

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

Objective 2. *To evaluate plant growth regulators for use on bedding plant plugs at cotyledon stage (drench application)*

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AUTHENTICATION

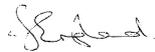
We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr Jill England

Senior Horticulture Consultant

ADAS

Signature



Date 30 April 2020

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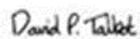
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Date 30 April 2020

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Date 30 April 2020

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Grower Summary

Headline

- Effective plant growth regulator (PGR) treatments for application at the cotyledon stage, with no follow-up PGR application required, were identified for *Cosmos* 'Sonata' carmine, *Dianthus* 'Festival' violet and French Marigold 'Durango' red.
- Primo Maxx II (trinexapac-ethyl, applied at 0.5 L/ha) on *Cosmos* 'Sonata' carmine, and Terpal (ethephon + mepiquat chloride, applied at 1.0 L/ha) on *Dianthus* 'Festival' violet are not recommended due to petal bleach or spotting with limited growth control.

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 British Protected Ornamental Association (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 2. *To evaluate plant growth regulators for use on bedding plant plugs at cotyledon stage (drench application).*

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.

Whilst growers do use cultural methods (e.g. temperature, diff/drop, controlling irrigation and nutrient supply) to control plant growth where possible, 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 could lead to unmarketable plants.

Many growers apply PGRs as drenches and have developed application rates specific to the crops they grow under the specific growing conditions on their nurseries. 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 at the Bedding and Pot Plant Centre in 2018, whereby PGR drenches were applied to a range of bedding species at the plug stage, two days prior to transplant. Low rates of the PGRs tested gave adequate growth control, with minimal or no phytotoxicity. A number of promising treatments and rates emerged from this trial, which prompted interest in treating plants in plug trays earlier, just after germination, to improve growth control in *Dianthus* and more vigorous species (*Cosmos* and Marigold), while minimising the risk of phytotoxicity.

In the 2019 trial, a range of plant growth regulators were trialled on three seed-raised bedding plant species (*Cosmos* 'Sonata' carmine, *Dianthus* 'Festival' violet and French Marigold 'Durango' red). Seed was sown into 240-cell trays in week 18 (02 May 2019) at ADAS Boxworth, and PGR treatments were applied to the plug trays once the seedlings had germinated and were at cotyledon stage. Treatments were applied as a drench 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 transferred to Baginton Nurseries and transplanted in week 22 (*Cosmos* and French Marigold) and week 23 (*Dianthus*), using standard 6-packs for the *Dianthus* and French Marigold, and jumbo 6-packs for the *Cosmos*.

Products tested are listed in **Table 1**. Due to the relatively small plug cell size, and the number of plugs per treatment (72), 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. All species were sown into 240-cell trays, with a cell volume of 12 cm³, meaning a 10% drench would be 1.2 ml per cell, or 14.4 ml per row of 12 plants. Treatment solutions (1 L) were made up in plastic containers, one for each treatment. Treatments were applied to plants using a syringe, one for each treatment, treating one row at a time.

Table 1. Approval status of PGR products tested in 2019 (Unauthorised or off-label treatments applied under experimental permit)

Product	Active ingredient	Approval status
Dazide Enhance (MAPP 16092)	daminozide	On-label approval
Canopy* (MAPP 16314)	mepiquat (as chloride) and prohexadione calcium	EAMU 4484/19 for spray application. 2 applications permitted per year
Moddus (MAPP 15151)	trinexapac-ethyl	EAMU 3062/10 for spray application. 1 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
Regalis Plus (MAPP 16485)	prohexadione	EAMU 2153/19 for spray application.
Terpal (MAPP 16463)	ethephon + mepiquat chloride	EAMU 0151/18 for drench application

*Canopy applied under experimental permit in 2019 and coded as HDC P005 in previous reports. Note that rates used in the trial may be higher than permitted in EAMU 4484/19 (issued 18 December 2019).

Treatments applied in this trial were developed using the 2018 trial results as a guide. *Cosmos* and French Marigold were new to the species list, and as PGRs hadn't been applied at such an early stage before in previous BPPC work, the treatment list was kept the same for each species (**Table 2**).

Table 2. PGR product and treatment list 2019 – *Cosmos*, *Dianthus* and French Marigold

Trt No.	Product*	Active ingredient	Dose rate (L or Kg/ha)**	Dose rate (ml or g/L)
1	Water control	N/A	N/A	N/A
2	Dazide Enhance	daminozide	1.8 kg/ha	6.0 g/L (full rate)
3	Canopy*	mepiquat chloride + prohexadione-calcium	0.505 kg/ha	1.68 g/L (3/4 rate)
4	Moddus*	trinexapac-ethyl	0.15 L/ha	0.5 ml/L (1/4 rate)
5	Pirouette	paclobutrazol	0.6 L/ha	2.0 ml/L
6	Primo Maxx II*	trinexapac-ethyl	0.5 L/ha	1.67 ml/L (1/4 rate)

7	Regalis Plus ⁺	prohexadione	0.62 kg/ha	2.08 g/L (1/2 rate)
8	Terpal	ethephon + mepiquat chloride	1.0 L/ha	3.33 ml/L (1/2 rate)

*Drenches 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 and Canopy) were expected to have a similar effect on plant growth as Stabilan 750; those containing prohexadione calcium (Regalis Plus, Canopy) 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 product

Dazide Enhance

Dazide Enhance was applied at 1.8 kg/ha (full rate) and gave mixed results across the three plant species. Height was not well controlled in the *Cosmos* or *Dianthus* trials and flowering was also delayed in the *Cosmos* trial. Growth was reasonably well controlled in the French Marigold trial. Dazide Enhance (1.8 kg/ha) can be considered as an early treatment at cotyledon stage for French Marigold, but would require a post-transplant follow-up treatment for *Cosmos* and *Dianthus*.

Canopy

Canopy was applied at 0.505 kg/ha (3/4 rate) and gave good results for *Cosmos* and French Marigold. Height was well controlled throughout the two trials and plants were within the target height specification, although there were fewer open flowers at the end of the *Cosmos* trial, and more in the French Marigold trial compared to the water control. Canopy was also effective in the *Dianthus* trial at this rate, with plants just below the height specification in week 26. Canopy (0.505 kg/ha) can be considered as an early treatment at cotyledon stage for all three species, and will produce plants within the desired height specification without the need for any follow-up PGR treatments.

Moddus

Moddus was applied at 0.15 L/ha (1/4 rate). Plant height was well controlled in the *Dianthus* and French Marigold trials, with plants within the target range, but the treatment was less effective in the *Cosmos* trial. There were no signs of phytotoxicity, although flowering was delayed in the *Cosmos* and *Dianthus* trials. Moddus (0.15 L/ha) is suitable for use on *Dianthus* and French Marigold as a drench at cotyledon stage. A higher rate would likely be needed for

Cosmos, although phytotoxic effects are unknown, and flowering would likely be delayed further.

Pirouette

Pirouette was applied at 0.6 L/ha. Height was well controlled for all three species, and there was no evidence of phytotoxicity or delays in flowering. Pirouette (0.6 L/ha) is suitable for use on *Cosmos*, *Dianthus* and French Marigold as a drench at cotyledon stage.

