

**Project title:** The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers.

***Objective 3.*** *To evaluate plant growth regulators for use on bedding plant plugs prior to transplant*

**Project number:** PO 019a

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**Previous report:** None

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## 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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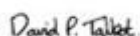
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Date 29 March 2019

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## Grower Summary

### Headline

- New recommended plant growth regulator (PGR) drench treatments for use on bedding plant plugs include: Terpal, Dazide Enhance and Pirouette on Geranium 'Horizon'; Pirouette on Pansy 'Matrix'.
- Treatments not recommended due to phytotoxicity at trial rates include: Primo Maxx II on *Dianthus* 'Festival' and Geranium 'Horizon'; HDC P005 on *Dianthus* 'Festival'.
- Pirouette was the most effective drench treatment on Pansy.

### Background

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries. Knowledge transfer events including trial open days and study tours are also included in the programme.

The work programme is guided by a grower-led Management Group that includes members of the BPOA Technical Committee, and representatives from Baginton Nurseries, Coventry the host nursery for the BPPC, and growers representing both the bedding and pot plant sectors.

*This is the Bedding and Pot Plant Centre report for:*

**Objective 3.** *To evaluate plant growth regulators for use on bedding plant plugs prior to transplant.*

### Summary

The evaluation of new plant growth regulators (PGRs) for use on bedding and pot plants was prompted by label changes to the plant growth regulator Bonzi (paclobutrazol), including removal of the option for drench application, and the potential restrictions or loss of approval for the use of chlormequat in protected ornamental plant production. Growers sometimes apply PGRs as drenches and have developed application rates specific to the crops grown under nursery specific growing conditions. The PGRs included in this trial have either been trialled in Denmark with promising results on bedding and pot plants, are new to the market or have recently received CRD approval for use on related crops in the UK. However, any phytotoxic effects and efficacy of these chemicals on bedding and pot plants grown under UK conditions are currently unknown.

This particular piece of work was prompted by trials work carried out in 2017, where sprays and drenches of the PGRs used were applied to a range of species post transplanting into

packs, and post potting / transplanting into pots. Many of the drench applications produced too strong an effect, drench applications are also labour intensive and thus expensive to apply. This, combined with the fact that a number of the plant growth regulators in this trial were not at the time authorised for use on ornamentals, with the potential for restrictions on the amount of active that can be applied per hectare (once approvals were issued), prompted interest in drenching plugs with small doses of active ingredient prior to transplanting. There is also the potential to explore drenching plugs in a closed, tray based system to minimise any potential environmental effects.

A range of plant growth regulators were trialled on four seed-raised bedding plant species (*Dianthus* 'Festival' violet; Geranium 'Horizon' red; Pansy 'Matrix' red blotch and *Osteospermum* 'Akila' purple). Plug plants were treated with PGRs whilst in the plug trays in week 22 (29 May 2018), at a rate of 10% of the tray volume, using the products at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. Plugs were then transplanted two days later (31 May 2018, week 22), at Baginton Nurseries, using standard six-packs for the *Dianthus*, Geranium and Pansy, and jumbo six-packs for the *Osteospermum*.

Products tested are listed in **Table 1**. Due to the relatively small plug cell size, and the number of plugs per treatment (36), plug plants were grouped into treatments within the plug tray and each PGR drench treatment was applied with a syringe over the plants, to ensure the correct amount of active ingredient was applied to each plug plant. *Dianthus* and Geranium were sown into a 288-cell tray, the volume of the 36 cells to be treated was 441 cm<sup>3</sup>, meaning a 10% drench would be 44.1 ml per treatment. This equated to 14.7 ml per row of 12 plants. *Osteospermum* and Pansy were sown into 240-cell trays, the volume of the 36 cells to be treated was 544 cm<sup>3</sup>, meaning a 10% drench would be 54.4 ml per treatment. This equated to 18 ml per row of 12 plants. Treatment solutions were made up in plastic containers, one for each treatment, which was enough for all species requiring that treatment. Treatments were applied to plants using a syringe, one for each treatment, treating one row at a time.

Plants were then transplanted into packs two days later, and no further PGR treatments were applied.

**Table 1.** Approval status of PGR products tested in 2018

Product	Active ingredient	Approval status
Dazide Enhance	Daminozide	On-label approval for spray application
HDC P005	-	Not approved on protected ornamentals in the UK
Moddus (MAPP 15151)	Trinexapac-ethyl	EAMU 3062/10 for spray application. One application only permitted per crop
Pirouette (MAPP 17203)	Paclobutrazol	On-label approval for spray application. EAMU 1269/17 for drench application
Primo Maxx II (MAPP 17509)	Trinexapac-ethyl	EAMU 0621/18 for spray application issued 22.03.18
Regalis Plus (MAPP 16485)	Prohexadione	EAMU 0181/15 for spray application. Three weeks must be allowed between applications
Terpal (MAPP 16436)	Ethephon + mepiquat chloride	EAMU 0151/18 for foliar drench application issued 30.01.18

Unauthorised or off-label treatments applied under experimental permit.

Treatments applied in this trial were developed using the 2017 trial results as a guide, therefore the treatment list for each species was different (**Table 2 - Table 5**). For *Osteospermum*, where there were no trials in 2017, products were applied at full label rate.

**Table 2.** PGR product and treatment list 2018 – *Dianthus*

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
3	HDC P005	-	Drench***	0.505 L/ha	1.68 ml/L (3/4 rate)
4	Primo Maxx II	Trinexapac-ethyl	Drench***	1.0 L/ha	3.33 ml/L (1/2 rate)
5	Primo Maxx II	Trinexapac-ethyl	Drench***	1.5 L/ha	5.0 ml/L (3/4 rate)
6	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\*Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 3.** PGR product and treatment list 2018 – Geranium

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.169 L/ha	0.56 ml/L (1/4 rate)
3	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
4	Terpal	Ethephon + mepiquat chloride	Drench	0.5 L/ha	1.67 ml/L (1/4 rate)
5	Terpal	Ethephon + mepiquat chloride	Drench	1.0 L/ha	3.33 ml/L (1/2 rate)
6	Regalis Plus	Prohexadione	Drench***	0.31 L/ha	1.03 g/L (1/4 rate)
7	Regalis Plus	Prohexadione	Drench***	0.62 L/ha	2.08 g/L (1/2 rate)
8	Dazide Enhance	Daminozide	Drench***	0.45 L/ha	1.5 g/L (1/4 rate)
9	Dazide Enhance	Daminozide	Drench***	0.9 L/ha	3.0 g/L (1/2 rate))
10	Primo Maxx II	Trinexapac-ethyl	Drench***	0.5 L/ha	1.67 ml/L (1/4 rate)
11	Primo Maxx II	Trinexapac-ethyl	Drench***	1.0 L/ha	3.33 ml/L (1/2 rate)
12	Moddus	Trinexapac-ethyl	Drench***	0.15 L/ha	0.5 ml/L (1/4 rate)
13	Moddus	Trinexapac-ethyl	Drench***	0.3 L/ha	1.0 ml/L (1/2 rate)
14	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 4.** PGR product and treatment list 2018 – Pansy

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
3	HDC P005	-	Drench***	0.505 L/ha	1.68 ml/L (3/4 rate)
4	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 5.** PGR product and treatment list 2018 – *Osteospermum*

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.675 L/ha	2.25 ml/L (full rate)
3	Terpal	Ethephon + mepiquat chloride	Drench	2.0 L/ha	6.67 ml/L (full rate)
4	Regalis Plus	Prohexadione	Drench***	1.25 L/ha	4.17 ml/L (full rate)
5	Dazide Enhance	Daminozide	Drench***	1.8 L/ha	6.0 g/L (full rate)
6	Primo Maxx II	Trinexapac-ethyl	Drench***	2.0 L/ha	6.67 ml/L (full rate)
7	Moddus	Trinexapac-ethyl	Drench***	0.6 L/ha	2.0 ml/ L (full rate)
8	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

Of the products included in this trial, those containing chlormequat or mepiquat chloride (Terpal) were expected to have a similar effect on plant growth as Stablan 750; those containing prohexadione calcium (Regalis Plus) or trinexapac-ethyl (Primo Maxx II and Moddus) were expected to have a similar effect to the more familiar daminozide products (e.g. B-nine, Dazide Enhance).

### ***Summary of results by plant species***

#### ***Dianthus 'Festival' violet***

- HDC P005 (0.337 L/ha) did not provide effective growth control, and caused slight petal bleach. Growth was controlled at higher rate (0.505 L/ha), but with more severe petal bleach.
- Primo Maxx II (1.0 L/ha and 1.5 L/ha) did control growth but caused phytotoxicity.
- Pirouette did not cause phytotoxicity but the plants were too compact, and flowers were not sufficiently high above the pack as the dose rate / or volume applied was too high.
- None of the treatments were particularly suitable as drenches prior to transplant. Other than Pirouette, those that did provide growth control also caused phytotoxicity (foliar and petal bleach).

#### ***Geranium 'Horizon' red***

- Although HDC P005 and Regalis Plus did not cause phytotoxicity at the rates tested, they did not provide adequate growth control.
- Primo Maxx caused phytotoxicity including petal bleach.

