  - Scheduling – improved flowering, predicting when crop will be optimal / production to target weeks
  - PGR – reduced height, increased branching, improved leaf colour
- Increase Crop Uniformity
- Customer Satisfaction
  - right quality at right time > repeat business

Farplants

Benefits

- Reduced :
  - Waste
    - »PGR – Hold crop
  - Transport Costs
    - »Reduced height
  - Labour Costs
    - »Increased quality – less need to clean
    - »Improved timing / Uniformity - less need to pick through

Farplants

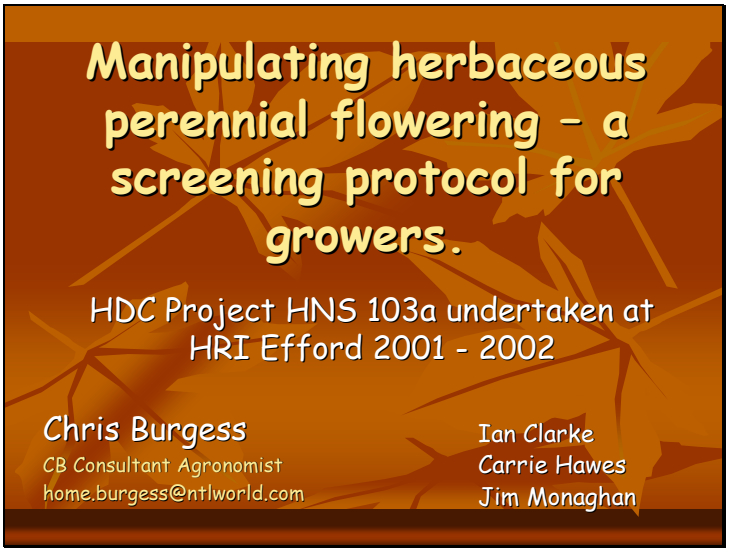
Thank-you for Listening

Steve Carter, Farplants

Farplants

Presentation 2: Manipulating herbaceous perennial flowering – a screening protocol for growers

Chris Burgess, Consultant



Potential

- Season extension (earlier – or later)
- Shorter production periods
- Produce batches of P.O.S. 'living labels'?
- Some work overseas that could be exploited
- NOT blueprints
  - Too many subjects
  - Would lead to overproduction
  - HNS 103 generated a simple protocol growers could follow on own holdings.
- Growers use '**toolkit**' to develop own protocols

HNS 103a

- Trial was a practical demonstration of screening
- Over winter to flower spring / early summer
- Asked these questions:
  - Do the plants require cold for initiation?
  - What is the duration of cold required?
  - Do plants develop flowers faster under long days or short days?
  - Is supplementary lighting necessary to maintain plant quality ?
  - Does temperature influence speed of flowering? If so –
    - Is heating necessary for commercial production?

Plant material

- 8 Species:
  - *Anemone x hybrida* (Jap anemone) 'Whirlwind'
  - *Aster* 'Marie Ballard'
  - *Crocosmia* 'Star of the East'
  - *Gaura lindheimerii*
  - *Lobelia* 'Queen Victoria'
  - *Penstemon* 'Mother of Pearl'
  - *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm'
  - *Sedum* 'Autumn Joy'

Treatments

- Cold store
  - 4°C, 8 hrs fluorescent tubes (0, 4, 8, 12 weeks)
- Heat
  - Cold (min 3°C, vent 8°C), Heated (15°C, v 18°C)
- Daylength
  - 2 hrs night break (23:00 - 01:00) to give long days
- Irradiance
  - 8 hrs supplementary light (SON-T lamps)
- Gives 32 treatments
  - 1 cold store and 4 glasshouse compartments

Treat-ment	Potted week 43	Potted week 47	Unheated glass	15 °C glass	4 °C Cold store	Potted week 51	Potted week 03
1	SD		17	CS	CS	SD	
2	Supp		18	CS	CS	Supp	
3	LD		19	CS	CS	LD	
4	Supp+LD		20	CS	CS	Supp+LD	
5	SD		21	CS	CS	SD	
6	Supp		22	CS	CS	Supp	
7	LD		23	CS	CS	LD	
8	Supp+LD		24	CS	CS	Supp+LD	
9	CS	SD	25	CS	CS	CS	SD
10	CS	Supp	26	CS	CS	CS	Supp
11	CS	LD	27	CS	CS	CS	LD
12	CS	Supp+LD	28	CS	CS	CS	Supp+LD
13	CS	SD	29	CS	CS	CS	SD
14	CS	Supp	30	CS	CS	CS	Supp
15	CS	LD	31	CS	CS	CS	LD
16	CS	Supp+LD	32	CS	CS	CS	Supp+LD

Culture

- Young plants bought in September
  - Penstemon (tissue culture)
  - Rudbeckia (open ground)
- Either placed in cold store or potted in 1.6 litre pots
  - 85% peat, 15% bark, 3 Kg m^{-3} 9 month CRF
- Benches with capillary matting
- Drip hoses on matting
- P&D all biological, until too great…

Screening trial – 1 of 8 trts.

Timetable

Environment	*Start*	*+ 4 weeks*	*+ 8 weeks*	*+ 12 weeks*
CS	480	320	160	0
SD	20	40	60	80
Supp	20	40	60	80
LD	20	40	60	80
Supp+LD	20	40	60	80
SD	20	40	60	80
Supp	20	40	60	80
LD	20	40	60	80
Supp+LD	20	40	60	80
Total	*640*	*640*	*640*	*640*

Results in brief

More flower?	LD	Supp.	Heat	Cold store
Anemone	✓	✓	×	✓
Aster	✓	✓	✓	✓
Crocosmia	✓	×	×	×
Gaura	✓	×	×	×
Lobelia	✓	×	✓	✓
Penstemon	✓	✓	✓	-
Rudbeckia	✓	✓	-	✓
Sedum	×	×	-	×

Anemone x hybrida 'Whirlwind'

% Plants with flower buds

Week 26	Unheated				Heated			
	SD	Supp	LD	Supp+LD	SD	Supp	LD	Supp+LD
No cold	0	5	60	30	0	0	70	60
4 weeks cold	0	0	75	85	5	0	75	95
8 weeks cold	0	0	80	80	0	5	70	75
12 weeks cold	0	5	85	80	0	0	65	55

- LD increased budding (60% vs 0%)
- Cold store increased budding to 85%
- Supplementary light increased budding only after cold store + LD (95%)
- Heating only stretched the plants

Rudbeckia 'Goldsturm'

% Plants with flower buds

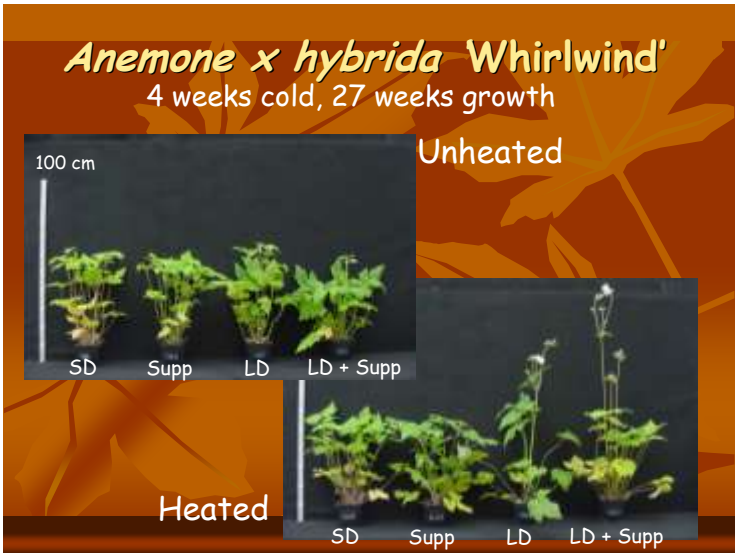
Week 24	Unheated				Heated			
	SD	Supp	LD	Supp+LD	SD	Supp	LD	Supp+LD
No cold	15	0	80	90	0	5	95	100
4 weeks cold	100	94	70	63	100	100	100	78
8 weeks cold	100	78	62	65	100	86	81	80
12 weeks cold	95	83	17	25	80	69	79	78