Primo Maxx II

Primo Maxx II was applied at 0.5 L/ha (1/4 rate). Height was reasonably well controlled in the *Cosmos* trial, with plants just above the height specification in week 26. However, for *Dianthus* and French Marigold, the treatment may have been too strong, with plants just below the height specification. There was bleaching to the flower petals and foliage in the *Cosmos* trial (**Figure 1**), but no evidence of phytotoxicity in the other species, although fewer flowers were produced in the *Dianthus* compared to the water control. Primo Maxx II (0.5 L/ha) could be considered for use on *Dianthus* and French Marigold as a drench at cotyledon stage. It is not recommended for use on *Cosmos* due to petal bleaching.

Regalis Plus

Regalis Plus was applied at 0.62 kg/ha (1/2 rate). Height was well controlled in the *Dianthus* and French Marigold trials, but plants in the *Cosmos* trial were above the target height specification. There was no evidence of phytotoxicity or delays in flowering for any of the species tested. Regalis Plus (0.62 kg/ha) would be suitable for use on *Dianthus* and French Marigold as a drench at cotyledon stage. A higher rate may be required for use on *Cosmos*.

Terpal

Terpal was applied at 1.0 L/ha (1/2 rate). Growth control was good in the French Marigold trials, although potentially this rate was too strong, with plants too compact. The treatment was not effective on *Cosmos* or *Dianthus*; plants were taller than the water control at the end of the *Dianthus* trial. There was no evidence of phytotoxicity in the *Cosmos* or French Marigold trials, however the *Dianthus* flowers had white spots on them (**Figure 2**), and the foliage was paler in this treatment. Terpal (1.0 L/ha) is not recommended for use on *Dianthus* as a drench at cotyledon stage due to phytotoxicity and poor growth control. It can be considered as a drench at cotyledon stage on *Cosmos* and French Marigold, although flowering is delayed, and a higher rate may be required for growth control in *Cosmos*. The effect of a higher rate on phytotoxicity and flowering is unknown. (Note: growth control without damage was achieved with Terpal on *Dianthus* in the pre/post transplanting trial, see work package one report).



Figure 1. Pale flowers seen in *Cosmos* plants treated with Primo Maxx II 0.5 L/ha (right) compared to the water control (left), week 28 2019.



Figure 2. White spots seen on flowers of *Dianthus* plants treated with Terpal 1.0 L/ha, week 28 2019

Although a number of treatments were effective in controlling growth at plug stage, either dose rates may need to be adjusted to achieve the appropriate height specification, or a follow-up application may be required post-transplant.

The growth control effect of a number of the treatments evaluated in this trial was sustained post-transplant. A second PGR application was not required to achieve height specifications in a number of treatments: Pirouette (0.6 L/ha) and Canopy (0.505 kg/ha) on *Cosmos*, French Marigold and *Dianthus*; Moddus (0.15 L/ha), Primo Maxx II (0.5 L/ha) and Regalis Plus (0.62 kg/ha) on *Dianthus* and French Marigold; Dazide Enhance (1.8 kg/ha) and Terpal (1.0 L/ha) on French Marigold. This is useful when product is sold in packs or small pots and avoiding further PGR applications is seen as a benefit, but for larger added value products where a greater bulk is required it could be an issue and add to production times.

All PGR treatments delayed flowering slightly with *Cosmos* and this should be borne in mind when scheduling.

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.

The cost per litre of spray solution of the products included in this trial at the specified rates ranges from 2p to 88.2p (**Table 3**) providing greater opportunity to increase business profit through reduced input cost and wastage minimisation.

The ability to apply PGRs to young plants in the plug tray prior to transplant not only reduces the cost by reducing the amount of product needed, it also saves on labour costs as smaller areas of higher density plant material can be treated. Where the impact of the PGR continues post-transplanting, it provides added benefit in that further PGR products may not need to be needed, depending on the final product being grown.

Table 3. 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 (6.0 g/L)	14.7/g	88.2
Canopy (1.68 g/L)	2.2/g	3.7
Moddus (0.5 ml/L)	3.9/ml	2.0
Pirouette (2.0 ml/L)	9.5/ml	19.0
Primo Maxx II (1.67 ml/L)	5.0/ml	8.4
Regalis Plus (2.08 g/L)	12.3/g	25.6
Terpal (3.33 ml/L)	1.7/ml	5.7

Action points

- Of the products currently approved for use on protected ornamentals in the UK, useful effects were achieved with drench treatments of Dazide Enhance (1.8 kg/ha), Pirouette 0.6 L/ha and Terpal 1.0 L/ha (not *Dianthus*) and these should be examined in small scale trials for potential use, if not already used commercially, to establish appropriate rates of application. (Drench application is not currently approved for Canopy, Moddus, Primo Maxx II or Regalis Plus and EAMU authorisations will be sought for these via AHDB where appropriate).
- 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. Applications made under EAMU authorisations are at the grower's own risk).

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, 2019-20 were:

Objective 1: 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 Stena (adjuvant) on bedding plants pre- and post-transplant (spray, sprench and drench application).

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 plant plugs at cotyledon stage (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 and Stena (adjuvant) on Poinsettia, and their effect on marketability.

This is the Bedding and Pot Plant Centre report for Objective 2.

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. Many growers apply PGRs as drenches and have developed application rates specific to the crops they grow under the specific growing conditions on their nurseries. 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.

Canopy (300 g/L mepiquat chloride + 50 g/L prohexadione-calcium, BASF) was developed for use on cereals and grass seed, and has label approval for use on cereals in the UK. 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* 'Carolin' when applied at a dose rate of 0.375%. Canopy did not reduce the number of *Bacopa* flowers produced although they were slightly smaller (Paaske, 2015). Canopy was used in PGR trials pre- and post-transplanting at the Bedding and Pot Plant Centre in 2017 and 2018, and although drenches were too strong, growth control was promising when applied as foliar sprays, particularly on *Osteospermum*. Canopy was authorised for use on protected and outdoor ornamental plant production – container grown crops under EAMU 4484/19 in December 2019.

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, Terpal was authorised for use in ornamental plant production on container grown plants under EAMU 0151/18 in January 2018.

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 projects 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, we are informed that Cutaway's authorisation for use is likely to be lost in the near future as some of its co-formulants are likely to be banned. Cutaway has been replaced in the trial with **Primo Maxx II** (116.4 g/L trinexapac-ethyl, Syngenta UK Ltd), approved for use in ornamental plant production in the UK under EAMU 0621/18.

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 EAMUs for Cutaway and Primo Maxx II. 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). In the Danish work, Regalis produced compact Marguerites (*Argyranthemum frutescens* Dana) at 0.1% (Paaske,

2010). Regalis Plus is the new formulation which includes a built-in water conditioner which reduces the time required for rain fastness from 6 hrs to 2 hrs. The new formulation has superseded Regalis.

PGR modes of action

The active ingredients of the products included in this trial are 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 (Canopy and 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, Canopy), 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 at the Bedding and Pot Plant Centre in 2018, when PGR drenches were applied to a range of bedding species at the plug stage, two days prior to transplant. Low rates of the PGRs tested gave adequate growth control, with minimal or no phytotoxicity. A number of promising treatments and rates emerged from this trial, which prompted interest in treating plants in plug trays earlier, just after germination, to improve growth control in *Dianthus* and more vigorous species (*Cosmos* and Marigold) while minimising the risk of phytotoxicity.

