

Project title:	The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers. <i>Objective 3. To evaluate efficacy and phytotoxicity of a range of plant growth regulators (PGRs), a fungicide, a seaweed based nutrient and Stena (adjuvant) on Poinsettia, and their effect on marketability.</i>
Project number:	PO 019b
Project leader:	Dr Jill England, ADAS Boxworth
Report:	Final Report 31 March 2020
Previous report:	Annual report, 31 March 2019
Key staff:	Dr Jill England (ADAS), Senior Horticulture Consultant Chloe Whiteside (ADAS), Horticulture Consultant David Talbot (ADAS), Horticulture Consultant Megan-Rose Beard (ADAS), Senior Research Technician Chris Need, Need Consulting Ltd
Location of project:	Roundstone Nurseries, Pagham Rd, Bognor Regis, Chichester PO20 1LL
Industry Representative:	Caroline Shove, Bryants Nurseries Ltd, Water Lane, Bovingdon, Hemel Hempstead, Hertfordshire, HP3 0NA
Date project commenced:	1 April 2019
Date project completed:	31 March 2020

DISCLAIMER

While the Agriculture and Horticulture Development Board seeks to ensure that the information contained within this document is accurate at the time of printing, no warranty is given in respect thereof and, to the maximum extent permitted by law the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

© Agriculture and Horticulture Development Board [2020]. No part of this publication may be reproduced in any material form (including by photocopy or storage in any medium by electronic mean) or any copy or adaptation stored, published or distributed (by physical, electronic or other means) without prior permission in writing of the Agriculture and Horticulture Development Board, other than by reproduction in an unmodified form for the sole purpose of use as an information resource when the Agriculture and Horticulture Development Board or AHDB Horticulture is clearly acknowledged as the source, or in accordance with the provisions of the Copyright, Designs and Patents Act 1988. All rights reserved.

All other trademarks, logos and brand names contained in this publication are the trademarks of their respective holders. No rights are granted without the prior written permission of the relevant owners.

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

Chloe Whiteside

Horticulture Consultant

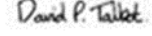
ADAS

Signature  Date 30 April 2020

David Talbot

Horticulture Consultant

ADAS

Signature  Date 30 April 2020

Report authorised by:

Dr Barry Mulholland

Head of Horticulture

ADAS

Signature  Date 30 April 2020

Contents

Grower Summary	1
Headline	1
Background	1
Summary	1
Financial benefits	3
Action points.....	4
Science Section.....	5
Introduction	5
Background	5
Aims and objectives	9
Methods and materials	9
Results	16
Discussion	22
Conclusions.....	23
Appendix 1	25
Appendix 2	26
Appendix 3	31
Appendix 4	34
Appendix 5	36
Appendix 6	39

Grower Summary

Headline

- Bonzi (paclobutrazol, 0.35 ml/L), Terpal (ethephon + mepiquat chloride, 1.67 ml/L) and Stablan 750 (chlormequat) provided effective growth control of Poinsettia alone and within spray programmes.
- The addition of the adjuvant Stena effectively halved the dose rate required of Stablan 750 and Terpal to achieve a 'full dose rate' effect on growth.
- Bonzi had a stronger effect when applied in water volumes greater than 300 L/ha.
- Control (seaweed-based nutrient) and Topas (penconazole) are safe to use on Poinsettia (as a nutrient and fungicide respectively), but may impact plant height.

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 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), a fungicide, a seaweed based nutrient and Stena (adjuvant) on Poinsettia, and their effect on marketability.*

Summary

Whilst growers use a range of cultural methods (e.g. temperature manipulation, deficit irrigation and management of the nutrient supply) to control plant growth where possible, lack of cost effective plant growth regulators (PGRs) approved for use on protected ornamentals would potentially reduce the range of products that can be produced profitably within challenging customer specifications. PGRs are particularly important when used to hold mature crops at specified height during periods of low demand where other physical/cultural methods could lead to unmarketable plants. PGRs, in conjunction with techniques such as graphical tracking, ensure poinsettias meet multiple retailer specifications throughout the production process regardless of environmental growing conditions.

A range of plant growth regulators, a fungicide, a seaweed-based fertiliser and an adjuvant (**Table 1**) were trialled on the Poinsettia variety 'Infinity' (Dummen) at Newey Roundstone Nurseries, Chichester for phytotoxicity and efficacy in controlling height. Rooted cuttings were potted into 13 cm pots (peat and perlite mix; liquid feed using Peters Excel Grower 15:5:15 + 7 CAO + 3 MgO + TE + calcium nitrate applied to an EC of 2.0) in week 30 and pinched in week 33. The trial was set out on 14 open-mesh benches covered with capillary matting and mypex prior to the first treatment. Plants were spaced in weeks 37 (9 September 2019) and 43 (22 October 2019).