- Cold had largest effect, reducing survival to 87%, 63% or 55%, but 4 weeks CS alone → flowering
- LD also → flowering without cold storage
- Supplementary lighting improved plant size, but only enhanced flowering with LD and no CS

Rudbeckia 'Goldsturm'

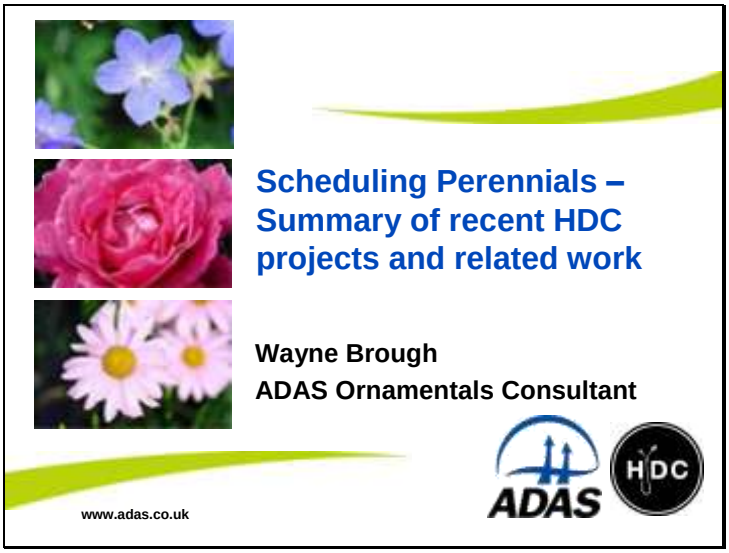
Potted week 43, No cold, 24 weeks growth

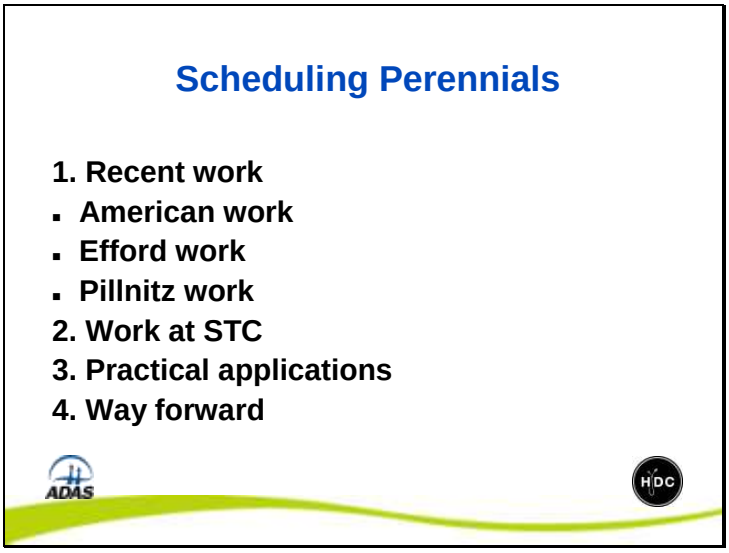
Unheated Heated



Presentation 3: Scheduling Perennials – Summary of recent HDC protects and related work (including PC246 and PC247)

Wayne Brough, ADAS





Scheduling Perennials

1. Recent work

(a). American work

- Michigan State University – Royal Heins, Art Cameron and Will Carson
- Early / mid 1990's onwards
- Identified 3 key areas to scheduling plants –

Plant juvenility response
Vernalisation response
Photoperiodic response

Scheduling Perennials

Key principles examined

- **Juvenility –** plants won't respond until 'mature' enough. Rough guide leaf count. E.g. Aquilegia 15, coreopsis 16.
- **Vernalisation response –** cold not required, beneficial or required. 3-5C for around 8 weeks**.**
- **Photoperiodic response –** Short day, long day or day neutral. Most species examined were either day neutral or needed long days - either beneficial or required. Night break using tungsten lamps.

Scheduling Perennials

(b). Efford work

- HNS 103 – screening protocols to test herbaceous.
- HNS 103a – practical demonstration of screening.
- Detail provided by Chris Burgess.

Scheduling Perennials

2. Work at STC

PC 246

- All work undertaken at STC.
- First year – verify the American work on scheduling.
- Trial commenced autumn 2005.
- 9 herbaceous / alpine species examined (Aquliegia, Arenaria, Delphinium, Digitalis, Lobelia, Lupin, Papaver, Saxifrage and Scabious).
- All seed grown and potted into 10.5cm pots.

Scheduling Perennials

- Potting commenced wk 41 through to wk 01 every 4 weeks from 2 plug sizes.
- Following treatment combinations then applied – **vernalisation** – unheated house or cold store, **daylength** – ambient or night break and **growing on temperatures** - 3 or 10C.
- Target – early flowering crop from mid February onwards.

Scheduling Perennials

- Only 3 species (Aquilegia, Arenaria and Saxifrage) flowered significantly, but only from mid / late March onwards at 10C.
- Others flowered sporadically or not within early target period.
- Growing on temperatures and to extent plug maturity had an impact.
- **However** - supplementary lighting is required to boost background light levels to attain early flowering.

Scheduling Perennials

Light levels (the other key principle missing from the US work)

- Av. Dec-Jan light levels at STC 3.2 moles per sq m per day.
- Av. Dec-Jan light levels in Northern US States 5-8 moles.
- Recent American work indicates that some species need 5-10 moles to be responsive to any forcing treatment.

Scheduling Perennials

PC 246 years 2 and 3

- To confirm the forcing protocols used at Pillnitz under UK growing conditions.
- 15 plant species were examined, reduced to 9 in year 3 including ajuga, anacyclus, androsace, aquilegia, barbarea, calceolaria, geum and silene (selected for response and plant habit).
- Sowing – weeks 27-29 (or purchase week 35).
- Potting – week 35.

Scheduling Perennials

- Pot size - 10-10.5cm.
- Growing on structure – cold glasshouse / polytunnel.
- Vernalisation – 6 weeks at 2C (cold store or polytunnel) from week 42.
- Forcing period – 20C and 18C night for 72 hours after vernalisation, thereafter 10-12C day / night.
- Light treatment – Supplementary lighting 18-20 hours using SONT lamps at 50 micro-moles/m/sec for early flowering and best quality plants.

Scheduling Perennials

- Other light treatments (photoperiodic and ambient) did work eventually.
- PGR treatments – often needed to manipulate growth.
- P&D control – needed to control botrytis, powdery mildew, aphids and whitefly in particular.
- Success with 10 species.
- Commercial suitability (as pot plants) varied with species.

Plug stage

Potting up

Post cold storage

Scheduling Perennials

3. Practical applications

- **Environmental tools for scheduling –**

Cold storage
Night break lighting
Supplementary lighting (**early production**)
Growing on temperatures
Black out covers (?)

Scheduling Perennials

- **Cultural tools for scheduling –**

Sowing / potting time
Starting material (plug, liner, bare root)
Final pot size
Species / variety selection
Watering regime

3C LD 10C LD 3C AMB 10C AMB

Scheduling Perennials

Some issues –

- Problems with longer periods of cold storage.
- Stretching due to higher temperatures.
- Often species specific response.
- Most species flowered April / May onwards, **is earlier flowering achievable?**

Scheduling Perennials

(c). Pillnitz work

Pillnitz Research Institute in the Saxon State, near Dresden

- Several hundred perennial species / varieties have been examined over last 3-4 years.
- Objective - to create a new product to increase grower revenues during Feb / Mar.
- Target – to make plants flower using a forcing procedure for **Valentines Day onwards**.