DIY stores and multiple retailers specify plant height in the range 4-8 cm, up to 10 cm for *Dianthus*, and 15-20 cm for *Cosmos* in addition to 100% pack cover for pack bedding, while independent garden centres may have a wider height range tolerance for selected marketable products.

A range of PGRs (**Table 4**) were tested on pot and bedding plant subjects at cotyledon stage under UK conditions. Treatment rates were based on the 2018 Bedding and Pot Plant Centre PGR trial results, and as *Cosmos* and French Marigold were introduced to the work programme for the first time, the treatment list for each plant species was the same. Treatments were applied as a drench to young seedlings at cotyledon stage in the plug tray, and then transplanted into 6-packs at Baginton Nurseries when the plants were fully rooted in the plug and of a suitable size for transplant.

Table 4. Approval status of PGR products tested in 2019 (Unauthorised or off-label treatments applied under experimental permit)

Product	Active ingredient	Approval status
Dazide Enhance (MAPP 16092)	daminozide	On-label approval
Canopy* (MAPP 16314)	mepiquat (as chloride) and prohexadione calcium	EAMU 4484/19 for spray application. 2 applications permitted per year
Moddus (MAPP 15151)	trinexapac-ethyl	EAMU 3062/10 for spray application. 1 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
Regalis Plus (MAPP 16485)	prohexadione	EAMU 2153/19 for spray application.
Terpal (MAPP 16463)	ethephon + mepiquat chloride	EAMU 0151/18 for drench application

*Canopy applied under experimental permit in 2019 and coded as HDC P005 in previous reports. Note that rates used in the trial may be higher than permitted in EAMU 4484/19.

Project objectives

Objective 2. 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 at cotyledon stage (drench application).

Specific objective 1: To evaluate efficacy of up to seven PGRs for drench application over seed-raised bedding and pot plant plugs at cotyledon stage.

Specific objective 2. To evaluate any phytotoxic effects of up to seven PGRs due to drench application over seed-raised bedding and pot plant plugs at cotyledon stage.

Methods and materials

Site and crop production details

Three seed-raised bedding plant species (*Cosmos* ‘Sonata’ carmine, *Dianthus* ‘Festival’ violet and French Marigold ‘Durango’ red) were used for this trial. Seed was obtained from Ball Colegrave and sown into 240-cell trays (four trays per species) in week 18 (02 May 2019) at ADAS Boxworth, using Levington F2 seed and modular compost. The trays were covered with

vermiculite to retain moisture, placed within a polytunnel and monitored daily for germination. Once the seeds had germinated and were just at cotyledon stage, PGR treatments (**Table 5**) were applied at a drench volume of 10% of the tray volume, using a syringe for accuracy. Growing media was moist when treatments were applied, and plants were not watered for 24 hours after treatment. Treatments were applied during the afternoon when it was cloudy and no further PGR treatments were applied at the plug stage. PGR application date differed for each species due to differences in germination timing (*Cosmos*, 10 May; *Dianthus*, 20 May; French Marigold, 09 May).

Table 5. PGR product and treatment list 2019 – *Cosmos*, *Dianthus* and French Marigold

Trt No.	Product*	Active ingredient	Dose rate (L or kg/ha)**	Dose rate (ml or g/L)
1	Water control	N/A	N/A	N/A
2	Dazide Enhance	daminozide	1.8 kg/ha	6.0 g/L (full label rate)
3	Canopy ⁺	mepiquat chloride + prohexadione-calcium	0.505 kg/ha	1.68 g/L (3/4 rate)
4	Moddus ⁺	trinexapac-ethyl	0.15 L/ha	0.5 ml/L (1/4 rate)
5	Pirouette	paclobutrazol	0.6 L/ha	2.0 ml/L
6	Primo Maxx II ⁺	trinexapac-ethyl	0.5 L/ha	1.67 ml/L (1/4 rate)
7	Regalis Plus ⁺	prohexadione	0.62 kg/ha	2.08 g/L (1/2 rate)
8	Terpal	ethephon + mepiquat chloride	1.0 L/ha	3.33 ml/L (1/2 rate)

*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.

Due to the relatively small plug cell size, and the number of plugs per treatment (72), plug plants were grouped into treatments within the plug tray 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. All species were sown into 240-cell trays, with a cell volume of 12 cm³, meaning a 10% drench would be 1.2 ml per cell, or 14.4 ml per row of 12 plants. Treatment solutions (1 L) were made up in plastic containers, one for each 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.

Plants were maintained at ADAS Boxworth until week 21, when they were transferred to Baginton Nurseries, and placed under glass. *Cosmos* and French Marigold were transplanted in week 22 and *Dianthus* were transplanted in week 23, using standard 6-packs for *Dianthus*

and French Marigold, and jumbo 6-packs for *Cosmos*. Plants were transplanted 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. Plants were monitored for pests and diseases throughout the trial. No insecticides or fungicides were applied.

Products not currently authorised for use on protected ornamentals or for drench application were applied under an experimental permit (2017/01098 and 2019/00967).

Trial design and statistical analysis

Each plant species was set-out separately, and treatments were arranged in a randomised block design with eight treatments replicated three times. For each species this gave an overall total of 576 plants (72 per treatment, per species). Plots consisted of four 6-packs (24 plants).

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

Assessments

Prior to transplant, plugs were assessed for root development (**Table 6**), plant quality (**Table 7**), phytotoxicity (**Table 8**) and height. A further assessment was made on plant height in week 25, the target marketing week, and week 26 (*Cosmos* and *Dianthus* only). Plant quality, phytotoxicity and number of plants in flower were assessed in weeks 25, 26, 28 and 30.

Inspections and assessments are summarised in **Table 9** and below.

Table 6. 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 7. 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 8. 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 9. Summary of bedding and pot plant trial inspections and assessments, 2019

Date	Week No.	Action	Plant species	Assessment
02 May	18	Seeds sown, 4 trays of 240-cell trays per species	<i>Cosmos</i> , <i>Dianthus</i> , French Marigold	N/A
09 May	19	PGR treatments applied	French Marigold	N/A
10 May	19	PGR treatments applied	<i>Cosmos</i>	N/A

20 May	21	PGR treatments applied	<i>Dianthus</i>	N/A
23 May	21	Plants transferred to Bagintons	<i>Cosmos</i> , <i>Dianthus</i> , French Marigold	N/A
30 May	22	Plugs assessed and transplanted. Trial set out	<i>Cosmos</i> , French Marigold	Plant height (cm), plant quality, root quality, phytotoxicity
06 June	23	Plugs assessed and transplanted. Trial set out	<i>Dianthus</i>	Plant height (cm), plant quality, root quality, phytotoxicity
17 June	25	Trial assessed	<i>Cosmos</i> , <i>Dianthus</i> , French Marigold	Plant height (cm), plant quality, phytotoxicity
21 June	25	Bonzi overspray (1.0 ml/L) applied to all plots by Bagintons	<i>Cosmos</i>	N/A
28 June	26	Trial assessed	<i>Cosmos</i> , <i>Dianthus</i> , French Marigold	Plant quality, phytotoxicity, no. of plants in flower
11 July	28	Trial assessed	<i>Cosmos</i> , <i>Dianthus</i>	Plant quality, phytotoxicity, no. of plants in flower
25 July	30	Monitoring	<i>Cosmos</i> , <i>Dianthus</i>	Phytotoxicity, no. of plants in flower

Results

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

Plant height

Plant height graphs are presented in **Appendix 2**, with photographs of treatment effects on all species presented in **Appendix 3**. Plant height at transplant and in weeks 25 and 26 are presented in **Table 10 - Table 12**. 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 varied between plant species.