Plants were arranged as two trials; the main (fully replicated) trial, treatments 1-13 (**Table 2**) and observation (non-replicated) plots, treatments OBS1-3 (**Table 3**). For the main trial, five treatment applications were made between weeks 39 and 43, followed by an overspray of Bonzi (0.50 ml/L, 300 L/ha water) to all plots except for the water only control in week 44. Graphical tracking was used to confirm if products would be applied, as used in commercial practice. Plant height was measured weekly from the top of the pot to the base of the tallest growing tip. Plant height graphs with graphical tracking are presented in **Appendix 2**. For the observation plots, either a single treatment application (OBS 1 and OBS 3), or six treatment applications (OBS 2) were made. All products were applied under full or EAMU approval (**Table 1**).

Sprays were applied by hand using a backpack and a 1.5 m boom (three 02f110 nozzles) to achieve a fine spray quality, in a water volume of 300 L/ha, except for treatment T10 (Bonzi, 0.35 ml/L) which was applied in 600 L/ha water. All treatments were applied during late afternoon / early evening with shade screens placed over the crop prior to treatment when appropriate. Growing media was moist when treatments were applied, and plants were not watered for 24 hours after treatment.

Table 1. PGR product list and approval status

T	Product		Active ingredient	Approval status
1	Terpal (MAPP 16463)	PGR	ethephon and mepiquat (as chloride)	EAMU 0151/18
2	Bonzi (MAPP 17095)	PGR	paclobutrazol	Label approval
3	Stabilan 750 (MAPP 09303)	PGR	chlormequat	EAMU 1416/17
4	Stena (ADJ 0895)	Adjuvant	polyglycerol based adjuvant	Label approval
5	Topas (MAPP 16765)	Fungicide	penconazole	EAMU 0169/19
6	Control	Fertiliser	seaweed based nutrients	n/a

Table 2. Main trial. Treatment list 2019

Treatment	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6**
1	Water	Water	Water	Water	Water	Water
2	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
3	Stabilan 750 + Stena, 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Stabilan 750 + Stena, 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
4	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
5	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
6	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
7	Stabilan 750 + Stena, 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Stabilan 750 + Stena, 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena, 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
8	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
9	Bonzi, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
10*	Bonzi, 0.35 ml/L; 0.21 L/ha	Bonzi, 0.35 ml/L; 0.21 L/ha	Bonzi, 0.35 ml/L; 0.21 L/ha	Bonzi, 0.35 ml/L; 0.21 L/ha	Bonzi, 0.35 ml/L; 0.21 L/ha	Bonzi, 0.35 ml/L; 0.21 L/ha
11	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Terpal, 1.67 ml/L; 0.5 L/ha	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Stabilan 750, 0.5 ml/L; 0.15 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
12	Topas, 1.67 ml/L; 0.5 L/ha	Topas, 1.67 ml/L; 0.5 L/ha	Topas, 1.67 ml/L; 0.5 L/ha	Topas, 1.67 ml/L; 0.5 L/ha	Topas, 1.67 ml/L; 0.5 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha
13	Topas, 0.83 ml/L; 0.25 L/ha	Topas, 0.83 ml/L; 0.25 L/ha	Topas, 0.83 ml/L; 0.25 L/ha	Topas, 0.83 ml/L; 0.25 L/ha	Topas, 0.83 ml/L; 0.25 L/ha	Bonzi, 0.35 ml/L; 0.105 L/ha

*Treatment 10 applied in 600 L/ha water rate. All other treatments applied at 300 L/ha. **Final holding treatment

Table 3. Observational plots. Treatment list 2019

Treatment*	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6
Obs 1	Topas, 3.33 ml/L; 1.0 L/ha	-	-	-	-	-
Obs 2	Control 5.0 ml/L; 1.5 L/ha	Control 5.0 ml/L; 1.5 L/ha	Control 5.0 ml/L; 1.5 L/ha	Control 5.0 ml/L; 1.5 L/ha	Control 5.0 ml/L; 1.5 L/ha	Control 5.0 ml/L; 1.5 L/ha
Obs 3	Control 10.0 ml/L 3.0 L/ha	-	-	-	-	-

*Treatments applied at 300 L/ha

Following the final assessment in week 47, six plants from each of the main trial treatments including the water control, and two plants from each of the observational plots, were sleeved, placed in cardboard boxes which were open at the top, and transferred to ADAS Boxworth, where they were then entered into the shelf life room (20°C). The plants remained boxed for three days (no light). After three days, three plants from each of the main trial treatments and one plant from each of the observational plots, were removed from the boxes and placed onto the benches in a randomised trial design, with a saucer beneath each pot. The lights were turned on, set to 12 hours light/dark, and the sleeves remained on the plants. Plants were irrigated by hand to the saucer as and when required. The sleeves were removed after a further seven days. Plants remained in the shelf life room until 02 January 2020 (week 1).