Scheduling Perennials

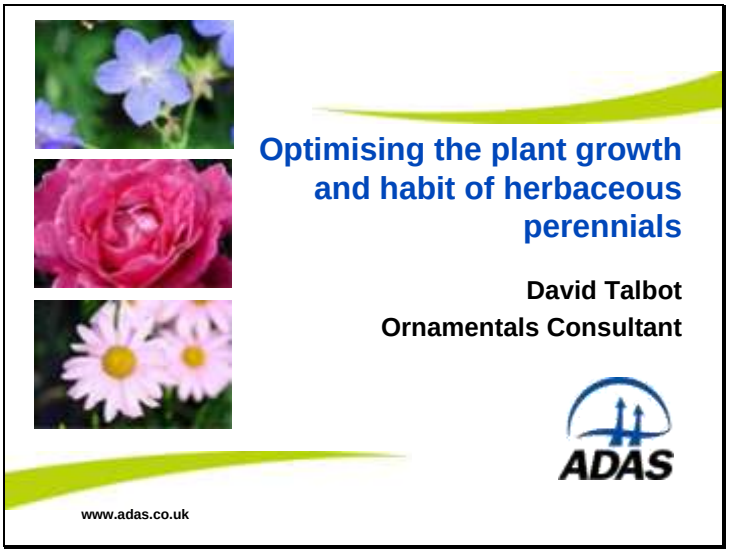
- Potting dates wk 31-38 into 10cm pots.
- Kept outside until wk 41 – polythene tunnel or cold glasshouse (cold treatment).
- Wk 50 forcing commences in glasshouse – initial boost 20C for 72 hrs, then 12C.
- Lighting – supplementary (20 hours or light sum) and ambient – energy intensive.
- Start of flowering wks 2-10.
- Work undertaken as part of PC 247 / 267).

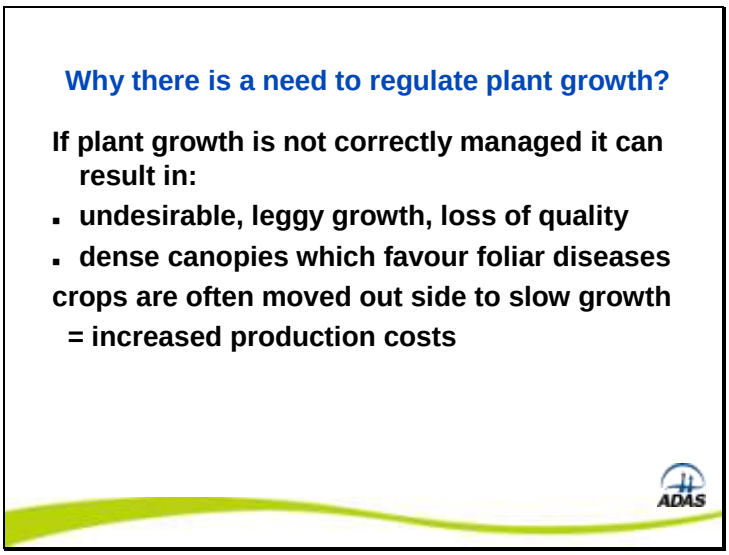
Scheduling Perennials

- Scheduling requirements examined for a large number of species (at least 40-50) and programmes developed.
- Dramatically increased sales of potted perennials (sold generically as garden plants for indoor or outdoor use) in USA.
- Success of scheduling proved difficult to replicate in the UK.

Presentation 4: Optimising the plant growth and habit of herbaceous perennials

David Talbot, ADAS





Minimise the need for PGRs

- Ensure plants are sufficiently spaced
- Manage temperatures / ventilation levels
- Ensure that protected structures are clean
- If liquid feeding use potassium/calcium N rather than ammonium N (Ammonium N < 50% of N)
- Remember that triazole fungicides have PGR properties

Using PGRs in the production of herbaceous perennials

- Plan PGR use
- Must apply before rapid extension
- Can apply at flower bud initiation to reduce stem length
- Species response
- Different cultivars within a species can react differently (e.g. *Dianthus* barbatus 4.41 g/l & *D.* caryophyllus 2.9 g/l B Nine)

Interpreting data / getting good results

- Majority of data from the USA
- Chlormequat, daminozide and paclobutrazol most widely used in UK
- Sprays are generally less persistent than drenches
- Cerone has replaced Ethrel C (both products 480 g/l)
- Growth regulation typically lasts 2 – 4 weeks Factors include rate/volume

Effects of PGRs

- Reduce / increase height
- Prolong / break dormancy
- Prolong flower / plant life
- Abort flowers
- Reduce leaf size
- Promote rooting, branching or flowering
- Improved leaf colour

Benefits of PGRs

- Improved plant habit
- More plants per square metre
- Improved shelf life
- Lower water demand

Potential problems associated with PGR use

- Phytotoxicity
- Increased chemical usage
- No one product / rate is effective on all crops
- Can be extremely persistent if applied at too higher rate / volume

PGR active ingredients

Chlormequat (e.g. New 5C cycocel)

- Different concentrations: 730 to 40 g/l
- Leaf / root uptake
- Apply at end of the day - only moves into leaf when wet, use recommended adjuvants to reduce phytotoxicity
- Do not irrigate for 12-18 hours
- Less effective below 10ºC
- May advance flowering by 10 days

PGR active ingredients

Daminozide (e.g. Dazide Enhance)

- Only absorbed by leaves when wet
- Apply at end of the day, no irrigation for 24 hours
- Less effective on vigorous growth or when temperatures are high
- Moderate growth control, relatively expensive
- Can delay flowering by 5 days
- Maximum of 2 applications

PGR active ingredients

Paclobutrazol (e.g. Bonzi)

- Absorbed by stems and roots
- Moves rapidly through waxy layers of stems, effective if spray dries rapidly
- Can not wash off foliage after about 30 minutes
- Rate and volume sensitive.
- Uniform application is essential
- Over application can have long term effects
- Effect increased by decrease in temperature following application

PGR active ingredients

Paclobutrazol (e.g. Bonzi) continued

- Over application can have long term effects
- Effect increased by decrease in temperature following application
- Bark/fibre can reduce the efficacy of a drench by a factor of 4
- Useful to hold plant growth, particularly prior to marketing

PGR active ingredients

2-chloroethylphosphonic acid (e.g. Cerone)

- Breaks down to form ethylene in the plant
- Increases branching
- Avoid run off, most effective over 10ºC

Prohexadione calcium (e.g. Regalis)

- Same mode of action as daminozide but stronger
- Can impact on petal colour

Rates of prohexadione-calcium (as Regalis) tested on herbaceous perennials. Only limited trials have been carried out so growers are strongly recommended to conduct their own trials prior to widespread use.

Plant species	Rate of Regalis	Effects on growth / tips	Country/ region where data sourced from
Bellis perennis	2.5 g/l	No effect on plant quality	Germany
Chrysanthemum morifolium R. *cv* Monalisa White	1, 2 & 4 g/l x 3	Treatment reduced plant height by 8.2%, 20.9% & 26.3% respectively. Flower numbers not affected.	South Korea
Coreopsis tinctoria	2.5 g/l	Plant quality significantly improved	Germany
Coreopsis grandiflora	2.5 g/l	Plant quality significantly improved	Germany
Dahlia variabilis	2.5 g/l	Plant quality improved	Germany
Delphinium grandiflorum	2.5 g/l	No effect on plant quality/Plant quality significantly improved (results from two trials)	Germany
Lobelia F1 Speciosa	2.5 g/l	No effect on plant quality	Germany
Myosotis sylvatica	2.5 g/l	No effect on plant quality	Germany
Osteospurmum ecklonis	2.5 g/l	Plant quality improved	Germany
Platycodon astra Hybr.	2.5 g/l	No effect on plant quality	Germany
Rudbeckia hirta	2.5 g/l	Plant quality significantly improved	Germany