Cosmos

Plants were treated with PGR at cotyledon stage eight days after sowing, and assessed for height at transplant, 20 DAT (days after treatment, **Table 10**), when all treatments controlled plant height compared with the water control. Plants in the water control were tallest (10.4 cm average) and shortest in the Pirouette (0.6 L/ha) and Terpal (1.0 L/ha) treatments (3.5 cm average). By week 25, plant height in all treatments had been significantly controlled compared to the water control ($p < .001$), apart from those treated with Dazide Enhance (1.8 kg/ha, average 12.0 cm). The water control measured 14 cm and the shortest plants had been treated with Pirouette (0.6 L/ha), with an average plant height of 7 cm.

A Bonzi overspray (1.0 ml/L) was applied to all plots, including the water control, in week 25, to prevent the plants from becoming stretched and unmarketable, as the plants needed to be monitored until flowering. Because the plants had not reached the target marketing specification of 15 cm – 20 cm in any of the treatments, including the water control, by week 25, a further height assessment was completed in week 26. Height differences between treatments remained significant, with the majority of treatments within the marketing specification (**Table 10**; $p < .001$). Pirouette (0.6 L/ha) was the most effective, with plants measuring 16 cm on average, compared to 24.5 cm in the water control. Canopy (0.505 kg/ha) was also within specification (19.9 cm). Dazide Enhance (1.8 kg/ha) did not provide adequate growth control, with plant height averaging 22.6 cm.

Table 10. *Cosmos*: average plant height at transplant (30 May 2019, week 22, 20 DAT), in the target marketing week (17 June 2019, week 25, 38 DAT) and one week later (28 June 2019, week 26, 49 DAT)

Product	Dose rate (L or kg/ha)	Ave. height (cm) (30.05.19)	Ave. height (cm) (17.06.19)	Ave. height (cm) (28.06.19)
1 Water control	N/A	10.4	14.0	24.5
2 Dazide Enhance	1.8 kg/ha (full rate)	6.4	12.0	22.6
3 Canopy	0.505 kg/ha (3/4 rate)	4.4	7.8	19.9*
4 Moddus	0.15 L/ha (1/4 rate)	4.1	9.0	21.0
5 Pirouette	0.6 L/ha	3.5	7.0	16.0*
6 Primo Maxx II	0.5 L/ha (1/4 rate)	5.0	10.0	20.9
7 Regalis Plus	0.62 kg/ha (1/2 rate)	4.5	10.4	21.5
8 Terpal	1.0 L/ha (1/2 rate)	3.5	9.9	20.8
s.e.d.			1.18	1.144
l.s.d.		n/a	2.533	2.453
F pr			<.001	<.001

Values highlighted red are significantly different to water control. * plant height within target specification

Height specification for Cosmos is 15 cm – 20 cm.

Dianthus

Plants were treated with PGR at cotyledon stage 18 days after sowing, and then assessed for height at transplant, 17 DAT. Moddus (0.15 L/ha) and Pirouette (0.6 L/ha) were the most effective treatments, with an average plant height of 2 cm compared to 4.2 cm in the water control. By week 25, plants in the majority of the treatments were significantly shorter than the water control (5.7 cm; $p < .001$), with the shortest plants produced in the Primo Maxx II (0.5 L/ha) treatment (2.2 cm). Only plants treated with Dazide Enhance (1.8 kg/ha) and Terpal (1.0 L/ha) were not significantly controlled.

Because the plants had not reached the target marketing specification of 8 cm – 10 cm in any of the treatments, including the water control by week 25, a further height assessment was completed in week 26. Height differences between treatments remained significant (**Table 11**; $p < .001$), with plants treated with Moddus (0.15 L/ha) within specification with an average height of 8.1 cm. Plants in the water control, the Dazide Enhance (1.8 kg/ha) treatment and the Terpal (1.0 L/ha) treatment were all above the target specification (10.8 cm, 10.3 cm and 11.3 cm respectively). Primo Maxx II (0.5 L/ha) was too strong, with the shortest plants in this treatment (6.3 cm).

Table 11. *Dianthus*: average plant height at transplant (06 June 2019, week 23, 17 DAT), in the target marketing week (17 June 2019, week 25, 28 DAT) and one week later (28 June 2019, week 26, 39 DAT)

Product	Dose rate (L or kg/ha)	Ave. height (cm) (06.06.19)	Ave. height (cm) (17.06.19)	Ave. height (cm) (28.06.19)
1 Water control	N/A	4.2	5.7	10.8
2 Dazide Enhance	1.8 kg/ha (full rate)	3.5	5.4	10.3
3 Canopy	0.505 kg/ha (3/4 rate)	2.2	2.5	7.8
4 Moddus	0.15 L/ha (1/4 rate)	2.0	2.7	8.1*
5 Pirouette	0.6 L/ha	2.0	2.9	7.6
6 Primo Maxx II	0.5 L/ha (1/4 rate)	2.1	2.2	6.3
7 Regalis Plus	0.62 kg/ha (1/2 rate)	2.2	3.0	7.6
8 Terpal	1.0 L/ha (1/2 rate)	3.1	5.3	11.3
s.e.d.			0.352	0.638
l.s.d.		n/a	0.755	1.368
F pr			<.001	<.001

Values highlighted red are significantly different to the water control

* plant height is within the target specification

Height specification for pack bedding is 8 cm – 10 cm.

French Marigold

Plants were treated with PGR at cotyledon stage seven days after sowing, and then assessed for height at transplant, 21 DAT. Moddus (0.15 L/ha) was the most effective treatment, with plants measuring 3.3 cm on average compared to 5.1 cm in the water control. Plants were assessed in week 25 and all treatments were effective, with plant height significantly shorter than the water control (**Table 12**; $p < .001$). Plants treated with Canopy (0.505 kg/ha), Moddus (0.15 L/ha) and Regalis Plus (0.62 kg/ha) were all within the target range of 8 – 10 cm. Dazide Enhance (1.8 kg/ha), Primo Maxx II (0.5 L/ha) and Terpal (1.0 L/ha) were too strong, with the shortest plants in these treatments (6.7 cm, 6.8 cm and 6.3 cm respectively).

Table 12. French Marigold: average plant height at transplant (30 May 2019, week 22, 21 DAT) and in the target marketing week (17 June 2019, week 25, 39 DAT)

Product	Dose rate (L or kg/ha)	Ave. height (cm) (30.05.19)	Ave. height (cm) (17.06.19)
1 Water control	N/A	5.1	10.5
2 Dazide Enhance	1.8 kg/ha (full rate)	3.8	6.7
3 Canopy	0.505 kg/ha (3/4 rate)	4.4	8.9*
4 Moddus	0.15 L/ha (1/4 rate)	3.3	9.0*
5 Pirouette	0.6 L/ha	4.2	7.7
6 Primo Maxx II	0.5 L/ha (1/4 rate)	3.6	6.8
7 Regalis Plus	0.62 kg/ha (1/2 rate)	3.9	9.0*
8 Terpal	1.0 L/ha (1/2 rate)	3.5	6.3
s.e.d.			0.641
l.s.d.		n/a	1.374
F pr			<.001

Values highlighted red are significantly different to the water control

* plant height is within the target specification

Height specification for pack bedding is 8 cm – 10 cm.