- Terpal gave good growth control with no phytotoxicity, although flowering was delayed.
- Dazide Enhance (0.45 L/ha) showed potential, with good growth control and no phytotoxicity.
- Moddus at 0.15 L/ha has potential; the higher rate (0.3 L/ha) caused phytotoxicity.
- Pirouette 0.3 L/ha has potential, producing compact plants with a good flower colour.

#### Pansy 'Matrix' red blotch

- HDC P005 did not cause phytotoxicity at the rates tested, but neither did it provide adequate growth control.
- Pirouette did not cause any phytotoxicity, and has potential as a treatment on Pansy.

#### Osteospermum 'Akila' purple

- HDC P005 and Regalis Plus showed promise, with good growth control, and no phytotoxicity.
- Primo Maxx II and Moddus did not show signs of phytotoxicity by week 30, but plants were perhaps too compact.
- Pirouette did not show signs of phytotoxicity, but did not control growth adequately.
- Dazide Enhance did not provide growth control, the plants were taller than the water only control.
- Terpal caused distortion to the foliage early on, which the plants did not grow away from, and flowering was also delayed.

### **Financial benefits**

The evaluation of plant growth regulators (PGRs) either approved in the UK or in other European Countries for use on bedding plants (spray and drench application), followed by appropriate AHDB EAMU applications will expand the range of active ingredients available to growers for controlling plant growth. Whilst growers do use cultural methods (e.g. temperature, diff/drop, controlling irrigation and nutrient supply) to control plant growth where possible, species specific responses and a lack of cost effective PGRs approved for use on protected ornamentals would reduce the range of plants that can be produced profitably within client specifications. PGRs are particularly important when used to hold mature crops at specified height during periods of low demand where other methods would lead to unacceptable effects e.g. leaf yellowing. The cost per litre of spray solution applied in this trial at the specified rates ranged from 88.2p to 0.09p (**Table 6**) and provides greater opportunity to increase profit through reduced input cost. The ability to apply PGRs to plants in the plug tray prior to transplant would not only reduce costs by reducing the amount of product needed, but would also save on labour in terms of application time per plant.

**Table 6.** PGR costs (non-discounted, excluding VAT and labour costs for application)

Product and rate	Cost of active (p)	Cost / L of spray (p)
Bonzi	9.5 / ml	11.9
Dazide Enhance (1.5; 3.0; 6.0 g/L)	14.7 / g	22.1; 44.1; 88.2
HDC P005 (0.56; 1.12; 1.68; 2.25 g/L)	2.2 /g	1.2; 2.5; 3.7; 5.0
Moddus (0.5; 1.0; 2.0 ml/L)	3.9 / ml	2.0; 3.9; 7.8
Pirouette (1.0 ml/L)	0.09 / ml	0.09
Primo Maxx II (1.67; 3.33; 5.0; 6.67 ml/L)	5.0 / ml	8.4; 16.7; 25; 33.4
Regalis Plus (1.03; 2.08; 4.17 g/L)	12.3 / g	12.7; 25.6; 51.3
Terpal (1.67; 3.33; 6.67 ml/L)	1.7 / ml	2.8; 5.7; 11.3

### Action points

- Useful growth regulator effects were achieved with treatments of Pirouette 0.3 L/ha and Terpal 0.5 L/ha and may be worth further evaluation on a range of other crops on nurseries.
- Growers should test new or unfamiliar products on a small number of plants before large scale use.
- Growers should familiarise themselves with and adhere to product labels, approvals and Extensions of Approval for Minor Use (EAMUs) prior to use. Note that a number of the treatments included in this trial have been carried out under experimental permit and are not currently authorised for nursery use in the UK.

## Science Section

### Introduction

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries. Knowledge transfer events including trial open days and study tours were also included in the programme.

The work programme is guided by a grower-led Management Group that includes members of the BPOA Technical Committee and representatives from Baginton Nurseries, Coventry the central host nursery for the BPPC. The agreed objectives for the Bedding and Pot Plant Centre, 2018-19 were:

**Objective 1:** To extend the range of plants in flower available to growers for early spring marketing to include herbaceous perennials using minimal energy input.

**Objective 2:** To evaluate the efficacy and phytotoxicity of a range of plant growth regulators (PGRs) either approved in the UK or in other European Countries on bedding and pot plants (spray and drench application).

**Objective 3:** To evaluate the efficacy and phytotoxicity of a range of plant growth regulators (PGRs) either approved in the UK or in other European Countries on bedding plant plugs (drench application) prior to transplant.

**Objective 4:** To evaluate the efficacy and phytotoxicity of a range of plant growth regulators (PGRs) (either approved in the UK or in other European Countries) and HDC P006 (adjuvant) on Poinsettia, and their effect on marketability.

*This is the Bedding and Pot Plant Centre report for Objective 3.*

### Background

The evaluation of new plant growth regulators (PGRs) for use on bedding and pot plants was prompted by label changes to the plant growth regulator Bonzi (paclobutrazol), including removal of the option for drench application, and the potential loss of approval for the use of chlormequat in protected ornamental plant production. Growers sometimes apply PGRs as drenches and have developed application rates specific to the crops grown under nursery specific growing conditions. New PGRs have either been trialled in Denmark with promising results on bedding and pot plants, are new to the market or have recently received CRD approval for use on related crops in the UK; any phytotoxic effects and efficacy of these chemicals under UK conditions are unknown. A number of PGRs were considered for inclusion in this trial.



**HDC P005** (-) was developed for use on cereals and grass seed. It was found to be less effective at controlling the growth of *Pelargonium* 'Dronning Ingrid' than Caryx (210 g/L mepiquat (as chloride) and 30 g/L metconazole), both of which have been trialled in Denmark, however, it did reduce growth of *Bacopa* 'Carolyn' when applied at a dose rate of 0.375%. HDC P005 did not reduce the number of *Bacopa* flowers produced although they were slightly smaller (Paaske, 2015). AHDB has confirmed that an EAMU application will be progressed for HDC P005 for use on protected ornamentals.

**Terpal** (155 g/L ethephon + 305 g/L mepiquat chloride, BASF) is a new product which was originally approved for use on protected ornamentals in Denmark, where results were promising on *Osteospermum* 'Naomi' (Paaske, 2013). In the UK EAMU 0151/18 was issued on 30 January 2018, giving authorisation for use in ornamental plant production on container grown plants.

**Cutaway** (121 g/L trinexapac-ethyl, Syngenta Crop Protection UK Ltd) is approved for spray application in ornamental plant production (EAMU 2140/16) in the UK. This EAMU was sought following promising results under AHDB project HNS 187 and HNS 187a on tree species using Cutaway, which reported leaf yellowing on *Populus* and to a lesser extent *Alnus*; slight narrowing of the leaves occurred on *Sorbus*; other species were not affected. However, Cutaway's authorisation for use is likely to be lost in the near future as some of its co-formulants are likely to be revoked. This product has now been replaced in the trial with **Primo Maxx II** (116.4 g/L trinexapac-ethyl), as this is the most similar formulation.

**Moddus** (250 g/L trinexapac-ethyl, Syngenta Crop Protection UK Ltd) is approved for use on cereals in the UK and has approval (EAMU 3062/10) for use on ornamentals. However, the formulation and application rates differ from the EAMU for Cutaway. Danish work has indicated that Moddus was too strong for *Osteospermum* 'Naomi', with dose rates of 0.5% to 1.0%, causing plant death (Paaske, 2013). However, it was not effective on Marguerites at the rates tested (Paaske, 2010).

**Regalis Plus** (100 g/kg prohexadione, BASF) is approved for use on protected ornamentals in the UK (EAMU 0181/15). It is in the same chemical group as daminozide, although with greater activity. Previous trials have indicated that Regalis, applied either as a drench or spray, is effective in controlling plant growth within some bedding plant species. However, its use can also result in flower petal bleaching in some plant species (Brough, 2011). Regalis Plus is the new formulation which includes a built-in water conditioner which will reduce the time required for rain fastness from six hrs to two hrs. The new formulation will supersede Regalis once existing stocks have been moved through the supply chain. In the Danish work, Regalis produced compact Marguerites (*Argyranthemum frutescens* 'Dana') at 0.1% (Paaske, 2010).

The active ingredients of the products included in this trial were predominately anti-gibberellins, which prevent production of gibberellin at various points in its biosynthesis. The three PGR groupings are: 1) Quaternary Ammonium Compounds (QAC) e.g. chlormequat chloride (Stabilan 750) and mepiquat chloride (a component of Terpal) which prevent gibberellin production early in its biosynthesis; 2) triazoles e.g. paclobutrazol (Bonzi, Pirouette); and 3) a group which prevents gibberellin production late in its biosynthesis: prohexadione calcium (Regalis Plus), trinexapac-ethyl (Primo Maxx II, Moddus and Cutaway) and daminozide (B-Nine). The exception is ethephon (a component of Terpal) which breaks down within the plant to produce the plant hormone, ethylene. Of the three groups the triazoles are the most active, although levels of activity varies within this group.