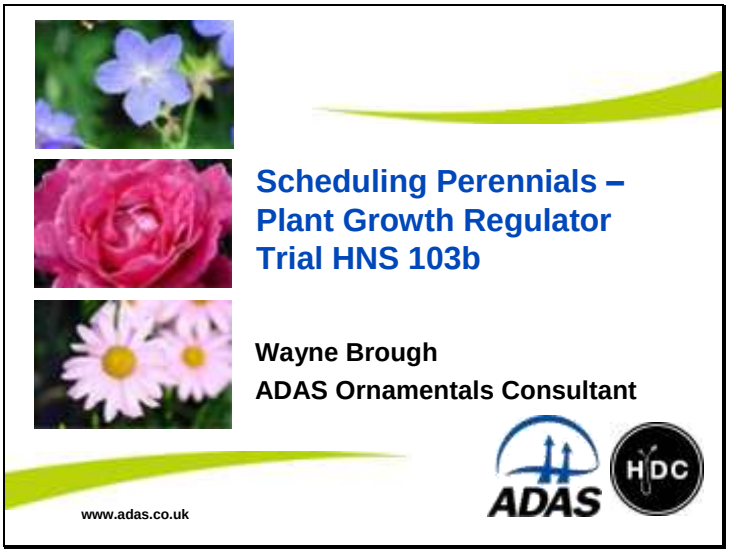
Chemical growth regulators

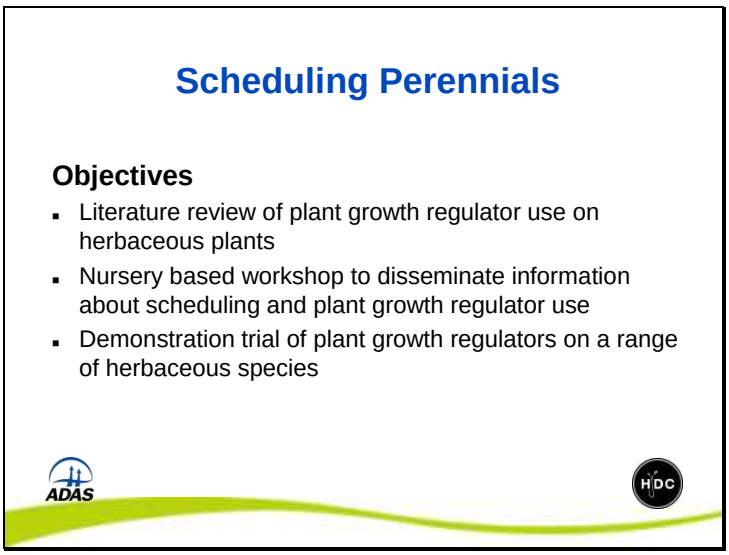
Rates of use

- **ppm = mg/litre**
- **Determine whether active ingredient or commercial product is quoted**
- **e.g. Fargro chlormequat (46%) 500 ppm active ingredient = 500 x 100 / 46 = 1087 ppm commercial product, to convert to ml/litre / 1000 = 1.08 ml product / litre**

Presentation 5: Scheduling perennials – plant growth regulator trial (HNS103b)

Wayne Brough, ADAS





Scheduling Perennials

Achillea ‘Moonshine’	Lavatera ‘Blushing Bride’
Campanula ‘Blue Waterfall’	Lavender ‘Bella Rouge’
Catanche caerula ‘Blue’	Leucanthemum ‘Broadway Lights’
Centurea ‘Amethyst Dream’	Monarda ‘Beauty of Cobham’
Coreopsis ‘Lime Rock Ruby’	Penstemon ‘Ice Cream – Sweet Cherry’
Diascia personata	Phygelius ‘Funfare – Wine’
Erysimum ‘Bowles Mauve’	Scabiosa ‘Burgundy Bonnets’
Gallardia ‘St Clements’	Salvia ‘Hot Lips’
Gaura neapolitanum ‘Tutti Frutti’	Verbena ‘Seabrook Lavender’

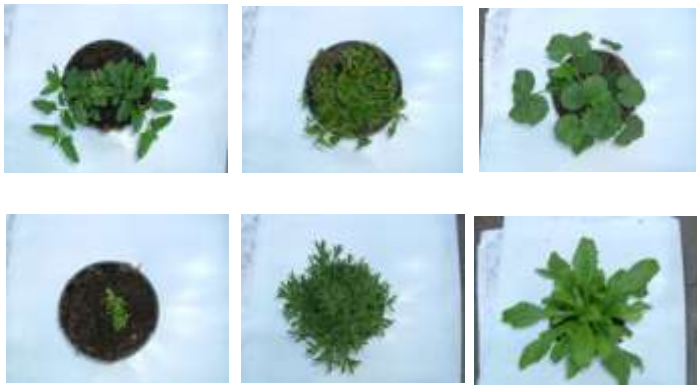
Scheduling Perennials

Untreated control	Fargro Chlormequat 2 sprays at 3.0 ml per litre
Bonzi 1 spray at 2.5 ml per litre	Regalis 2 sprays at 1.25 g per litre
Dazide Enhance 1 spray at 5.0 g per litre	Bonzi drench treatment at 2.5 ml per litre
Fargro Chlormequat 1 spray at 6.0 ml per litre	Dazide Enhance drench treatment at 5.0 g per litre
Regalis 1 spray at 2.5 g per litre (prohexadione calcium)	Fargro Chlormequat drench treatment at 6.0 ml per litre
Bonzi 2 sprays at 1.25 ml per litre	Regalis drench treatment at 2.5 g per litre
Dazide Enhance 2 sprays at 3.0g per litre	Sprays applied in approx 1000 litres water per ha. Drenches applied at 150 ml solution per 2 litre pot via watering can and washed off.

Scheduling Perennials

Crop diary

- Most species potted on from 60 or 84 plugs between weeks 12-16 (with the exception of the lavender week 8).
- Grown on under glass on benching until 9 June then moved out under open sided tunnels.
- Pinching occurred as required after potting.
- PGRs applied on 11 May and 26 May 2010.
- Pesticides applied as required for P&D control
- Grown as a commercial crop



Scheduling Perennials

Trial detail

- Species selected where possible for vigour, flower stem height, open habit as a test for treatments.
- Treatments applied where possible to plants at optimum size, however diascia was too small and lavender and scabiosa were a little too large.
- Trial was laid out by treatment, now laid out 2 plant species per bench via PGR treatments – untreated, 1 spray treatments, 2 spray treatments and drenches.
- Regalis possesses a SOLA for use on outdoor ornamentals - 2866/08

Scheduling Perennials

Product	Cost of product	Cost at rate trialled
46% chlormequat	1.8p per ml of product	10.8p per litre at 6ml/l rate
B. Nine SG	14.0p per gram of product	70p per litre at 5g/l rate
Bonzi	6.9p per ml of product	17.25p per litre at 2.5ml/l rate

Chemical Growth regulators

Rates of use

- **Chlormequat – depending upon concentration, 46% - 3-6.4 ml/l, 64.5 % - 2.8 ml/l. To avoid yellowing (and if used on plugs) from 1 ml/litre**
- **Daminozide –B-Nine SG 3-6 g/l, Dazide Enhance 1.4 – 2.8 g/l**
- **Paclobutrazol 1.25 ml/l, from 0.5 ml to 5 ml/l with care**

Summary

- **Essential to trial / refine rates contained within the handout prior to widespread use**
- **Generally PGRs improve plant habit**
- **Take re-entry periods into account for products containing daminozide e.g. Dazide Enhance 4 – 9 days, B-Nine SG 8 days**
- **Regalis SOLA for outdoor ornamentals only**

Annex II

This section contains a literature review of plant growth regulator use on herbaceous perennials which was produced as part of HNS 103b Objective 1.

The document is intended to be used as a reference document. Rates are presented as guidance only to provide an indication of potential suitable rates under UK growing conditions. Where the crop response in not known it is advised that a small proportion of a given crop is treated prior to widespread use of the chemical plant growth regulator. Neither HDC nor ADAS can be held responsible for crop losses or damage incurred from the rates detailed within this publication.

There is potential to make more use of chemical plant growth regulators to manipulate the growth of herbaceous plant species. Plant growth regulator products can be used to reduce plant internode length and hence reduce plant height, improve the degree of side branching and hence improve plant habit and reduce flower stem height enabling more plants to be transported on each trolley. This potentially gives growers more control over crop development reducing the need for costly operations such as pinching and pruning and hand cleaning at dispatch.

To maximise their effect, plant growth regulator products should be applied to new growth prior to any rapid extension. They can also be applied to plants at the flower bud initiation stage to reduce flower stem length, but note when applied at this stage they can also potentially delay the time to flower and reduce flower size.

Depending upon their mode of action, plant growth regulator products can be applied to plants either as a spray or drench. Spray applications tend to have less impact on plant growth (depending upon the product and rate applied) and so often need to be applied on several occasions to have the desired effect. Drench applications are generally more effective, although they are more costly to apply in terms of application time and there may be issues with product build up in capillary matting etc. beneath the crop.