Phytotoxicity and quality

Cosmos

At the first assessment at transplant, and then at subsequent assessments prior to flowering, there were no signs of phytotoxicity in any of the treatments. All plants were growing well, with no signs of yellowing, distortion or chlorosis, although the foliage in Primo Maxx II (0.5 L/ha) appeared slightly paler than the water control. Flowers started to emerge at the end of week 27, and when the trial was assessed in week 28, there was evidence of petal bleach in the Primo Maxx II (0.5 L/ha) treatment (**Figure 3**). By the end of the trial (week 30), there was no

evidence of petal bleach in any treatments; new flowers in the Primo Maxx II (0.5 L/ha) treatment were less severely affected than observed in week 28.



Figure 3. Pale flowers seen in plants treated with Primo Maxx II 0.5 L/ha (right) compared to the water control (left), week 28 2019

Dianthus

There were no signs of phytotoxicity in any of the treatments either at transplant (week 23) or the first assessment (week 25). By week 26, plants treated with Primo Maxx II (0.5 L/ha) appeared slightly pale, but were marketable. Plant quality was also reduced in the Terpal (1.0 L/ha) treatment, as growth had not been controlled, and the plants were starting to look stretched.

At the final phytotoxicity assessment in week 28, there were significant differences between treatments ($p < .001$). The foliage of plants in all treatments, except for the Pirouette (0.6 L/ha) treatment, were paler than the water control. In addition, the flowers in the Terpal (1.0 L/ha) treatment had small white spots on them (**Figure 4**). Plants were monitored for a further two weeks, and no spotting occurred in any of the other treatments.



Figure 4. White spots seen on flowers of plants treated with Terpal 1.0 L/ha, week 28 2019

French Marigold

At transplant, and at each assessment post-transplant, there was no evidence of phytotoxicity in any of the treatments on French Marigold, and there were no adverse effects on plant quality. All plants grew well with no discolouration or distortion to foliage or flowers.

Flowering

A full assessment of flowering was completed at the end of each trial and the results are presented in **Table 13 - Table 15**.

Cosmos

By week 30, all of the treatments had started to flower, with the most plants in flower in the water control (50%). There were significantly fewer flowers in all treatments ($p < .001$), with the least number of plants in flower in the Canopy (0.505 kg/ha) and Moddus (0.15 L/ha) treatments (9.7% in flower).

Table 13. *Cosmos*: average percentage of plants in flower compared to the water control

Product	Dose rate (L or Kg/ha)	% of plants in flower
1 Water control	N/A	50.0
2 Dazide Enhance	1.8 kg/ha (full rate)	16.7
3 Canopy	0.505 kg/ha (3/4 rate)	9.7
4 Moddus	0.15 L/ha (1/4 rate)	9.7
5 Pirouette	0.6 L/ha	22.2
6 Primo Maxx II	0.5 L/ha (1/4 rate)	20.8
7 Regalis Plus	0.62 kg/ha (1/2 rate)	22.2
8 Terpal	1.0 L/ha (1/2 rate)	12.5
s.e.d.		6.32
l.s.d.		13.56
F pr		<.001

Values highlighted red are significantly different to the water control.

Final assessment date for flowering was 25 July 2019, week 30, 76 DAT.

Dianthus

Dianthus started to flower in week 28, with flowers present in the water control (20.3% of plants in flower), Dazide Enhance (1.8 kg/ha) (3.7% of plants in flower), Pirouette (0.6 L/ha) (3.7% of plants in flower) and Terpal (1.0 L/ha) (33.3% of plants in flower). Flowering was delayed in the other treatments.

At the end of the trial (week 30), 100% of the plants in the water control were in flower. Flowering was significantly delayed in three treatments (Moddus 0.15 L/ha, 77.8%; Primo Maxx II 0.5 L/ha, 63.0% and Regalis Plus 0.62 kg/ha, 74.1%; $p < .001$) compared with the water control. All other treatments had more than 90% of plants in flower.

Table 14. *Dianthus*: average percentage of plants in flower compared to the water control

	Product	Dose rate (L or Kg/ha)	% of plants in flower
1	Water control	N/A	100.0
2	Dazide Enhance	1.8 kg/ha (full rate)	96.3
3	Canopy	0.505 kg/ha (3/4 rate)	90.7
4	Moddus	0.15 L/ha (1/4 rate)	77.8
5	Pirouette	0.6 L/ha	92.6
6	Primo Maxx II	0.5 L/ha (1/4 rate)	63.0
7	Regalis Plus	0.62 kg/ha (1/2 rate)	74.1
8	Terpal	1.0 L/ha (1/2 rate)	96.3
	s.e.d.		6.38
	l.s.d.		13.68
	F pr		<.001

Values highlighted red are significantly different to the water control.

Final assessment date for flowering was 25 July 2019, week 30, 66 DAT.

French Marigold

Flowering was assessed in the French Marigold trial in week 26. All treatments were flowering, and there were no significant differences between treatments. Interestingly, there were more plants in flower in the majority of the treatments compared with the water control, where 31.9% of plants were in flower. Only Dazide Enhance (1.8 kg/ha) and Terpal (1.0 L/ha) had fewer plants in flower than the water control at the end of the trial (27.8% and 23.6% respectively).

Table 15. French Marigold: average percentage of plants in flower compared to the water control

	Product	Dose rate (L or Kg/ha)	% of plants in flower
1	Water control	N/A	31.9
2	Dazide Enhance	1.8 kg/ha (full rate)	27.8
3	Canopy	0.505 kg/ha (3/4 rate)	48.6
4	Moddus	0.15 L/ha (1/4 rate)	47.2
5	Pirouette	0.6 L/ha	47.2
6	Primo Maxx II	0.5 L/ha (1/4 rate)	45.8
7	Regalis Plus	0.62 kg/ha (1/2 rate)	51.4
8	Terpal	1.0 L/ha (1/2 rate)	23.6
	s.e.d.		9.78
	l.s.d.		20.97

Final assessment date for flowering was 28 June 2019, week 26, 50 DAT.

Summary of results by plant species

Cosmos 'Sonata' carmine

- All PGR treatments controlled plant growth in the plug tray compared with the water control; the most effective treatments were the Pirouette (0.6 L/ha) and (Terpal 1.0 L/ha) treatments at transplant stage (week 22).
- An overspray of Bonzi (1.0 ml/L) was applied in week 25 to prevent the plants from becoming unmarketable, prior to flowering.
- Pirouette (0.6 L/ha) was the most effective treatment, with the shortest plants by week 26 in this treatment.
- Dazide Enhance (1.8 kg/ha) was least effective. Although the plants were smaller than the water control at transplant, control was not maintained, and the plants were similar in size to the water control by week 26.
- Primo Maxx II (0.5 L/ha) caused petal bleach, although later flowers were less severely affected. No other treatments caused phytotoxicity.
- There were significantly fewer plants in flower in all treatments compared with the water control in week 30, with Canopy (0.505 kg/ha) and Moddus (0.15 L/ha) causing the greatest delay in flowering. Therefore extra time in production scheduling may be needed to ensure any flowering requirement is reached.