This particular piece of work was prompted by trials work carried out in 2017, where sprays and drenches of the PGRs used were applied to a range of species post transplanting into packs, and post potting / transplanting into pots. Many of the drench applications produced too strong an effect, drench applications to transplanted crops are also labour intensive and thus expensive to apply; this combined with the fact that many of the plant growth regulators in this trial are not currently authorised for use in ornamentals with potential restrictions on the amount of active ingredient that can be applied per hectare, prompted interest in drenching plugs with small amounts of active ingredient prior to transplanting. There is also the potential to explore drenching plugs in a closed, tray based system to minimise any potential environmental effects.

DIY stores and multiple retailers generally specify plant height in the region of 40 – 80 mm for the majority of the species included in this trial; up to 100 mm for taller varieties such as *Dianthus* (excluding 'flower stems') and 100% pack cover for pack bedding. Garden centres can have a less rigid approach and accept product with less pack cover, while reject primarily 'stretched' or 'floppy' plants. The distance between Danish trolley shelves (typically 8 shelves plus base) presents a practical limitation on plant height of around 160 mm.

A range of PGRs (**Table 7**) were tested on pot and bedding plant subjects prior to transplant under UK conditions. Treatment rates were based on the 2017 Bedding and Pot Plant Centre PGR trial results, and therefore the treatment list for each plant species was different. As there had been no work on *Osteospermum* in 2017, each product was tested at the full rate only. In 2017, treatments were applied as sprays and drenches to a range of species post transplanting into packs, and pots / jumbo packs. Terpal + Activator 90 (2.0 L/ha + 40 ml/100 L spray solution) was perhaps the most promising product tested, controlling the growth of all subjects (compared to the water only control) when applied as both a spray and drench. However, spray applications at the rate used did result in some delayed flowering in both

Pansy and *New Guinea Impatiens*, and drench applications at this rate had too strong an effect.

Spray applications of HDC P005 showed promise controlling growth in *Dianthus*, Pansy, *New Guinea Impatiens* and *Zantedeschia*, while Primo Maxx II controlled the growth of *Pelargonium* and *New Guinea Impatiens*. Drench applications all had a strong effect controlling height to varying degrees, for some species the effect was too strong resulting in excessive plant growth regulation and associated phytotoxicity. Treatments were therefore refined for the 2018 trial.

**Table 7.** PGR products tested in the 2018 trials

Product	Active ingredient	Approval status
Dazide Enhance	Daminozide	On-label approval for spray application
HDC P005	-	Not approved on protected ornamentals in the UK
Moddus (MAPP 15151)	Trinexapac-ethyl	EAMU 3062/10 for spray application. One application only permitted per crop
Pirouette (MAPP 17203)	Paclobutrazol	On-label approval for spray application. EAMU 1269/17 for drench application
Primo Maxx II (MAPP 17509)	Trinexapac-ethyl	EAMU 0621/18 for spray application issued 22.03.18
Regalis Plus (MAPP 16485)	Prohexadione	EAMU 0181/15 for spray application. Three weeks must be allowed between applications
Terpal (MAPP 16436)	Ethephon + mepiquat chloride	EAMU 0151/18 for foliar drench application issued 30.01.18

Unauthorised or off-label treatments applied under experimental permit.

## Project objectives

**Objective 3.** To evaluate a range of plant growth regulators (PGRs) either approved in the UK or in other European Countries for use on bedding plant plugs (drench application) prior to transplant.

**Specific objective 1:** To evaluate efficacy of up to seven PGRs for drench application over seed raised bedding and pot plants plugs.

**Specific objective 2:** To evaluate any phytotoxic effects of up to seven PGRs due to drench application over seed raised bedding and pot plants.

**Specific objective 3:** To carry out a financial assessment for the most promising treatments.

## Methods and materials

### *Site and crop production details*

Four seed-raised bedding plant species (*Dianthus* 'Festival' violet; Geranium 'Horizon' red; Pansy 'Matrix' red blotch; and *Osteospermum* 'Akila' purple) were used for this trial. Plug plants were treated with PGRs (**Table 8 - Table 11**) whilst in the plug trays in week 22 (29 May 2018), at a drench volume of 10% of the tray volume, and were then transplanted two days later (31 May 2018, week 22) into standard six-packs for the *Dianthus*, Geranium and Pansy, and jumbo six-packs for the *Osteospermum*. The trial was based at Baginton Nurseries, Coventry.

Due to the relatively small plug cell size, and the number of plugs per treatment (36), plug plants were grouped into treatments within the plug tray (**Figure 1**) and each PGR treatment was applied with a syringe, to ensure the correct amount of active ingredient was applied to each plug plant. A different syringe was used for each treatment, treating one row at a time. *Dianthus* and Geranium had been sown into a 288-cell tray, the volume of the 36 cells to be treated was 441 cm<sup>3</sup>, meaning a 10% drench would be 44.1 ml per treatment. This equated to 14 ml per row of 12 plants. *Osteospermum* and Pansy were sown into 240-cell trays, the volume of the 36 cells to be treated was 544 cm<sup>3</sup>, meaning a 10% drench would be 54.4 ml per treatment. This equated to 18 ml per row of 12 plants. Treatment solutions were made up in plastic containers, one for each treatment, sufficient for all species requiring that treatment, using the products at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. Growing media was moist when treatments were applied, and plants were not watered for 24 hours after treatment. Treatments were applied during the afternoon with shade screens across. No further PGR treatments were applied.

Plants were transplanted two days post-treatment into Everris growing media (60% peat, 40% woodfibre, plus Osmocote Protect 5 to 6 months 14-8-11+2MgO+TE). No liquid feeding was required for any of the varieties.

Products not currently authorised for use on protected ornamentals or for drench application were applied under an experimental permit (2017/01098 and 2017/02964).

**Table 8.** PGR product and treatment list 2018 – *Dianthus*

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
3	HDC P005	-	Drench***	0.505 L/ha	1.68 ml/L (3/4 rate)

4	Primo Maxx II	Trinexapac-ethyl	Drench***	1.0 L/ha	3.33 ml/L (1/2 rate)
5	Primo Maxx II	Trinexapac-ethyl	Drench***	1.5 L/ha	5.0 ml/L (3/4 rate)
6	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 9.** PGR product and treatment list 2018 – Geranium

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.169 L/ha	0.56 ml/L (1/4 rate)
3	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
4	Terpal	Ethephon + mepiquat chloride	Drench	0.5 L/ha	1.67 ml/L (1/4 rate)
5	Terpal	Ethephon + mepiquat chloride	Drench	1.0 L/ha	3.33 ml/L (1/2 rate)
6	Regalis Plus	Prohexadione	Drench***	0.31 L/ha	1.03 g/L (1/4 rate)
7	Regalis Plus	Prohexadione	Drench***	0.62 L/ha	2.08 g/L (1/2 rate)
8	Dazide Enhance	Daminozide	Drench***	0.45 L/ha	1.5 g/L (1/4 rate)
9	Dazide Enhance	Daminozide	Drench***	0.9 L/ha	3.0 g/L (1/2 rate))
10	Primo Maxx II	Trinexapac-ethyl	Drench***	0.5 L/ha	1.67 ml/L (1/4 rate)
11	Primo Maxx II	Trinexapac-ethyl	Drench***	1.0 L/ha	3.33 ml/L (1/2 rate)
12	Moddus	Trinexapac-ethyl	Drench***	0.15 L/ha	0.5 ml/L (1/4 rate)
13	Moddus	Trinexapac-ethyl	Drench***	0.3 L/ha	1.0 ml/L (1/2 rate)
14	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 10.** PGR product and treatment list 2018 – Pansy

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.337 L/ha	1.12 ml/L (1/2 rate)
3	HDC P005	-	Drench***	0.505 L/ha	1.68 ml/L (3/4 rate)
4	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.

**Table 11.** PGR product and treatment list 2018 – *Osteospermum*

Trt No.	Product	Active ingredient	Application method*	Dose rate (L/ha)**	Dose rate (ml/L)
1	Water control	N/A	Drench	N/A	N/A
2	HDC P005	-	Drench***	0.675 L/ha	2.25 ml/L (full rate)
3	Terpal	Ethephon + mepiquat chloride	Drench	2.0 L/ha	6.67 ml/L (full rate)
4	Regalis Plus	Prohexadione	Drench***	1.25 L/ha	4.17 ml/L (full rate)
5	Dazide Enhance	Daminozide	Drench***	1.8 L/ha	6.0 g/L (full rate)
6	Primo Maxx II	Trinexapac-ethyl	Drench***	2.0 L/ha	6.67 ml/L (full rate)
7	Moddus	Trinexapac-ethyl	Drench***	0.6 L/ha	2.0 ml/ L (full rate)
8	Pirouette	Paclobutrazol	Drench	0.3 L/ha	1.0 ml/L

\* Drenches were applied by hand with a syringe, at 10% of the tray volume. \*\*Products used at a concentration calculated to provide the same quantity of product as if treatments had been applied as a spray at 300 L/ hectare. \*\*\*Treatments applied under experimental permit.



**Figure 1.** Plug set-up for PGR treatment within the tray, Pansy 'Matrix' red blotch (left) and *Osteospermum* 'Akila' purple (right), week 22 2018.

Prior to plug dispatch and use in the trial, one PGR treatment was applied to the Geranium 'Horizon' red only, by the propagator (daminozide + chlormequat, rate confidential). Plants were monitored for pests and diseases throughout the trial. No insecticides or fungicides were applied.