Chemical plant growth regulator use on herbaceous plants is summarised within the six tables in this document; Table 1 lists the various products available in the UK, Table 2 their approval status whilst Table 3 onwards summarises the various published work undertaken with their use on herbaceous plant subjects (sources are listed in the reference section for further information). Product labels / technical information / SOLAs should be read prior to application to ascertain the relevant or maximum rate, frequency of application, water volume etc. for UK products.

Table 1. *Plant growth regulators currently approved for use in the UK*

Product name	MAPP Number	Active ingredients (A.I.)	A.I. content	Main supplier	Final use date
B-Nine SG	12698	Daminozide	85% w/w	Chemtura Europe Limited	31/08/11
B-Nine SG	12734	Daminozide	85% w/w	Certis	31/08/11
B-Nine SG	14435	Daminozide	85% w/w	Certis	28/02/16
Dazide Enhance	11943	Daminozide	85% w/w	Fine	31/08/11
Dazide Enhance	14433	Daminozide	85% w/w	Fine	08/03/13
BASF 3C Chlormequat 720	06514	Chlormequat*	720 g / litre	BASF	31/12/13
Clayton Standup	11760	Chlormequat*	700 g / litre	Clayton Plant Protection (UK) Ltd	31/12/13
Fargro Chlormequat	02600	Chlormequat*	460 g / litre	Fargro	31/12/13
Hive	11392	Chlormequat*	730 g / litre	Nufarm UK Limited	31/10/13
Mirquat	11406	Chlormequat*	730 g / litre	Nufarm UK Limited	31/10/13
New 5C Cycocel	01482	Chlormequat*	645 g / litre	BASF	30/04/13
New 5C Quintacel	12074	Chlormequat*	645 g / litre	Nufarm UK Limited	31/12/13
Stabilan 700	11393	Chlormequat*	700 g / litre	Nufarm UK Limited	31/08/13
Terbine	11407	Chlormequat*	730 g / litre	Nufarm UK Limited	31/10/13
Cerone	09985	2-chloroethylphosphonic acid	480 g / litre	Bayer CropScience	30/07/12
Bonzi	13623	Paclobutrazol	4 g / litre	Syngenta Bioline	31/12/13
Pirouette	13073	Paclobutrazol	4 g / litre	Fine	31/12/13
Regalis	12414	Prohexadione-calcium*	10% w/w	BASF	31/12/11
Moddus	08801	Trinexapac-ethyl	250 g / litre	Syngenta Crop Protection UK Limited	31/12/13

* Adjuvants: A suitable non-ionic surfactant should be used with chlormequat. A water conditioner must be used with Regalis e.g. X-Change at a rate of 1litre in 400 litres.

Table 2. *Approval status of plant growth regulators approved in the UK*

Product name	MAPP Number	Approval status
B-Nine SG	12698	Label approval for use in ornamental plant production.
B-Nine SG	12734	Label approval for use in ornamental plant production.
B-Nine SG	14435	Label approval for use in ornamental plant production (protected).
Dazide Enhance	11943	Label approval for use in ornamental plant production.
Dazide Enhance	14433	Label approval for use in ornamental plant production (protected).
BASF 3C Chlormequat 720	06514	Label approval for use in *Geranium***.
Clayton Standup	11760	Label approval for use in ornamental plant production.
Fargro Chlormequat	02600	Label approval for use in ornamental crops.
Hive	11392	Label approval for use in ornamental plant production.
Mirquat	11406	Label approval for use in ornamental plant production.
New 5C Cycocel	01482	Label approval for use in ornamental plant production.
New 5C Quintacel	12074	Label approval for use in ornamental plant production.
Stabilan 700	11393	Label approval for use in ornamental plant production.
Terbine	11407	Label approval for use in ornamental plant production.
Cerone	09985	Specific Off-Label Approval (ref. SOLA 1382/09) for use in protected ornamental plant production as a horticultural growth regulator.
Bonzi	13623	Label approval for use in ornamental plant production.
Pirouette	13073	Label approval for use in ornamental plant production (container grown).
Regalis	12414	Specific Off-Label Approval (ref. SOLA 2866/08) for use in outdoor ornamental plant production as a horticultural growth regulator.
Moddus +	08801	SOLA for use in ornamentals requested by HDC.

** It is worth noting that the Chemicals regulation directorate (CRD) no longer specifies approvals in this way and any future approvals will probably just specify 'Ornamental Plant Production'. In such a case products can be used on any ornamental at your own risk as long as there are no other restrictions on the product label.

+ Moddus is only likely to be effective on monocotyledon plant species (e.g. grasses); its main use is for growth regulation of cereals.

Plant responses

It is not safe to assume that a plant growth regulator that is effective on one species will be effective on another species. It is also generally not safe to assume that all cultivars within a species respond in the same way to a given plant growth regulator. Several applications of a plant growth regulator, using the appropriate rate are generally required to achieve height control. Growth regulation typically lasts from two to four weeks before plants return to their normal rates of growth.

Table 3. *Rates relating to foliar applications of daminozide (as B-Nine), chlormequat (as Cycocel) and paclobutrazol (as Bonzi) tested on herbaceous perennials*