Dianthus 'Festival' violet

- All PGR treatments controlled plant growth in the plug tray compared with the water control; at transplant, the Pirouette (0.6 L/ha) and Moddus (0.15 L/ha) treatments were the most effective.
- Moddus (0.15 L/ha) was the most effective treatment overall, controlling growth and producing plants within the height specification.
- Primo Maxx II (0.5 L/ha) was very effective on *Dianthus*; by week 26 these plants were the shortest and below specification. However, this treatment did not cause phytotoxicity and could achieve height specification with an adjustment to the dose rate.
- Terpal (1.0 L/ha) and Dazide Enhance (1.8 kg/ha) did not control growth overall. Although the plants were shorter than the water control at transplant, control was not maintained, and by week 26, these plants were similar, or taller than the water control.

- Canopy (0.505 kg/ha), Pirouette (0.6 L/ha) and Regalis Plus (0.62 kg/ha) all gave adequate growth control, with plants just below specification in week 26.
- The foliage of plants in all treatments apart from Pirouette (0.6 L/ha) was slightly paler than the water control at the end of the trial.
- Terpal (1.0 L/ha) caused small white spots on the flowers, making the plants unmarketable.
- The percentage of plants in flower at the end of the trial was reduced in the Moddus (0.15 L/ha), Primo Maxx II (0.5 L/ha) and Regalis Plus (0.62 kg/ha) treatments.

French Marigold 'Durango' red

- All PGR treatments controlled plant growth in the plug tray compared with the water control at transplant, the Moddus (0.15 L/ha) treatment was the most effective.
- Growth control was well maintained, and by week 25, all treatments were significantly shorter. The most effective treatments were Canopy (0.505 kg/ha), Moddus (0.15 L/ha) and Regalis Plus (0.62 kg/ha).
- Terpal (1.0 L/ha), Primo Maxx II (0.5 L/ha) and Dazide Enhance (1.8 kg/ha) were possibly too strong, with plant height below specification in week 25.
- There was no evidence of phytotoxicity from any of the treatments throughout the trial.
- There were no significant effects on flowering, with more flowers in most of the PGR treatments compared to the water control. Only Dazide Enhance (1.8 kg/ha) and Terpal (1.0 L/ha) had less plants in flower at the end of the trial.

Discussion

All the PGR treatments worked well at controlling growth in the plug tray when applied to seedlings at cotyledon stage. However, the persistence of these products and the effect on plants post-transplant differed between species.

Dazide Enhance

Dazide Enhance was applied at 1.8 kg/ha (full rate) and gave mixed results across the three plant species. Height was not well controlled in the *Cosmos* or *Dianthus* trials and flowering was delayed in the *Cosmos* trial. Growth was reasonably well controlled in the French Marigold trial. Dazide Enhance (1.8 kg/ha) can be considered as an early treatment at cotyledon stage for French Marigold, but would require a post-transplant follow-up treatment for *Cosmos* and *Dianthus*.

Canopy

Canopy was applied at 0.505 kg/ha (3/4 rate) and gave good results for *Cosmos* and French Marigold. Height was well controlled throughout the two trials and plants were within the target height specification, although there were fewer open flowers at the end of the *Cosmos* trial, and more in the French Marigold trial compared to the water control. Canopy was also effective in the *Dianthus* trial at this rate, with plants just below the height specification in week 26. Canopy (0.505 kg/ha) can be considered as an early treatment at cotyledon stage for all three species, and will produce plants within the desired height specification without the need for any follow-up PGR treatments.

Moddus

Moddus was applied at 0.15 L/ha (1/4 rate). Plant height was well controlled in the *Dianthus* and French Marigold trials, with plants within the target range, but the treatment was less effective in the *Cosmos* trial. There were no signs of phytotoxicity, although flowering was delayed in the *Cosmos* and *Dianthus* trials. Moddus (0.15 L/ha) is suitable for use on *Dianthus* and French Marigold as a drench at cotyledon stage. A higher rate would likely be needed for *Cosmos*, although phytotoxic effects are unknown, and flowering would likely be delayed further.

Pirouette

Pirouette was applied at 0.6 L/ha. Height was well controlled for all three species, and there was no evidence of phytotoxicity or delays in flowering (except *Cosmos*). Pirouette (0.6 L/ha) is suitable for use on *Cosmos*, *Dianthus* and French Marigold as a drench at cotyledon stage.

Primo Maxx II

Primo Maxx II was applied at 0.5 L/ha (1/4 rate). Height was reasonably well controlled in the *Cosmos* trial, with plants just above the height specification in week 26. However, for *Dianthus* and French Marigold, the treatment may have been too strong, with plants just below the height specification. There was bleaching to the flower petals and foliage in the *Cosmos* trial, but no evidence of phytotoxicity in the other species, although fewer flowers were produced in the *Dianthus* compared to the water control. Primo Maxx II (0.5 L/ha) could be considered for use on *Dianthus* and French Marigold as a drench at cotyledon stage. It is not recommended for use on *Cosmos* due to petal bleaching.

Regalis Plus

Regalis Plus was applied at 0.62 kg/ha (1/2 rate). Height was well controlled in the *Dianthus* and French Marigold trials, but plants in the *Cosmos* trial were above the target height

specification. There was no evidence of phytotoxicity or delays in flowering for any of the species tested. Regalis Plus (0.62 Kg/ha) would be suitable for use on *Dianthus* and French Marigold as a drench at cotyledon stage. A higher rate may be required for use on *Cosmos*.

Terpal

Terpal was applied at 1.0 L/ha (1/2 rate). Growth control was good in the French Marigold trials, although potentially this rate was too strong, with plants too compact. The treatment was not effective on *Cosmos* or *Dianthus*; plants were taller than the water control at the end of the *Dianthus* trial. There was no evidence of phytotoxicity in the *Cosmos* or French Marigold trials, however the *Dianthus* flowers had white spots on them, and the foliage was paler in this treatment. Terpal (1.0 L/ha) is not recommended for use on *Dianthus* as a drench at cotyledon stage due to phytotoxicity and poor growth control. It can be considered as a drench at cotyledon stage on *Cosmos* and French Marigold, although flowering is delayed, and a higher rate may be required for growth control in *Cosmos*. The effect of a higher rate on phytotoxicity and flowering is unknown.

In this work using small plugs, 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.
- All PGR treatments were effective at controlling growth in the plug tray when applied to seedlings at cotyledon stage.
- Although a number of treatments were effective in controlling growth at plug stage, either dose rates may need to be adjusted to achieve the appropriate height specification, or a follow-up application may be required post-transplant.
- The growth control effect of a number of the treatments evaluated in this trial was sustained post-transplant. A second PGR application was not required to achieve height specifications in a number of treatments: Pirouette (0.6 L/ha) and Canopy (0.505 kg/ha) on *Cosmos*, French Marigold and *Dianthus*; Moddus (0.15 L/ha), Primo Maxx II (0.5 L/ha) and Regalis Plus (0.62 kg/ha) on *Dianthus* and French Marigold; Dazide Enhance (1.8 kg/ha) and Terpal (1.0 L/ha) on French Marigold. This is useful when product is sold in packs or small pots, and avoiding further PGR applications is seen as a benefit, however for larger added value products where a greater bulk is required it could be an issue and add to production times.