### *Trial design and statistical analysis*

Each plant species was set-out separately, and treatments were arranged in a randomised block design with either six treatments (*Dianthus*), 14 treatments (Geranium), four treatments (Pansy) or eight treatments (*Osteospermum*). Within each trial there were three replicate blocks, with an overall total of 1152 plants (36 per variety, per treatment). Plots consisted of two 6-packs (12 plants).

Results were examined by ANOVA with use of Duncan's multiple range test to separate treatments.

### *Assessments*

Prior to treatment, plug root development (**Table 12**), plant quality (**Table 13**), and height were assessed. Plant height and phytotoxicity were assessed at 14 days after treatment (DAT), 20 DAT and 37 DAT (**Table 14**). Final observations on phytotoxicity were made in week 30, 56 DAT.

Inspections and assessments are summarised in **Table 15** and below.

**Table 12.** Root development scores

Score	Definition
0	No root development
1	Rooting in up to 25% of plug
2	Rooting in 26-50% of plug
3	Rooting in 51–75% of plug
4	Rooting in 100% of plug

**Table 13.** Plant quality scores

Score	Definition
0	Dead
1	Very poor quality
2	Poor quality
3	Good quality, some damage visible
4	Good quality, very little damage
5	Excellent quality, no damage visible

**Table 14.** Phytotoxicity scores

Score	Definition
0	Dead
1	Nearly dead
2	Severely damaged / reduced growth / lots of discolouration
3	Damaged / reduced growth / some discolouration
4	Damaged / reduced growth
5	Slightly damaged / stunting
6	Very slightly damaged / slight yellowing
7	Very slightly damaged but still commercially acceptable
8	Commercially acceptable - barely affected
9	Comparable with control

**Table 15.** Summary of bedding and pot plant trial inspections and assessments, 2018

Date	Week no.	Action	Assessment
29 May	22	Treatments applied to plants in plug tray	Root development score, plant quality score, plant height (mm)
31 May	22	Transplant into packs, set down in glasshouse	Plants checked for signs of damage
12 June	24	Post treatment assessment 1	Plant quality score, phytotoxicity score, plant height (mm)
18 June	25	Post treatment assessment 2	Plant quality score, phytotoxicity score, plant height (mm)
05 July	27	Final assessment	Plant quality score, phytotoxicity score, plant height (mm), no. of plants in flower
24 July	30	Final observations	Phytotoxicity score

## Results

The effect of each PGR treatment on the height, growth, quality and flowering of the four plant species included in the trial is compared with that of the water only (water) control. The effect of the different treatments is presented below including a summary list by plant species. Temperature and humidity was monitored throughout the trial (**Appendix 1**).



All plants obtained for the trial were of good quality prior to treatment and transplant.

## Plant height and growth

Plant height graphs are presented in **Appendix 2**, with photographs of treatment effects on all species presented in **Appendix 3**. Plant growth between transplant and the final assessment, with a calculation of the percentage growth difference compared with the water only control are presented in **Table 16 - Table 19**. It should be noted that for growers the focus is on products that will control plants sufficiently to keep them within the required height specification. The treatment effects on plant height and growth varied between plant species.

### *Dianthus*

Plant height was significantly reduced by Pirouette (0.3 L/ha), Primo Maxx II at both rates tested, and HDC P005 at the higher rate (0.505 L/ha), compared to the water only control (**Table 16**,  $p=0.014$ , **Appendix 2A**). All of these treatments produced plants which were within the maximum height specification of 100 mm. HDC P005 at the lower rate of 0.337 L/ha did not control height sufficiently, producing plants with an average height of 119 mm.

**Table 16.** *Dianthus*: average plant height, growth (height increase from day of treatment) and average height reduction relative to the water only control

	Treatment	Application method	Ave. height (mm)	Ave. growth (mm)	Height change (%)
1	Water control	Drench	137.8	46.0	-
2	HDC P005 0.337 L/ha	Drench	119.2	27.4	-41%
3	HDC P005 0.505 L/ha	Drench	94.0	2.2	-95%
4	Primo Maxx II 1.0 L/ha	Drench	90.5	-1.3	-103%
5	Primo Maxx II 1.5 L/ha	Drench	76.8	-15.0	-133%
6	Pirouette 0.3 L/ha	Drench	96.5	4.7	-90%
	s.e.d.		13.82		
	l.s.d.		30.79	n/a	n/a
	F pr		0.014		
Values highlighted red are significantly different to the water only control.					

Final assessment date was 05 July 2018, week 27, 37 DAT (days after first treatment). Height specification for pack bedding is 40 mm – 100 mm.

### *Geranium*

By week 27, there were significant differences between treatments for Geranium plant height (**Table 17**,  $p < 0.001$ , **Appendix 2B**). Plants were significantly shorter than the water control when treated with Terpal (1.0 L/ha), Dazide Enhance (0.45 L/ha), Primo Maxx II (1.0 L/ha), and Moddus at (0.15 and 0.3 L/ha). These treatments all produced plants which were within the specification of 40 – 80 mm. HDC P005 (both rates) and Regalis Plus (both rates) did not

effectively control plant height. Pirouette at 0.3 L/ha was borderline, with an average plant height of 80.2 mm.

**Table 17.** Geranium: average plant height, growth (height increase from day of treatment) and average height reduction relative to the water only control

	Treatment	Application method	Ave. height (mm)	Ave. growth (mm)	Height change (%)
1	Water control	Drench	96.2	18.4	-
2	HDC P005 0.169 L/ha	Drench	91.0	13.2	-28%
3	HDC P005 0.337 L/ha	Drench	94.2	16.4	-11%
4	Terpal 0.5 L/ha	Drench	79.3	1.5	-92%
5	Terpal 1.0 L/ha	Drench	73.5	-4.3	-123%
6	Regalis Plus 0.31 L/ha	Drench	84.7	6.9	-63%
7	Regalis Plus 0.62 L/ha	Drench	89.0	11.2	-39%
8	Dazide Enhance 0.45 L/ha	Drench	77.7	-0.1	-101%
9	Dazide Enhance 0.9 L/ha	Drench	90.2	12.4	-33%
10	Primo Maxx II 0.5 L/ha	Drench	79.3	1.5	-92%
11	Primo Maxx II 1.0 L/ha	Drench	62.5	-15.3	-183%
12	Moddus 0.15 L/ha	Drench	69.5	-8.3	-145%
13	Moddus 0.3 L/ha	Drench	65.2	-12.6	-169%
14	Pirouette 0.3 L/ha	Drench	80.2	2.4	-87%
	s.e.d.		7.18		
	l.s.d.		14.76	n/a	n/a
	F pr		<0.001		
Values highlighted red are significantly different to the water only control.					

Final assessment date was 05 July 2018, week 27, 37 DAT (days after first treatment). Height specification for pack bedding is 40 mm – 80 mm.

### Pansy

In the pansy trial, only Pirouette 0.3 L/ha produced plants which were significantly shorter than the water only control (**Table 18**,  $p = 0.028$ , **Appendix 2C**), with an average height of 53.7 mm, within general plant height specifications. Plants treated with HDC P005 (0.337 and 0.505 L/ha) were taller than the height specification of 40 – 80 mm.

**Table 18.** Pansy: average plant height, growth (height increase from day of treatment) and average height reduction relative to the water only control

	Treatment	Application method	Ave. height (mm)	Ave. growth (mm)	Height change (%)
1	Water control	Drench	102.7	51.7	-
2	HDC P005 0.337 L/ha	Drench	104.0	53.0	3%
3	HDC P005 0.505 L/ha	Drench	88.5	37.5	-27%
4	Pirouette 0.3 L/ha	Drench	53.7	2.7	-95%
	s.e.d.		13.20		
	l.s.d.		32.29	n/a	n/a

	F pr		0.028		
	Values highlighted red are significantly different to the water only control.				

Final assessment date was 05 July 2018, week 27, 37 DAT (days after first treatment). Height specification for pack bedding is 40 mm – 80 mm.

### *Osteospermum*

There were significant differences in the *Osteospermum* (Table 19,  $p < 0.001$ , Appendix 2D), with four of the PGR treatments producing plants which were significantly shorter than the water only control; Terpal (2.0 L/ha), Regalis Plus (1.25 L/ha), Primo Maxx II (2.0 L/ha) and Moddus (0.6 L/ha). Dazide Enhance (1.8 L/ha) and Pirouette (0.3 L/ha) appeared to promote growth.

**Table 19.** *Osteospermum*: average plant height, growth (height increase from day of treatment) and average height reduction relative to the water only control

	Treatment	Application method	Ave. height (mm)	Ave. growth (mm)	Height change (%)
1	Water control	Drench	61.0	11.5	
2	HDC P005 0.675 L/ha	Drench	59.0	9.5	-17%
3	Terpal 2.0 L/ha	Drench	54.5	5.0	-57%
4	Regalis Plus 1.25 L/ha	Drench	53.5	4.0	-65%
5	Dazide Enhance 1.8 L/ha	Drench	69.3	19.8	72%
6	Primo Maxx II 2.0 L/ha	Drench	43.2	-6.3	-155%
7	Moddus 0.6 L/ha	Drench	42.0	-7.5	-165%
8	Pirouette 0.3 L/ha	Drench	72.5	23.0	100%
	s.e.d.		4.67		
	l.s.d.		10.01	n/a	n/a
	F pr		<0.001		
	Values highlighted red are significantly different to the water only control.				