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Achillea 'Coronation Gold'	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Achillea filipendulina	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Achillea millefolium 'Summer Pastels'***	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Slight response.	Michigan, USA.
Achillea 'Moonshine'	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Aegopodium podagraria	2.9 g/l	-	-	-	-	-	N.USA.
Agastache 'Blue Fortune'	2.9 g/l	-	-	-	-	-	N.USA.
Alcea rosea 'Chater's Double Mix'***	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	Strong response. 1.9ml/l may be more appropriate.	0.38 or 0.75 ml/l applied at least 3 times.	Moderate response. Rates of up to 1.25 ml recommended in the USA.	Michigan, USA.
Anthemis hybrida tinctoria	2.9 g/l	-	-	-	-	-	N.USA.
Aquilegia alpina, A. caerulea, A. chrsantha, A. vulgaris	2.9 g/l	-	1.9 ml/l	-	0.75 ml/l	-	N.USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Aquilegia 'Star Series'	2.9 g/l x 3	Reduced plant height by 18%.	-	-	-	-	Michigan, USA.
Arabis blepharophylla	2.9 g/l	-	-	-	-	-	N.USA.
Arabis caucasica	2.9 g/l	-	-	-	-	-	N.USA.
Artemesia arborescens	2.9 g/l	-	-	-	-	-	N.USA.
Artemesia ludoviciana	2.9 g/l	-	-	-	-	-	N.USA.
Artemesia schmidtiana	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Asclepias tuberosa	5.9 g/l applied at least 3 times.	Strong response, 2.5 g/l may be more appropriate.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Moderate response. Rates of up to 1.25 ml recommended in the USA.	Michigan, USA.
Aster alpinus 'Alpine Mix'***	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Slight response.	Michigan USA.
Aster frikartii	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Aster tongolensis	2.9 g/l	-	-	-	-	-	N.USA.
Astilbe x arendsii 'Bressingham Beauty'	5.9 g/l x 4	Start applying weekly just after inflorescence begins to elongate.	2.3 ml/l applied at least 3 times.	Slight response.	0.75 ml/l	Slight response reported.	N. USA.
Aubrieta deltoidea	2.9 g/l	-	-	-	-	-	N.USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Aurinia saxatilis	2.9 g/l	-	-	-	-	-	N.USA.
Bellis perennis	2.9 g/l	-	-	-	-	-	N.USA.
Bidens 'Hannahs Lemon Drops'	4 to 5 g/l	-	-	-	-	-	EU.
Boltonia asteroids	2.9 g/l	-	-	-	-	-	N.USA.
Campanula carpatica 'Blue Chips'***	5.9 g/l x 2 to 4	Apply at 10 – 14 day intervals. 4 applications resulted in a strong response. Try 2.5g/l.	1.2 ml/l	-	0.25 ml/l	-	N. USA.
Campanula glomerata	2.9 g/l	-	0.78 ml/l	-	0.75 ml/l	-	N.USA.
Campanula medium	2.9 g/l	-	-	-	-	-	N.USA.
Campanula persicifolia 'Blue'	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	No response.	N. USA.
Centaurea montana 'Violet'	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l applied at least 3 times.	No response.	Greater than 0.75 ml/l x 4.	No response.	N. USA.
Chelone glabra	5.9 g/l x 4	No response.	2.3 ml/l applied at least 3 times.	No response in terms of growth, severe chlorosis.	Greater than 0.75 ml/l x 4.	No response.	N. USA.
Chrysanthemum morifolium R. *cv* Monalisa 'White'	1.06 g/l x 3	Suppressed growth by 27%.	-	-	-	-	South Korea.
Chrysanthemum coccineum 'James Kelway'***	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l applied at least 3 times.	Strong response.	Greater than 0.75 ml/l x 4.	No response.	N. USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Coreopsis grandiflora 'Baby Sun'	5.9 g/l x 3	May delay flowering. Apply at 10 – 14 day intervals. C. Sunray showed a strong response when applied at least 3 times. 2.5 g/l may be appropriate.	2.3 ml/l x 3	No response.	-	-	N. USA.
Coreopsis grandiflora 'Sunray'***	5.9 g/l x 3	May delay flowering. Apply at 10 – 14 day intervals. C. Sunray showed a strong response when applied at least 3 times. 3.5 g/l is a common recommendation in the EU, applied once or twice with a 14 day interval.	2.3 ml/l applied at least 3 times.	Slight response.	0.75 ml/l applied at least 3 times.	Slight response. 2 – 2.5 ml/l may be more effective, (recommend ation in the USA).	N. USA.
Coreopsis rosea	2.9 g/l	-	-	-	-	-	N.USA.
Coreopsis verticillata 'Moonbeam'***	5.9 g/l x 2	Some flower delay. Apply at 10 – 14 day intervals. Strong response when applied at least 3 times. 2.5 g/l may be appropriate.	2.3 ml/l x 4	No response.	0.75 ml/l applied at least 3 times.	No response. 2 – 2.5 ml/l may be more effective, (recommend ation in the USA).	USA.
Coreopsis verticillata 'Zagreb'	5.9 g/l x 2	Apply at 10 – 14 day intervals.	-	-	-	-	USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Delphinium x elatum 'Magic Fountains'	5.9 g/l x 3	No response.	2.3 ml/l x 3	No response.	Less than 0.75 ml/l x 4, 0.75ml/l x 1.	Caused an excessive reduction in height. Reduce rate or frequency.	N. USA.
Delphinium grandiflorum	-	-	-	-	0.75 ml/l	-	N. USA.
Delphinium 'Pacific Giant Group'	-	-	-	-	0.75 ml/l	-	N. USA.
Delphinium 'Pacific Hybrid'	2.9 g/l x 2 and 5.9 g/l x 2	Proved unsuccessful in controlling growth.	6 ml/l x 2 and 9 ml/l x 2.	Proved unsuccessful in controlling growth.	0.63 ml/l x 2 and 1.25 ml/l x 2.	Proved unsuccessful in controlling growth.	UK.
Dendranthema zawadskii	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Dianthus barbatus	4.41 g/l	-	-	-	1.13 ml/l	-	N. USA.
Dianthus caryophyllus	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.
Dianthus deltoides	-	-	1.9 ml/l	-	-	-	N. USA.
Dicentra eximia	2.9 g/l	-	-	-	-	-	N.USA.
Dicentra formosa	2.9 g/l	-	-	-	-	-	N.USA.
Dicentra spectabilis	2.9 - 5.9 g/l	5.9 g/l reduced height of forced potted plants by 10cm and had no effect on flower number.	-	-	0.75 ml/l	-	N.USA/ Denmark.
Digitalis purpurea	-	-	-	-	0.75 ml/l	2 - 4 ml/l recommended in the USA.	N. USA.
Doronicum orientale	2.9 g/l	-	-	-	0.75 ml/l	-	N.USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Echinacea Purpurea 'Bravado'	5.9 g/l applied at least 3 times.	Apply at 10 – 14 day intervals. Slight response.	2.3 ml/l x 5	Discoloured leaves, strong response, 1.9 ml/l may be more appropriate.	0.75 ml/l	-	USA.
Euphorbia polychroma	2.9 g/l	-	-	-	-	-	N.USA.
Eupatorium					> 6 ml/l	Recommended rate in the USA.	USA.
Galium odoratum	-	-	2.3 ml/l	-	-	-	N. USA.
Gallardia aristata	5 g/l	-	-	-	1.13 ml/l	-	N. USA / EU.
Gallardia x grandiflora 'Burgundy'	5.9 g/l applied at least 3 times.	No response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	No response.	Michigan, USA.
Gaura lindheimeri 'Whirling Butterflies'	5.9 g/l applied at least 3 times.	No response – 5g/l x 2 may be effective in the EU.	1.5 ml/l applied at least 3 times.	No response.	0.75 ml/l x 4	No response, use a higher rate.	Michigan USA.
Geranium himalayense	2.9 g/l	-	1.9 ml/l	-	0.75 ml/l	-	N.USA.
Geum chiloense	-	-	-	-	0.75 ml/l	-	N. USA.
Geum coccineum	-	-	1.9 ml/l	-	0.75 ml/l	-	N. USA.
Goniolimon tataricum	2.9 g/l	-	-	-	-	-	N. USA.
Gypsophila paniculata 'Double Snowflake'	5.9 g/l x 4	No response.	2.3 ml/l ml/l applied at least 3 times.	Slight response.	0.75 ml/l applied at least 3 times.	Slight response.	N. USA.
Helenium autumnale	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	No response.	N. USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from.
Heliopsis helianthoides	2.9 g/l x 2 or 5.9 g/l x 2	5 g/l applied twice resulted in plants being half the height of controls.	-	-	1, 2, 3 and 4 ml/l	Plant height not significantly affected.	N.USA.
Hemerocallis (most varieties)	5.9 g/l x 4	No response.	2.3 ml/l applied at least 3 times.	No response.	1.5 ml/l	No response to 0.75 ml/l.	N. USA.
Heuchera sanguinea 'Bressingham Hybrids'***	5.9 g/l x 4	Slight or no response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l x 4	No response.	N. USA.
Hosta plantaginea	2.9 g/l	-	-	-	-	-	N. USA.
Iberis sempervirens	-	-	-	-	0.75 ml/l	-	N. USA.
Iris nigricans	-	-	0.4, 0.8, 1.6, 2.3 ml/l	Rates up to 1 ml/l had the least effect on height. Drenches were also applied at 0.4, 0.6 and 0.8 ml/l, only the highest rate reduced height but also reduced flowering between 10 – 30%.	2.5, 6.3, 12.5 and 25 ml/l	Caused severe stunting and leaf distortion. High rates reduced the number of shoots.	Jordan.
Lamium maculatum	-	-	0.75 ml/l	-	-	-	N. USA.
Lavandula angustifolia 'Munstead Dwarf'***	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l x 3	No response.	0.75 ml/l applied at least 3 times.	No response.	N. USA.
Lavandula intermedia	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Leucanthemum x superbum 'Marconi'	5.9 g/l applied at least 3 times.	No response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Moderate response.	Michigan, USA.
Liatris spicata	2.9 g/l	-	-	-	-	-	N. USA.
Lilium (Asiatic lily)	-	-	-	-	0.25 ml/l	-	N. USA.
Linum perenne Sapphire	5.9 g/l x 4	Apply at 10 – 14 day intervals. No response.	-	-	Greater than 0.75 ml/l x 4.	Slight response.	N. USA.
Lobelia cardinalis	2.9 g/l	-	1.9 ml/l	-	0.75 ml/l	-	N. USA.
Lobelia fulgens	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Lobelia x speciosa 'Compliment Scarlet'***, 'Queen Victoria'***	5.9 g/l x 4	Apply at 10 – 14 day intervals. Moderate response.	2.3 ml/l applied at least 3 times.	Slight response.	Greater than 0.75 ml/l x 1.	May require multiple applications, slight response.	N. USA.
Lupinus 'My Castle'	-	-	6 ml/l x 2 and 9 ml/l x 2.	Proved unsuccessful in controlling growth.	0.63 x 2 and 1.25 ml/l x 2	Proved unsuccessful in controlling growth.	UK.
Lychnis coronaria	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Lythrum salicaria	2.9 g/l	-	-	-	-	-	N. USA.
Monarda didyma	2.9 - 5 g/l	-	-	-	0.75 ml/l	Rates of 1.5 – 4 ml recommended in the USA.	N. USA.
Nepeta faassenii	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Papaver orientale	2.9 g/l	-	-	-	-	-	N. USA.
Penstemon 'Garnet'	2.9 g/l	-	1.9 ml/l	-	-	-	N. USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Penstemon 'King George'	2.9 g/l x 2 or 5.9 g/l x 2.	Best growth control.	6 ml/l x 2 or 9 ml/l x 2.	Ineffective.	1.25 x 2	No visible growth control.	UK.
Phlox paniculata 'Eva Cullum'	5.9 g/l x 4	No response.	2.3 ml/l applied at least 3 times.	Slight response.	Greater than 0.75 ml/l x 4.	Slight response.	N. USA.
Phygelius capensis	-	-	-	-	2.5 or 5 ml/l applied once.	Good growth control but reduced the length of the flower spike.	UK.
Physostegia virginiana 'Summer Snow'	5.9 g/l x 4	No response.	2.3 ml/l x 7	No response.	2.5 ml/l x1	No response.	N. USA.
Platycodon grandiflorus	-	-	-	-	0.75 ml/l	-	N. USA.
Polemonium caeruleum	2.9 g/l	-	-	-	-	-	N. USA.
Ranunculus repens	2.9 g/l	-	-	-	-	-	N. USA.
Rudbeckia fulgida var. sullivantii 'Goldstrum'	5 g/l x 4	Slight response.	2.3 ml/l applied at least 3 times.	Slight response.	0.75 ml/l applied at least 3 times.	Slight response. 1.5 ml/l may be more appropriate.	N. USA.
Rudbeckia hirta	4.41 g/l	-	-	-	-	-	N. USA.
Salvia nemorosa	2.9 g/l	-	-	-	-	-	N. USA.
Salvia x superba 'Blue Queen'***	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	No response.	Greater than 0.75 ml/l x 4.	-	Michigan, USA.
Scabiosa caucasica	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Scabiosa columbaria	2.9 g/l	-	-	-	-	-	N. USA.