- All PGR treatments delayed flowering slightly with *Cosmos* and this should be borne in mind when scheduling production.
- Terpal (1.0 L/ha) was not effective on *Dianthus*. Dazide Enhance (1.8 kg/ha) was not effective on *Cosmos* or *Dianthus* at the label rate of 6 g/L water (1.8 kg/ha).
- Phytotoxicity was recorded in only two treatments; petal bleach on *Cosmos* due to Primo Maxx II (0.5 L/ha) and white spots on *Dianthus* flowers due to Terpal (1.0 L/ha).
- For all treatments, applications under EAMU authorisations are made at the growers own risk, and should be tested on a limited number of plants before wider use. Where successful treatments have been made under experimental permit in this trial, EAMU authorisations will be sought via AHDB where appropriate.

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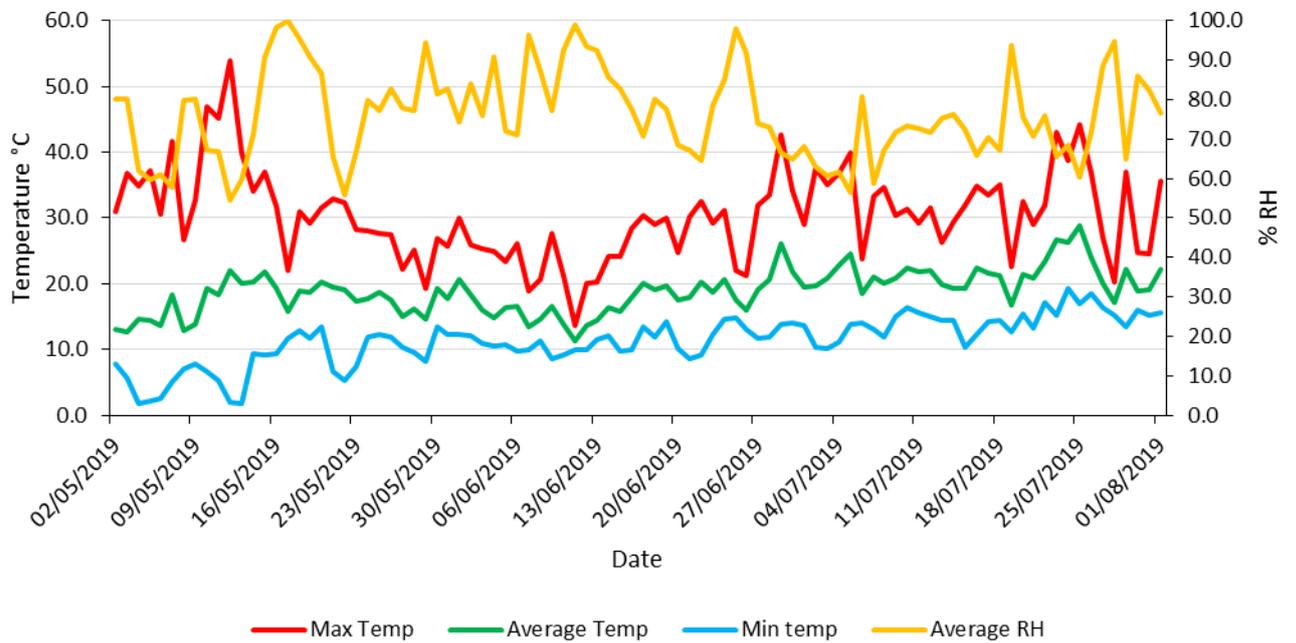
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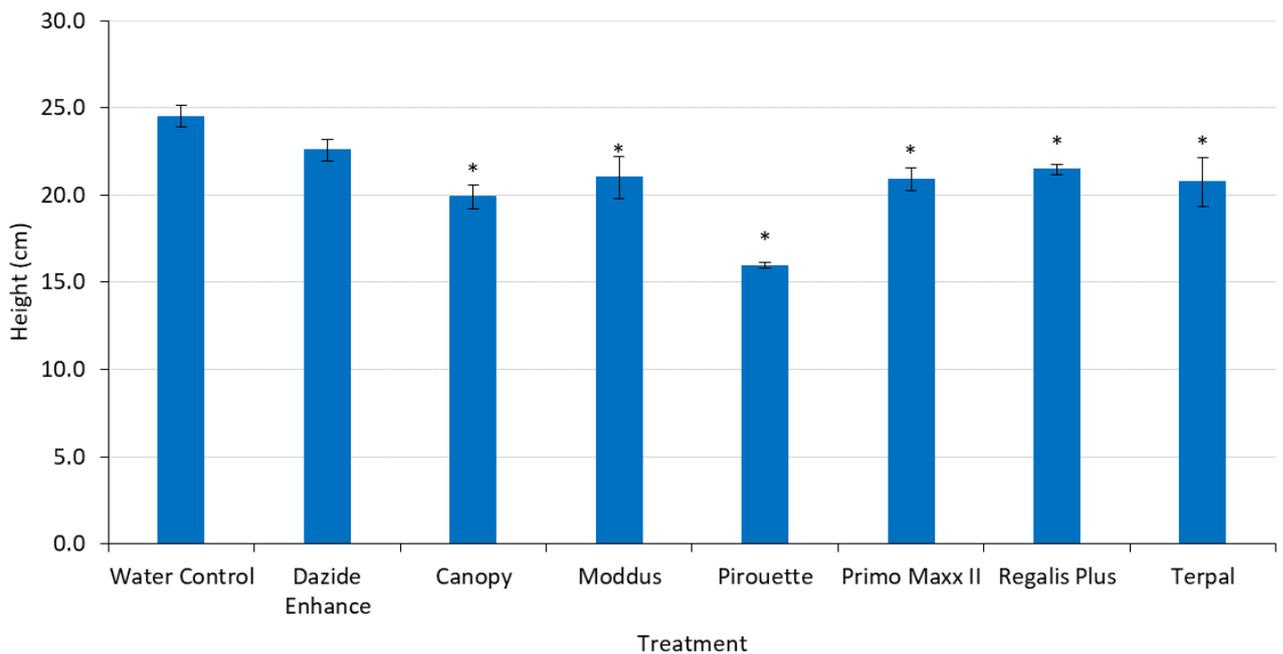
Appendix 1