Final assessment date was 05 July 2018, week 27, 37 DAT (days after first treatment). Height specification for pack bedding is 40 mm – 80 mm.

### Phytotoxicity

#### *Dianthus*

At the first assessment (14 DAT), plants treated with both treatments of Primo Maxx II were showing signs of phytotoxicity, with paler leaves compared to the water only control. None of the other treatments were showing symptoms. By the time of the second assessment (20 DAT), the Primo Maxx II plants appeared to have grown away from the phytotoxicity, and all treatments were comparable to the control (there were no flowers present at this stage). At the 3<sup>rd</sup> assessment (37 DAT), flowers were open in all treatments, and phytotoxicity was evident as petal bleach in both Primo Maxx II treatments, and was more severe at the higher rate (1.5 L/ha). By the end of the trial, none of the plants treated with Primo Maxx II at either rate were marketable due to petal bleach (Table 20). Petal bleach was also evident in plants

treated with HDC P005 (0.505 L/ha), rendering them unmarketable; plants treated with the lower rate of HDC P005 (0.337 L/ha) showed very slight petal bleach. Pirouette 0.3 L/ha did not cause phytotoxicity (**Figure 2**).

**Table 20.** *Dianthus* – average phytotoxicity scores

	Treatment	Application method	Phyto 12.06.18 14 DAT	Phyto 18.06.18 20 DAT	Phyto 05.07.18 37 DAT	Phyto 24.07.18 56 DAT*
1	Water control	Drench	9.0	9.0	9.0	9.0
2	HDC P005 0.337 L/ha	Drench	9.0	9.0	9.0	7.0
3	HDC P005 0.505 L/ha	Drench	9.0	9.0	9.0	6.0
4	Primo Maxx II 1.0 L/ha	Drench	6.7	9.0	7.0	5.0
5	Primo Maxx II 1.5 L/ha	Drench	6.7	9.0	3.0	5.0
6	Pirouette 0.3 L/ha	Drench	8.3	9.0	9.0	7.0
	s.e.d.		0.463	n/a	1.155	n/a
	l.s.d.		1.033	n/a	2.573	n/a
	F pr		<0.001	n/a	0.002	n/a
Values highlighted red are significantly different to the water only control. Values highlighted blue were unmarketable in week 30.						

\*Assessment was observational only, statistics are not available.

Assessment dates were: 14 DAT (12 June 2018, week 24), 20 DAT (18 June 2018, week 25), 37 DAT (05 July 2018, week 27) and 56 DAT (24 July, week 30). Phytotoxicity score: scale of 0-9, where 0 = dead; 5 = slight damage, slight yellowing; 9 = comparable with water only control. DAT = days after first treatment.



**Figure 2.** *Dianthus* 'Festival' violet treated with HDC P005 (left), Primo Maxx II (centre) and Pirouette (right), in week 30, 24 July 2018

## Geranium

At the first assessment 14 DAT, significant phytotoxicity was evident (**Table 21**,  $p=0.002$ ) on plants treated with Terpal (0.5 L/ha and 1.0 L/ha), foliage was paler than the water control and the lower leaves were yellowing. The high rate Dazide Enhance (0.9 L/ha) and high rate Moddus (0.3 L/ha) also had slight yellowing effects on the foliage. However, plants quickly grew away from this early phytotoxicity (Dazide Enhance and Moddus treatments), and by 56 DAT (Terpal treatments). At the final assessment, only plants treated with Primo Maxx II (0.5 L/ha and 1.0 L/ha) and Moddus (0.3 L/ha) were unmarketable due to phytotoxicity (**Figure 3**). This was evident as foliar and petal bleach in both treatments. There did appear to be some slight phytotoxicity in the Pirouette treatment 37 DAT, with yellowing on the older leaves, but this was not evident at the final assessment.

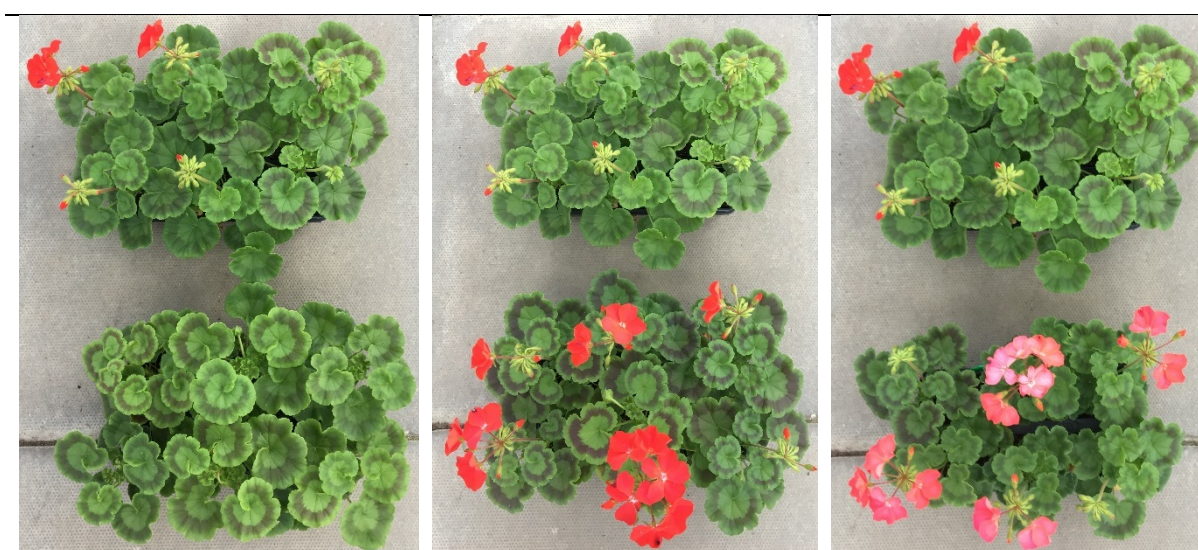
**Table 21.** Geranium – average phytotoxicity scores

	Treatment	Application method	Phyto 12.06.18 14 DAT	Phyto 18.06.18 20 DAT	Phyto 05.07.18 37 DAT	Phyto 24.07.18 56 DAT*
1	Water control	Drench	9.0	9.0	9.0	9.0
2	HDC P005 0.169 L/ha	Drench	9.0	9.0	8.0	8.0
3	HDC P005 0.337 L/ha	Drench	9.0	8.7	9.0	8.0
4	Terpal 0.5 L/ha	Drench	6.0	7.3	8.3	8.0
5	Terpal 1.0 L/ha	Drench	5.7	6.7	6.3	8.0
6	Regalis Plus 0.31 L/ha	Drench	7.7	9.0	7.0	8.0
7	Regalis Plus 0.62 L/ha	Drench	8.3	9.0	7.7	7.0
8	Dazide Enhance 0.45 L/ha	Drench	8.3	9.0	6.7	8.0
9	Dazide Enhance 0.9 L/ha	Drench	7.0	9.0	9.0	8.0
10	Primo Maxx II 0.5 L/ha	Drench	8.3	8.0	8.3	6.0
11	Primo Maxx II 1.0 L/ha	Drench	8.3	8.0	6.0	6.0
12	Moddus 0.15 L/ha	Drench	7.7	8.7	7.3	7.0
13	Moddus 0.3 L/ha	Drench	7.0	8.3	7.0	6.0
14	Pirouette 0.3 L/ha	Drench	9.0	9.0	5.0	8.0
	s.e.d.		0.762	0.5027	0.857	n/a
	l.s.d.		1.565	1.0334	1.762	n/a
	F pr		0.002	<0.001	0.001	n/a
Values highlighted red are significantly different to the water only control. Values highlighted blue were unmarketable in week 30.						

\*Assessment was observational only, statistics are not available.

Assessment dates were: 14 DAT (12 June 2018, week 24), 20 DAT (18 June 2018, week 25), 37 DAT (05 July 2018, week 27) and 56 DAT (24 July, week 30). Phytotoxicity score: scale of 0-9, where 0 = dead; 5 = slight damage, slight yellowing; 9 = comparable with water only control. DAT = days after first treatment.





Water only (top) vs. Terpal 1.0  
L/ha (below)

Water only (top) vs. Dazide  
Enhance 0.45 L/ha (below)

Water only (top) vs. Primo  
Maxx II 1.0 L/ha (below)

**Figure 3.** Geranium 'Horizon' red treated with Terpal (left), Dazide Enhance (centre) and Primo Maxx II (right), in week 30, 24 July 2018

### Pansy

Throughout the pansy trial there was little evidence of phytotoxicity from the HDC P005 treatments (0.337 L/ha and 0.505 L/ha) (**Table 22**). There was some slight distortion to the foliage in the Pirouette treatment early on, but the plants grew away from this. Once the plants started flowering, there were no signs of petal bleach, and plants in all treatments were marketable (**Figure 4**).