Plant species	Rate of B-Nine	Effects on growth	Rate of Cycocel	Effects on growth	Rate of Bonzi	Effect on growth	Country / region where data sourced from
Sedum spectabile	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Sedum spurium 'Dragon's Blood'	5.9 g/l x 4	No response.	2.3 ml/l applied at least 3 times.	No response.	Greater than 0.75 ml/l x 4.	Slight response.	N. USA.
Solidago sphacelata	2.9 g/l	-	-	-	0.75 ml/l	-	N. USA.
Stokesia laevis	2.9 g/l	-	1.9 ml/l	-	0.75 ml/l	-	N. USA.
Tanacetum Coccineum group	2.9 g/l	-	-	-	0.75 ml/l	1 - 2 ml/l recommended in the USA.	N. USA.
Veronica longifolia 'Red Fox'	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Slight response. 0.5 – 1 ml/l recommended in the USA.	Michigan, USA.
Veronica longifolia 'Border Blue'	5.9 g/l applied at least 3 times.	Strong response, 2.5 g/l may be more appropriate.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	Strong response. 0.5 – 1 ml/l recommended in the USA.	Michigan, USA.
Veronica spicata 'Blue'	5.9 g/l applied at least 3 times.	Moderate response.	2.3 ml/l applied at least 3 times.	No response.	0.75 ml/l applied at least 3 times.	No response. 0.5 – 1 ml/l recommended in the USA.	Michigan, USA.

*** Species where flowering was delayed by 5 or more days by applications of B-Nine every 10 days compared to untreated plants.

Table 4. Rates of paclobutrazol (as Bonzi) tested on herbaceous perennials as a drench

Plant species	Rate of Bonzi	Effects on growth / comments	Country / region where data sourced from
Alcea rosea	0.025 – 0.05 ml/l	Recommended rate in the USA.	USA.
Astilbe x arendsii 'Bressingham Beauty'	0.75 ml/l x 1	-	N. USA.
Chelone glabra	0.75 ml/l x 1	No response.	N. USA.
Chrysanthemum coccineum James Kelway	Greater than 0.75 ml/l.	-	N. USA.
Coreopsis 'American Dream'	Plugs drenched with 0.04, 0.08, 0.11 and 0.15 mg/l 23 days prior to potting, then drenched with 0.25, 0.50, 0.75 and 1 ml/l drench respectively (48 ml drench per litre of growing media).	0.50 ml/l provided adequate height control (bark based media). Rates of up to 0.13 – 0.25 ml/l are recommended on *Coreopsis spp.* in general in the USA.	Georgia, USA.
Cortaderia argentea	0.025, 0.05, 0.1, 0.2 and 0.4 ml/l	Plant height was reduced between 14 and 61%.	USA.
Delphinium x elatum 'Magic Fountains'	Greater than 0.75 ml/l x 1.	-	N. USA.
Digitalis	0.05 – 0.1 ml/l	Recommended rate in the USA.	USA.
Eupatorium	0.2 – 0.25 ml/l	Recommended rate in the USA.	USA.
Gaura	0.75 ml/l	Recommended rate in the USA.	USA.
Hemerocalis Halls Pink	Greater than 0.75 ml/l x 1 drench.	-	N. USA.
Iris nigricans	0.006, 0.01, 0.03 and 0.05 ml/l	Plants did not respond to drenches except when 0.05 ml/l was applied, however plants drenched with the lowest rate were first to flower.	Jordan.
Jacobinia	0.01 – 0.03 ml/l.	Recommended rate in the USA.	USA.
Liatris 'Floristan Violet'	Plugs drenched with 0.04, 0.08, 0.11 and 0.15 ml/l 23 days prior to potting, then drenched with 0.25, 0.50, 0.75 and 1 ml/l drench respectively (48 ml drench per litre of growing media).	Plants grown in bark based media. PGR treated plants that were flowering appeared shorter than non treated plants in flower.	Georgia, USA.

Plant species	Rate of Bonzi	Effects on growth / comments	Country / region where data sourced from
Monarda	> 0.1 ml/l	Recommended rate in the USA.	USA.
Phlox 'Blue Boy'	Plugs drenched with 0.04, 0.08, 0.11 and 0.15 ml/l 23 days prior to potting, then drenched with 0.25, 0.50, 0.75 and 1 ml/l drench respectively (48 ml drench per litre of growing media).	1 ml/l appeared to be the most effective rate (bark based media).	Georgia, USA.
Physostegia 'Red Beauty'	Plugs drenched with 0.04, 0.08, 0.11 and 0.15 ml/l 23 days prior to potting, then drenched with 0.25, 0.50, 0.75 and 1 ml/l drench respectively (48 ml drench per litre of growing media).	Plants grown in bark based media. PGR treated plants that were flowering appeared shorter than non treated plants in flower.	Georgia, USA.
Rudbeckia fulgida var. sullivantii 'Goldstrum'	Greater than 0.75 ml/l	-	Michigan, USA.
Salvia x sylvestris 'Blue Queen'	Greater than 0.75 ml/l	-	N. USA.
Sedum spurium 'Dragon's Blood'	Greater than 0.75 ml/l	Slight response.	N. USA.
Solidago sphacelata 'Golden Fleece'	Greater than 0.75 ml/l	-	N. USA.
Verbena	0.075 ml/l	Recommended rate in the USA.	USA.

Growing media containing bark can reduce the effectiveness of plant growth regulators applied as drenches.