Glasshouse temperature and humidity during the PGR bedding plants trial

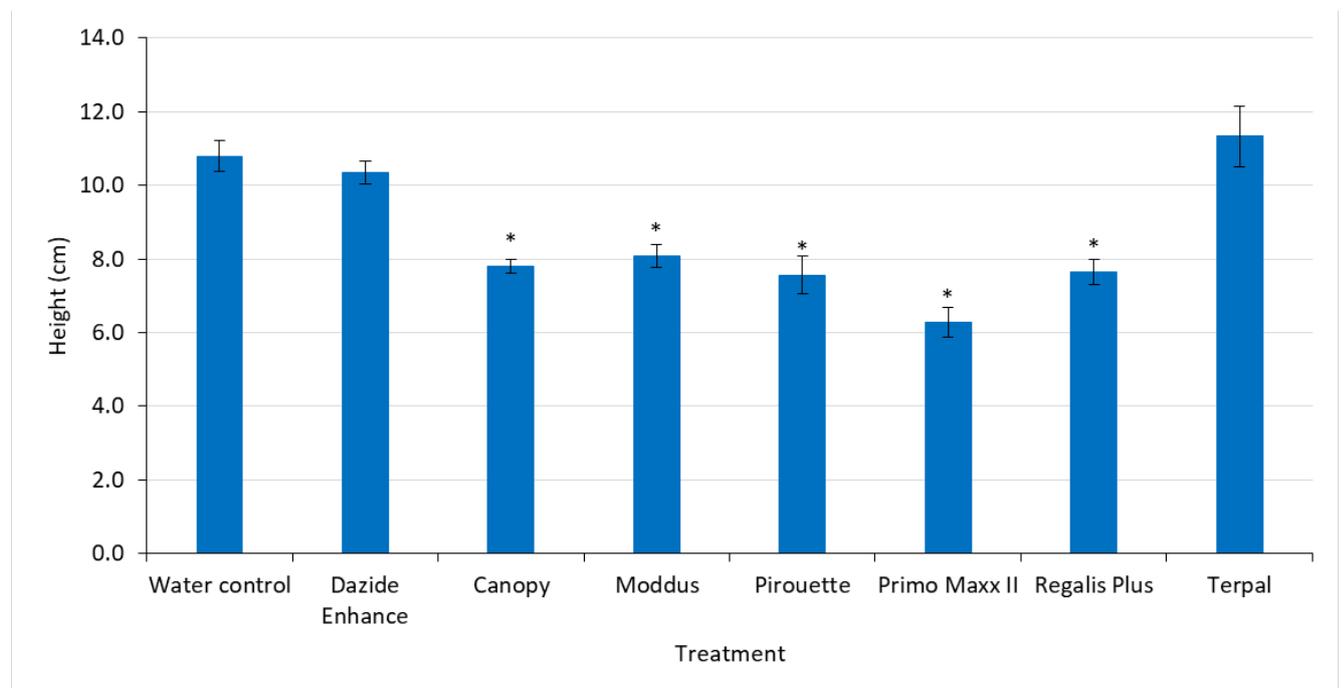


Appendix 2

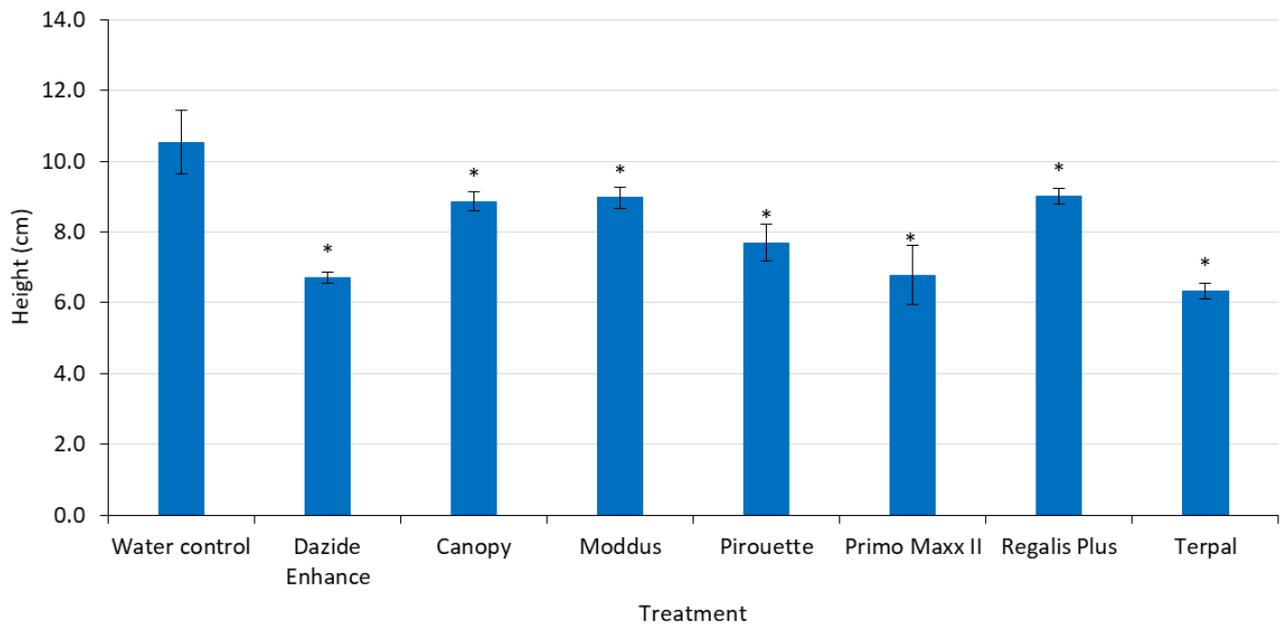
Plant height



A. *Cosmos* 'Sonata' carmine height (cm), 49 DAT (28 June 2019, week 26). All plants were treated once 20 days prior to transplant. * = treatments are significantly different to the water control ($p < .001$, I.s.d = 2.453). Height specification for *Cosmos* is 15 cm – 20 cm



B. *Dianthus* 'Festival' violet height (cm), 39 DAT (28 June 2019, week 26). All plants were treated once 17 days prior to transplant. * = treatments are significantly different to the water control ($p < .001$, I.s.d = 1.368). Height specification for pack bedding is 8 cm – 10 cm



C. French Marigold 'Durango' red height (cm), 39 DAT (17 June 2019, week 25). All plants were treated once 21 days prior to transplant. * = treatments are significantly different to the water control ($p < .001$, l.s.d = 1.374). Height specification for pack bedding is 8 cm – 10 cm

Appendix 3

Photographic records of treatment effects

A. *Cosmos* 'Sonata' carmine - effects of treatments compared with the water control, week 31 2019

	
<p>Water control (left) vs. Dazide Enhance 1.8 kg/ha</p>	<p>Water control (left) vs. Canopy 0.505 kg/ha</p>
	
<p>Water control (left) vs. Moddus 0.15 L/ha</p>	<p>Water control (left) vs. Pirouette 0.6 L/ha</p>
	
<p>Water control (left) vs. Primo Maxx II 0.5 L/ha</p>	<p>Water control (left) vs. Regalis Plus 0.62 kg/ha</p>
	
<p>Water control (left) vs. Terpal 1.0 L/ha</p>	

B. *Dianthus* 'Festival' violet - effects of treatments compared with the water control, week 30 2019

	
<p>Water control (left) vs. Dazide Enhance 1.8 kg/ha</p>	<p>Water control (left) vs. Canopy 0.505 kg/ha</p>
	
<p>Water control (left) vs. Moddus 0.15 L/ha</p>	<p>Water control (left) vs. Pirouette 0.6 L/ha</p>
	
<p>Water control (left) vs. Primo Maxx II 0.5 L/ha</p>	<p>Water control (left) vs. Regalis Plus 0.62 kg/ha</p>
	
<p>Water control (left) vs. Terpal 1.0 L/ha</p>	

C. French Marigold 'Durango' red - effects of treatments compared with the water control, week 28 2019

	
Water Control	Dazide Enhance 1.8 kg/ha
	
Canopy 0.505 kg/ha	Moddus 0.15 L/ha
	
Pirouette 0.6 L/ha	Primo Maxx II 0.5 L/ha
	
Regalis Plus 0.62 kg/ha	Terpal 1.0 L/ha