None of the treatments included in this trial had a significant adverse effect on the number of heads per plant or cyathia quality, and no phytotoxicity was recorded for any treatment. The target height specification was 22 – 28 cm.

- **Stabilan 750** (0.5 ml/L) is the standard commercial treatment for Poinsettia and it was effective as expected (Treatment 2). In this treatment it was followed by applications of Bonzi (0.35 ml/L) as use of Stabilan 750 is now restricted to two applications per crop (EAMU 1416/17). When applied at the lower rate of 0.25 ml/L and combined with the adjuvant **Stena** (2.5 ml/L), height control was comparable to applying Stabilan 750 alone at the higher rate (0.5 ml/L), and bract size was slightly larger. Plants in both treatments scored well in shelf life.
- **Terpal** again proved to be an effective PGR on Poinsettia, producing plants within the height specification with no phytotoxicity (Treatment 4, 1.67 ml/L). This treatment achieved the same bract quality score as Stabilan 750 (/ Bonzi), overcoming issues with small bract size recorded in previous trials. These results indicate that 1.67 ml/L is an appropriate rate for use on Poinsettia. When Terpal was applied at the lower rate of 0.83 ml/L and combined with the adjuvant **Stena** (2.5 ml/L), height control was comparable to applying Terpal alone

at the higher rate (1.67 ml/L), and bract size was slightly larger. Plants in both treatments scored well in shelf life.

- **Bonzi** achieved growth control at all rates and water volumes used, without causing phytotoxicity or affecting bract, cyathia or head development compared with the water control. Three Bonzi treatments were evaluated, two dose rates (0.35 ml/L and 0.5 ml/L), with the 0.35 ml/L rate applied in 300 and 600 L/ha water. The two water rates were included as growers using Ripa sprayers need a higher water rate to propel pesticides to the furthest reaches of the crop. However, using the higher water rate also increases the volume of active ingredient intercepted by each plant. All three treatments controlled Poinsettia growth below 28 cm, with a greater effect at the higher dose rate than the lower dose rate (300 L/ha water); and at the higher water volume (600 L/ha water) than the lower volume (300 L/ha water). When translating the recommendations from this trial, growers will need to reduce dose rates when applying in higher volumes of water. Growers should always trial new products and rates on a small number of plants prior to wide scale use.
- **Spray programmes.** Three spray programmes were included in this trial; these were combinations of Stablan 750 Terpal and Stena and were designed to identify any benefit of early or later applications of Terpal and Stablan 750 compared with other treatments. The spray programmes were: Stablan 750 followed by Terpal (Treatment 6), Stablan 750 + Stena followed by Terpal + Stena (Treatment 7), and Terpal followed by Stablan 750 (Treatment 11). All of these treatments produced Poinsettias that were within the height specification, with no phytotoxicity, and with comparable cyathia scores and average number of heads per plant. However, bract size was larger in treatments where Stablan 750 applications (with and without Stena, Treatments 6 and 7) were followed by Terpal; bract size in these treatments was also larger than when Stablan 750 was followed by Bonzi (Treatment 2).
- **Topas** (fungicide), produced no phytotoxic effects on Poinsettia at any of the dose rates used in this trial. However, when applied at the two higher rates (Treatments 12 and OBS1), it did have an effect growth, producing shorter plants than the water control. At the higher rate (OBS1), the effect on growth was due to a single application at double the EAMU rate. Growers will therefore need to take into account when applying Topas to control powdery mildew, that although it is safe to use on Poinsettia, it may reduce plant height at higher rates.
- The seaweed-based fertiliser **Control** applied at label rate (6 applications, 5.0 ml/L) and at double the rate (1 application, 10.0 ml/L) did not cause phytotoxicity and treated Poinsettia achieved comparable quality and cyathia scores. However, plants were shorter at both dose rates. Slightly fewer heads were produced per plant in at the higher dose rate

(OBS3, 10.0 ml/L, average 3.6 heads per plant) compared with the lower dose rate treatment (OBS2, 5.0 ml/L, average 4.2 heads per plant) and the water control (average 4.7 heads per plant).

- The adjuvant **Stena** (previously coded as HDC P006) again proved effective in reducing the PGR dose rate require to achieve comparable height control when used at the label rate (2.5 ml/L) in combination with Stabilan 750 and Terpal.