Application of Bonzi as a drench (taken from Fargro product label): The growing media must be moist at the time of application to ensure uniform distribution of the drench. Volume of drench liquid required is related to the pot/container size. Recommended volume rates are:

Pot size	**Drench volume per pot**
10 cm	50 ml
15cm	100 ml
20cm	200 ml

Table 5. Growth regulatory effects of 2-chloroethylphosphonic acid (e.g. Cerone)

Plant species	Rate of 2-chloroethylphosphonic acid	Effects on growth / comments	Country / region where data sourced from
Achillea millefolium 'Weser River Sandstone'	1.25 ml/l x1, x2, x3 and 2.5 ml/l x1, x2 x3	Plants sprayed 3 times at 2.5 ml/l were 13 cm shorter than controls. The effect of 1ml/l on stem elongation was not pronounced but the higher rate was in proportion to the number of applications. Number of flowers was increased by treatment whilst no effects on the number of shoots were noted. Effects persisted for up 2 weeks. Trials in the USA have shown plant sprayed with 2.5 ml/l 3 times increased the number of flowers and gave moderate height control.	Japan/USA.
Achillea 'Coronation Gold' /*Achillea filipendulina*	1.25 ml/l	Delayed flowering, apply before visible bud.	USA.
Alcea rosea	1.25 ml/l x1, x 2	-	USA.
Canna x generalis/Canna x orchiodes	2.5 ml x 1	-	USA.
Coreopsis verticillata 'Moonbeam'	1.25 ml/l x1, x2, x 3 and 2.5 ml/l x1, x2 x 3	No effect on plant height, 2.5 ml/l increased the number of flowers by about 40%. The number of shoots per pot was unaffected.	Japan.
Echinacea Purpurea 'Bravado'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x1, x 2 x 3	Increased number of applications and increase in concentration resulted in a significant decrease in plant height. Effects persisted for up 2 weeks. 1.25 ml/l applied once to three times is recommended in the USA.	Japan/USA.
Heliopsis helianthoides 'Summer Sun'	1.25 ml/l x 2	15 – 18 percent reductions in plant height that persisted through 12 weeks after treatment but did not delay flowering.	Unknown, interpret with caution.
Gaillardia aristata	1.25 ml/l	-	USA.
Gallardia x *grandiflora* 'Goblin'	1.25 ml/l x 2	-	USA.
Gaura lindheimeri 'Corrie's Gold'	1.25 ml/l x 2	Over 25 percent reduction in plant height which persisted for weeks after treatment but was no longer significant 8 weeks after treatment. 1.25 ml/l recommended in the USA, higher rates may delay flowering.	Unknown, interpret with caution/USA.
Geranium himalayense	1.25 ml/l	-	USA.
Heliopsis helianthoides	1.25 ml/l x 2	Moderate growth control.	USA.
Lamium maculatum	3.1 ml/l	-	USA.

Plant species	Rate of 2-chloroethylphosphonic acid	Effects on growth / comments	Country / region where data sourced from
Leucanthemum x superbum 'Thomas Killen'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x1, x 2 x 3	Plant height decreased as dose increased. A single application at 2.5 ml/l was nearly as effective at reducing elongation as two sprays at 1.25 ml/l. The number of flowers and shoots decreased as dose increased, flower size also decreased. An application at 2.5 ml/l persisted for approx. 5 weeks.	Japan.
Liatris spicata 'Kobold'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x1, x 2 x 3	Highly variable response, flowering generally slightly delayed. Significant increase in stem diameter with increasing concentration and number of applications. Effects on elongation, flower number and shoot number were not detectable. 1.9 ml/l recommended in the USA.	Japan/USA.
Lychnis coronaria	1.25 ml/l	-	USA.
Lythrum virgatum 'Morden Pink'	1.25 ml/l x 2	-	USA.
Monarda didyma 'Blue Stocking'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x1, x 2 x 3	Flowering delayed relative to the concentration and number of applications. Suppressed stem elongation and decreased the number of flowers as dosage increased. 2.5 ml/l caused necrosis on Monarda foliage. Effects persisted for approx. 3 weeks regardless of concentration. 1.25 ml/l (up to 3 applications) recommended in the USA.	Japan/USA.
Nepeta faassenii	1.25 ml/l x 2	May require multiple applications.	USA.
Phlox paniculata 'Mt Fuji'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x1, x 2 x 3	Flowering delayed. No effect on plant height, the number of flowers or shoots per pot but did increase the number of flowers per shoot.	Japan.
Physostegia virginiana 'Summer Snow'	1.25 ml/l x1, x 2, x 3 and 2.5 ml/l x 1, x 2 x 3	Flowering delayed. Plant height decreased linearly with increasing concentration and number of applications. Decreased the number of flowers per shoot. Effects on stem elongation persisted for 2-3 weeks. 1.25 ml/l recommended in the USA.	Japan/USA.
Salvia farinacea 'Victoria Blue'	1.25 to 1.9 ml/l	-	USA.
Salvia leucantha	1.25 ml/l	-	USA.
Salvia nemorosa	1.25 ml/l	-	USA.
Salvia x *sylvestris* 'May Night'	0.6 – 2.5 ml/l	Some delay in flowering with eventual increase in inflorescence numbers.	USA.
Scabiosa columbaria	1.25 to 1.9 ml/l	Higher rates delay flowering.	USA.

Plant species	Rate of 2-chloroethylphosphonic acid	Effects on growth / comments	Country / region where data sourced from
Sedum spectabile	1.25 ml/l	-	USA.
Stokesia laevis	1.25 ml/l	-	USA.
Verbena canadensis 'Homestead Purple'	1.25 – 2.5 ml/l	-	USA.

UK SOLA specifies that Cerone can only be used once per crop up to 1 litre per 1000 litres of water.

Tank mixes

There is increasing interest in using a combination of two growth regulators as a tank mix on certain crops. Most growers apply a single plant growth regulator to a crop, however some species respond better to a tank mix of two or more. It is generally best to apply plant growth regulators singly initially to gain experience as to how plants respond. Where varieties do not respond to individual products consider a tank mix to improve growth control. Always test tank mixes on a small proportion of the crop prior to widespread use. Application at growers own risk.

Table 6. *Tank mix suggestions*

Plant species	Rate of B-Nine / Cycocel	Effects on growth	Rate of B-Nine / Bonzi	Effects on growth	Country / region where data sourced from
Achillea millefolium	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Agastache 'Blue Fortune'	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Anthemis hybrida tinctoria	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Aquilegia alpina, A. caerulea, A. chrsantha, A. vulgaris	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Artemesia schmidtiana	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Coreopsis grandiflora	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Coreopsis verticillata	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Delphinium grandiflorum	2.9 g/l / 1.5 ml/l	-	2.4 g/l /0.75 ml/l	-	N. USA.
Delphinium Pacific Giant Group	-	-	2.4 g/l / 0.75 ml/l	-	N. USA.
Dendranthema zawadskii	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Doronicum orientale	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Echinacea Purpurea 'Bravado'	2.4 g/l / 1.5 ml/l	-	-	-	N. USA.
Gallardia aristata	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.75 ml/l	-	N. USA.
Gallardia grandiflora	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Gaura lindheimeri	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Geum chiloense	-	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Heliopsis helianthoides	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Hemerocallis	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Hosta plantaginea	2.9 g/l / 1.5 ml/l	-	2.3 g/l / 0.75 ml/l	-	N. USA.
Lavandula intermedia	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Leucanthemum x superbum	-	-	1.2 g/l / 0.38 ml/l	-	N. USA.
Monarda didyma	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Nepeta faassenii	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.

Plant species	Rate of B-Nine / Cycocel	Effects on growth	Rate of B-Nine / Bonzi	Effects on growth	Country / region where data sourced from
Polemonium caeruleum	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Rudbeckia fulgida	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Scabiosa caucasica	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Sedum spectabile	2.9 g/l / 1.5 ml/l	-	2.2 g/l / 0.38 ml/l	-	N. USA.
Stokesia laevis	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Veronica longifolia	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.
Veronica spicata	2.9 g/l / 1.5 ml/l	-	-	-	N. USA.

In the case of Tables 3-6:

Rates of chlormequat from abroad are based on ppm conversions using New 5C Cycocel (645g/l) chlormequat. The rate will have to be adjusted for other chlormequat formulations of different concentrations.

– this symbol indicates no crop response was reported or no data was available.

Where information is obtained from the USA the rates stated are from trials from Northern States as opposed to Southern States to make the data more relevant to UK growing conditions.

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