**Table 22.** Pansy – average phytotoxicity scores

	Treatment	Application method	Phyto 12.06.18 14 DAT	Phyto 18.06.18 20 DAT	Phyto 05.07.18 37 DAT	Phyto 24.07.18 56 DAT*
1	Water control	Drench	9.0	9.0	9.0	9.0
2	HDC P005 0.337 L/ha	Drench	9.0	9.0	9.0	9.0
3	HDC P005 0.505 L/ha	Drench	8.7	8.7	7.7	8.0
4	Pirouette 0.3 L/ha	Drench	6.0	6.0	9.0	9.0
	s.e.d.		0.2722	0.2357	0.943	n/a
	l.s.d.		0.6660	0.5767	2.307	n/a
	F pr		<0.001	<0.001	0.455	n/a
Values highlighted red are significantly different to the water only control.						

\*Assessment was observational only, statistics are not available.

Assessment dates were: 14 DAT (12 June 2018, week 24), 20 DAT (18 June 2018, week 25), 37 DAT (05 July 2018, week 27) and 56 DAT (24 July, week 30). Phytotoxicity score: scale of 0-9, where 0 =

dead; 5 = slight damage, slight yellowing; 9 = comparable with water only control. DAT = days after first treatment.



**Figure 4.** Pansy 'Matrix' red blotch treated with HDC P005 (left) and Pirouette (right), in week 30, 24 July 2018

### *Osteospermum*

At the first assessment 14 DAT, there were significant signs of phytotoxicity on the plants treated with Terpal 2.0 L/ha, Regalis Plus 1.25 L/ha, Primo Maxx II 2.0 L/ha and Moddus 0.6 L/ha (**Table 23**,  $p < 0.001$ ). Terpal and Regalis Plus had caused some slight distortion and the plants were more compact compared to the water only control. Primo Maxx II and Moddus also caused slight distortion, with some foliar bleach. However, most of the plants had grown away from these symptoms by week 30 (56 DAT), apart from those treated with Terpal (**Figure 5**). These plants were still showing signs of distortion, and flowering was delayed.

**Table 23.** *Osteospermum* – average phytotoxicity scores

	Treatment	Application method	Phyto 12.06.18 14 DAT	Phyto 18.06.18 20 DAT	Phyto 05.07.18 37 DAT	Phyto 24.07.18 56 DAT*
1	Water control	Drench	9.0	9.0	9.0	9
2	HDC P005 0.675 L/ha	Drench	9.0	9.0	9.0	8
3	Terpal 2.0 L/ha	Drench	6.3	7.0	7.0	6
4	Regalis Plus 1.25 L/ha	Drench	7.7	9.0	9.0	8
5	Dazide Enhance 1.8 L/ha	Drench	9.0	9.0	9.0	9
6	Primo Maxx II 2.0 L/ha	Drench	6.7	7.7	9.0	9
7	Moddus 0.6 L/ha	Drench	6.7	8.7	9.0	8
8	Pirouette 0.3 L/ha	Drench	9.0	9.0	9.0	7



s.e.d.		0.441	0.3619	n/a	n/a
l.s.d.		0.946	0.7761	n/a	n/a
F pr		<0.001	<0.001	n/a	n/a
Values highlighted red are significantly different to the water only control.					
Values highlighted blue were unmarketable in week 30.					

\*Assessment was observational only, statistics are not available.

Assessment dates were: 14 DAT (12 June 2018, week 24), 20 DAT (18 June 2018, week 25), 37 DAT (05 July 2018, week 27) and 56 DAT (24 July, week 30). Phytotoxicity score: scale of 0-9, where 0 = dead; 5 = slight damage, slight yellowing; 9 = comparable with water only control. DAT = days after first treatment.



**Figure 5.** *Osteospermum* 'Akila' purple treated with HDC P005 (left), Terpal (centre) and Dazide Enhance (right), in week 30, 24 July 2018

## Flowering

A full assessment of flowering was completed at the end of the trial in week 27 (05 July 2018). The plants were maintained until week 30 (24 July 2018) for further observation.

In the *Dianthus* trial, all treatments delayed flowering, with significantly fewer flowers present in all treatments than the water only control (**Table 24**,  $p=0.006$ ) by week 27. Plants treated with Primo Maxx II (1.0 L/ha and 1.5 L/ha) produced fewest flowers, with an average of 1.7 and 12 plants in flower respectively.



**Table 24.** *Dianthus* – number of plants in flower at the final assessment date on 05 July 2018 (week 27, 37 DAT)

	Treatment	Application method	No in flower
1	Water control	Drench	9.3
2	HDC P005 0.337 L/ha	Drench	4.0
3	HDC P005 0.505 L/ha	Drench	4.0
4	Primo Maxx II 1.0 L/ha	Drench	1.7
5	Primo Maxx II 1.5 L/ha	Drench	1.7
6	Pirouette 0.3 L/ha	Drench	5.7
	s.e.d.		1.575
	l.s.d.		3.510
	F pr		0.006
	Values highlighted red are significantly different to the water only control.		

DAT = days after first treatment.

No Geraniums were in flower by the final assessment in week 27 (05 July 2018). In week 30 (24 July 2018), observations were made on flower development, and whether any of the treatments had delayed flowering, compared to the water only control. While the majority of treatments did not adversely affect time to flower, flower size, or the number of plants in flower, Terpal (both rates), Dazide Enhance (0.9 L/ha) and Primo Maxx II (both rates) appeared to delay flowering slightly; this was more evident in the Terpal treatments.

For the pansy trial, none of the treatments had any effect on time to flower (**Table 25**). All plants were in flower by week 27.

**Table 25.** Pansy – number of plants in flower at the final assessment date on 05 July 2018 (week 27, 37 DAT)

	Treatment	Application method	No in flower
1	Water control	Drench	12
2	HDC P005 0.337 L/ha	Drench	12
3	HDC P005 0.505 L/ha	Drench	12
4	Pirouette 0.3 L/ha	Drench	12
	s.e.d.		n/a
	l.s.d.		n/a
	F pr		n/a
	None of the treatments were significantly different to the water only control.		

DAT = days after first treatment.

The *Osteospermum* were not in flower at the time of the final assessment in week 27 (05 July 2018). By week 30 (24 July 2018), it was evident that only the Terpal (2.0 L/ha) had delayed flowering compared with the untreated control (**Figure 5**). Flowers were present on plants in all other treatments by week 30.

## Summary of results by plant species

### Dianthus 'Festival' violet

- HDC P005 (0.337 L/ha) did not provide effective growth control, and caused slight petal bleach. Growth was controlled at higher rate (0.505 L/ha), but with more severe petal bleach.
- Primo Maxx II (1.0 L/ha and 1.5 L/ha) did control growth but caused phytotoxicity.
- Pirouette did not cause phytotoxicity but the plants were too compact, with a reduction in stem length resulting in the plants flowering too low.
- None of the treatments were particularly suitable as drenches prior to transplant. Those that did provide growth control also caused phytotoxicity (foliar and petal bleach).

### Geranium 'Horizon' red

- Although HDC P005 and Regalis Plus did not cause phytotoxicity at the rates tested, they did not provide adequate growth control.
- Primo Maxx caused phytotoxicity including petal bleach.
- Terpal gave good growth control with no phytotoxicity, although flowering was delayed.
- Dazide Enhance (0.45 L/ha) showed potential, with good growth control and no phytotoxicity.
- Moddus at 0.15 L/ha has potential; the higher rate (0.3 L/ha) caused phytotoxicity.
- Pirouette 0.3 L/ha has potential, producing compact plants with a good flower colour.

### Pansy 'Matrix' red blotch

- HDC P005 did not cause phytotoxicity at the rates tested, but neither did it provide adequate growth control.
- Pirouette did not cause any phytotoxicity, and has potential as a treatment on Pansy

### Osteospermum 'Akila' purple

- HDC P005 and Regalis Plus showed promise, with good growth control, and no phytotoxicity.
- Primo Maxx II and Moddus did not show signs of phytotoxicity by week 30, but plants were perhaps a little too compact.
- Pirouette did not show signs of phytotoxicity, but did not control growth adequately.
- Dazide Enhance did not provide growth control, the plants were taller than the water only control.

- Terpal caused distortion to the foliage early on, which the plants did not grow away from, and flowering was also delayed.

## Discussion

HDC P005 alone did not provide adequate growth control for *Dianthus*, Geranium or Pansy, and caused some phytotoxicity at the higher rates. However, the product was promising on *Osteospermum*, providing good growth control, with no phytotoxicity. This product could prove useful as part of a PGR programme at lower rates, particularly on longer term crops such as *Osteospermum*.

Regalis Plus did not provide adequate growth control of Geranium, but was promising on *Osteospermum*, so like HDC P005, could prove useful as part of a PGR programme, particularly on longer term crops.

Primo Maxx caused phytotoxicity on *Dianthus* and Geranium at the rates tested, but appeared to be safe on *Osteospermum*. The rate was perhaps too high though, resulting in plants which were quite compact, so a lower rate may be preferable.

Terpal gave good growth control of Geranium, although flowering was delayed. Some distortion was caused in the *Osteospermum* trial, along with delayed flowering, so a lower rate in this crop may be better.

Dazide Enhance did not provide adequate control in the *Osteospermum*, however, the lower rate of 0.45 L/ha showed potential on Geranium, with good growth control and no phytotoxicity. Moddus also showed potential at the lower rate of 0.15 L/ha on Geranium. The higher rate of 0.3 L/ha caused phytotoxicity.

Pirouette did not cause phytotoxicity, however the effect may have been too strong on *Dianthus* and Pansy, with compact plants which flowered low. On Geranium however it did show potential, with good growth control and good flower colour.

In this work using small plots, treatments were applied by syringe to individual plants, to ensure treatment consistency; application of treatments over larger areas of plug plants as a drenching spray from a conventional nursery sprayer, is needed to confirm treatment efficacy and safety.

## Conclusions

- Application of PGRs prior to transplant is both time and cost efficient, and could prove useful as part of a PGR programme, particularly on longer term crops.
- Pirouette 0.3 L/ha worked well on *Dianthus*, Geranium and Pansy, providing adequate growth control, with minimal or no phytotoxicity; plants were all marketable at the end of the trial.
- Terpal was effective at the lower rates tested (0.5 L/ha), higher rates caused some distortion to plant foliage and the plants were probably a little too compact.
- Useful effects were achieved with treatments of Moddus 0.15 L/ha, Regalis Plus and HDC P005. Some species were more sensitive to HDC P005 than others, which may restrict its use to certain species.

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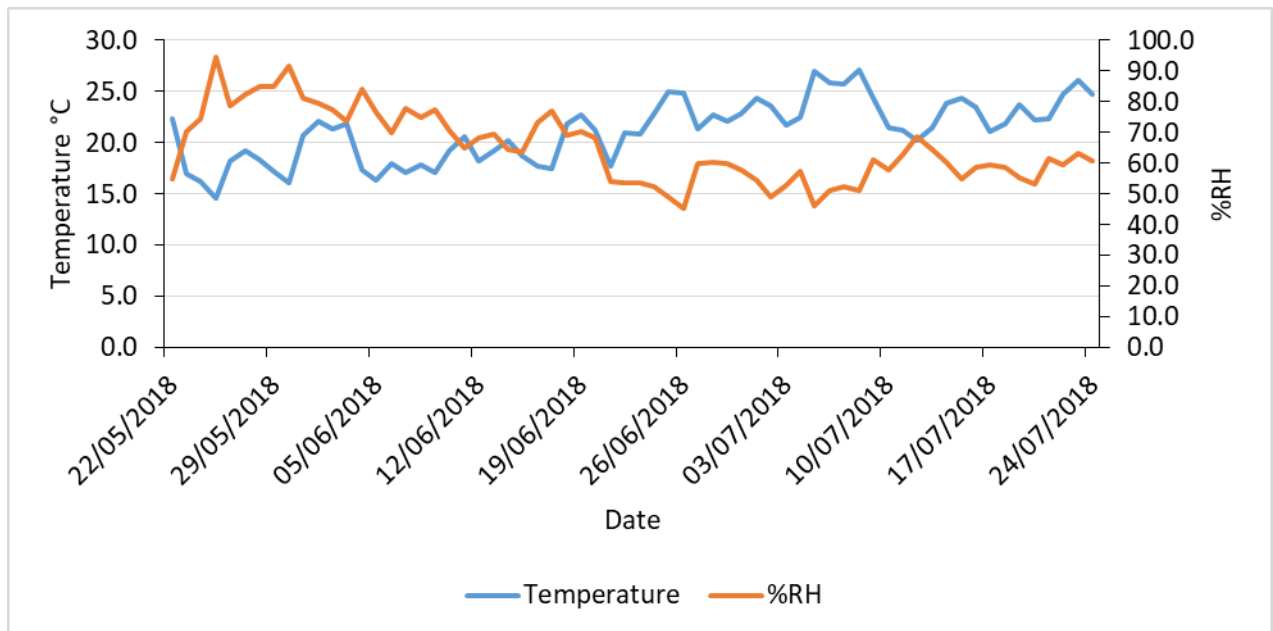
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## Appendices

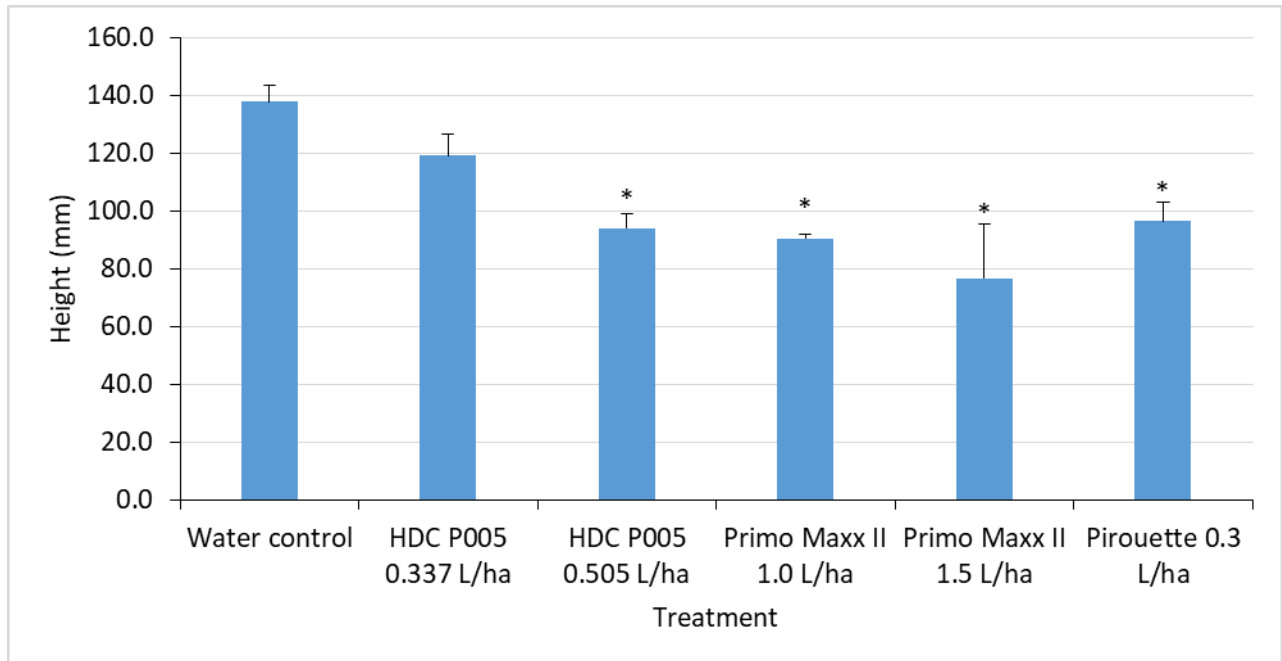
### Appendix 1

Glasshouse temperature and humidity during the PGR bedding plant trial

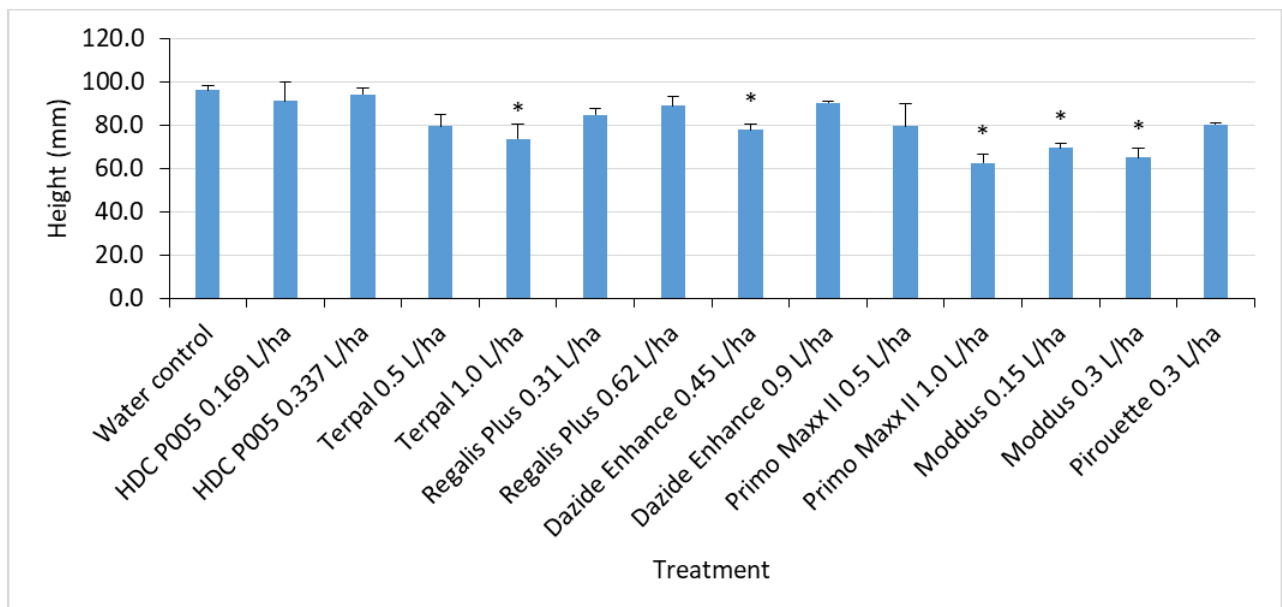


## Appendix 2

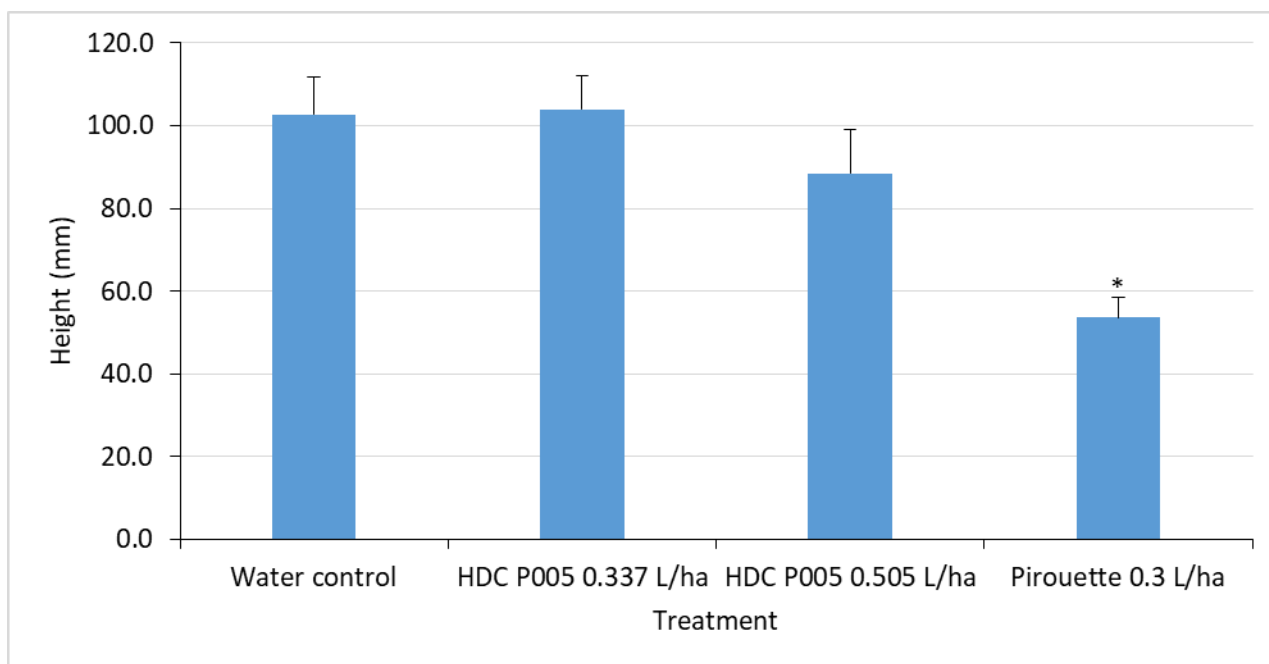
### Plant height



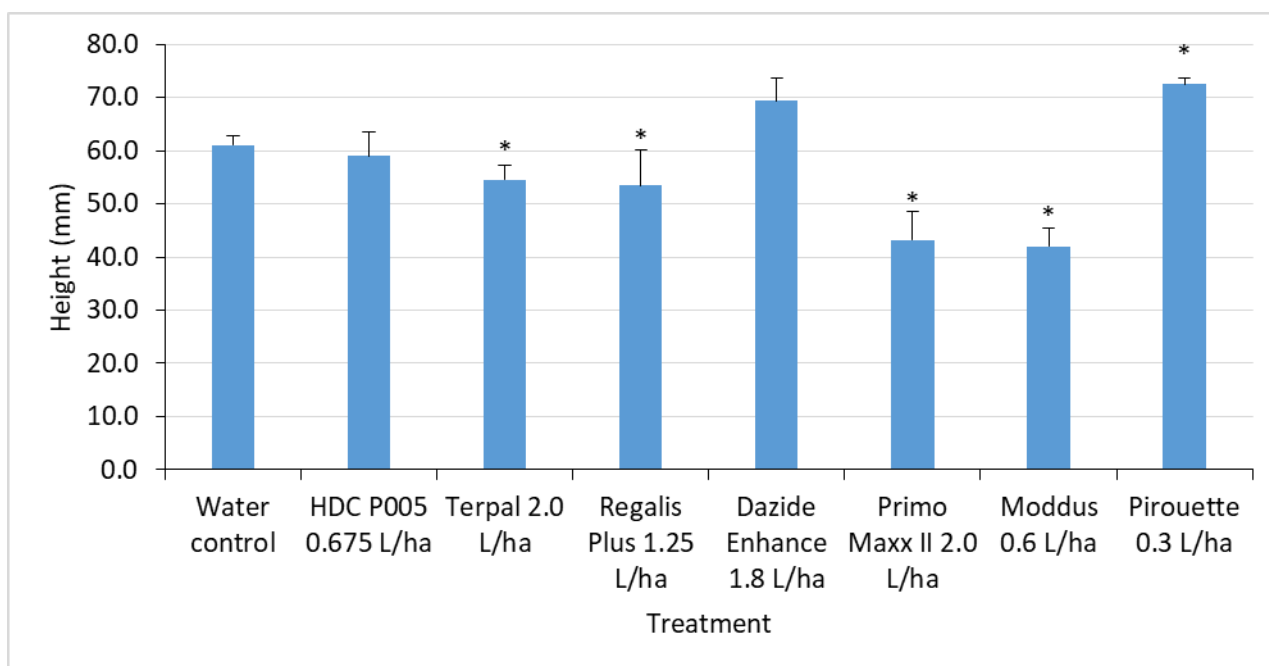
**A.** *Dianthus* 'Festival' violet height (mm), 37 DAT (05 July 2018, week 27). All plants were treated once two days prior to transplant. \* = treatments are significantly different to the water control ( $p = 0.014$ , l.s.d = 30.79).



**B.** *Geranium* 'Horizon' red height (mm), 37 DAT (05 July 2018, week 27). All plants were treated once two days prior to transplant. \* = treatments are significantly different to the water control ( $p < 0.001$ , l.s.d = 14.76).



**C.** Pansy 'Matrix' red blotch height (mm), 37 DAT (05 July 2018, week 27). All plants were treated once two days prior to transplant. \* = treatments are significantly different to the water control ( $p = 0.028$ , l.s.d = 32.29).



**D.** *Osteospermum* 'Akila' purple height (mm), 37 DAT (05 July 2018, week 27). All plants were treated once two days prior to transplant. \* = treatments are significantly different to the water control ( $p < 0.001$ , l.s.d = 10.01).




## Appendix 3

Photographic records of treatment effects.





A. *Dianthus* 'Festival' violet. Effects of treatments compared with the water only control, week 30 2018

	
Untreated (top) vs. HDC P005 0.337 L/ha	Untreated (top) vs. HDC P005 0.505 L/ha
	
Untreated (top) vs. Primo Maxx II 1.0 L/ha	Untreated (top) vs. Primo Maxx II 1.5 L/ha



	
Untreated (top) vs. Pirouette 0.3 L/ha	

**B. Geranium 'Horizon' red. Effects of treatments compared with the water only control, week 30 2018**

	
<p>Untreated (top) vs. HDC P005 0.169 L/ha</p>	<p>Untreated (top) vs. HDC P005 0.337 L/ha</p>
	
<p>Untreated (top) vs. Terpal 0.5 L/ha</p>	<p>Untreated (top) vs. Terpal 1.0 L/ha</p>



	
<p>Untreated (top) vs. Regalis Plus 0.31 L/ha</p>	<p>Untreated (top) vs. Regalis Plus 0.62 L/ha</p>
	
<p>Untreated (top) vs. Dazide Enhance 0.45 L/ha</p>	<p>Untreated (top) vs. Dazide Enhance 0.9 L/ha</p>



	
<p>Untreated (top) vs. Primo Maxx II 0.5 L/ha</p>	<p>Untreated (top) vs. Primo Maxx II 1.0 L/ha</p>
	
<p>Untreated (top) vs. Moddus 0.15 L/ha</p>	<p>Untreated (top) vs. Moddus 0.3 L/ha</p>



Untreated (top) vs. Pirouette 0.3 L/ha



C. Pansy 'Matrix' red blotch. Effects of treatments compared with the water only control, week 25 2018

	
<p>Untreated (top) vs. HDC P005 0.337 L/ha</p>	<p>Untreated (top) vs. HDC P005 0.505 L/ha</p>
	
<p>Untreated (top) vs. Pirouette 0.3 L/ha</p>	



D. *Osteospermum* 'Akila' purple. Effects of treatments compared with the water only control, week 30 2018

	
<p>Untreated (top) vs. HDC P005 0.675 L/ha</p>	<p>Untreated (top) vs. Terpal 2.0 L/ha</p>
	
<p>Untreated (top) vs. Regalis Plus 1.25 L/ha</p>	<p>Untreated (top) vs. Dazide Enhance 1.8 L/ha</p>



	
<p>Untreated (top) vs. Primo Maxx II 2.0 L/ha</p>	<p>Untreated (top) vs. Moddus 0.6 L/ha</p>
	
<p>Untreated (top) vs. Pirouette 0.3 L/ha</p>	