In summary, all PGR treatments were effective in controlling Poinsettia growth to achieve the height specification, with no phytotoxicity. The adjuvant Stena can be applied at the label rate with Terpal and Stabilan 750, but the dose rate of the PGR needs to be reduced by 50% to achieve the height specification. The order of Terpal and Stabilan 750 in spray programmes has minimal effect on Poinsettia growth, but bract size was slightly smaller when Terpal was followed by Stabilan 750. Bonzi provided effective growth control, but has a stronger effect when applied in water volumes greater than 300 L/ha. Control (nutrient) and Topas (fungicide) are safe to use on Poinsettia but may affect plant height.

Financial benefits

Although water deficit irrigation is currently being examined as a means of controlling growth in Poinsettia, it is yet to be fully adopted by the majority of industry and short term alternatives are still required to ensure compliance with retailer height specifications.

The evaluation of plant growth regulators (PGRs) either approved in the UK or in other European Countries for use on Poinsettia, 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 PGR spray solution of the products included in this trial at the specified rates ranges 0.2p from to 3.3p (**Table 4**).

Table 4. Product costs (non-discounted, excluding VAT and labour costs for application)

Product	Cost of active (p/ml)	Cost /L of spray (p)
Terpal (1.67 ml/L)	1.7	2.8
Bonzi (0.35 ml/L)	9.5	3.3
Stabilan 750 (0.5 ml/L)	0.3	0.2
Stena (2.5 ml/L)	2.0	5.0
Topas (1.67 ml/L)	7.7	12.8

Control	2.7	13.4
---------	-----	------

Due to the fact that chlormequat based products are used in cereal production to control growth and minimise stem lodging, Stabilan 750 is an inexpensive PGR to purchase due to the market size. Other PGR products, which are not aimed at broad acre crops, tend to be more expensive as a result, and Terpal is around 14x the cost per litre of spray solution in comparison. Relative to Bonzi, it is slightly less expensive per litre of spray solution.

The adjuvant Stena proved successful, allowing a reduction in the rates of both Terpal and Stabilan 750 applied, but its cost per litre of spray solution in relation to any PGR cost savings may limit its uptake by industry based on a purely financial basis.

Action points

- Terpal is already approved for use as a plant growth regulator in ornamental plant production (EAMU 0151/18), so can be commercially adopted. It has potential for use as a PGR with low risk of phytotoxicity on Poinsettia at a rate of 1.67 ml/L. (There may be a risk of the ethephon used in the formulation promoting unwanted side branches and/or cyathia abortion, but this has not been seen in the three years of trials completed in the 2017/18, 2018/19 and 2019-20 seasons).
- The combination of Terpal and Stabilan 750 with the adjuvant Stena at the recommended rate (2.5 ml/L) enables a reduction of dose rate of these PGRs, but a comparative costing (with and without Stena) should be undertaken as part of any adoption process.
- To avoid any potential reductions in bract size Terpal should be applied after Stabilan 750 within spray programmes.
- Bonzi has long been used on Poinsettia without crop damage, but care should be used when determining dose rates. The rates used in this trial (0.35 ml/L and 0.50 ml/L in 300 L/ha water; and 0.35 ml/L in 600 L/ha water) did not cause excessive height control under the growing conditions experienced in the 2019-20 Poinsettia season.
- 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. 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 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 central host nursery for the BPPC. The agreed project 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), a fungicide, a seaweed based nutrient and Stena (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) and an adjuvant (Stena) for use on bedding and pot plants was prompted by label changes to the plant growth regulator Stablan 750 (chlormequat), including the reduction of the application rate to 0.5 ml/L (EAMU 1416/17) with a maximum of two applications per annum. At the start of this trial programme, the PGRs selected had either been trialled in Denmark with promising results on bedding and pot plants, were new to the market or had recently received CRD approval for use on related crops in the UK, however any phytotoxic effects and efficacy of these chemicals on Poinsettia grown under UK conditions were currently unknown. Subsequently, all products used in the 2019 trial may be applied either under full label approval or EAMU approval. The products included in the 2019 trial were:

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). However, in trials on Poinsettia 'Scandic Early' (GASA Young Plants), Terpal was not effective when applied at 0.1% (Hartvig and Hjelmroth, 2016). The ethephon component of this product breaks down within the plant to produce ethylene, which may increase bud development, leading to the production of multiple weak shoots that would need to be removed prior to marketing, or cause cyathia drop. The Terpal label originally stated that the addition of a non-ionic adjuvant (Activator 90, 40 ml per 100 L of spray solution) can enhance the efficacy of Terpal. EAMU 0151/18 has been issued for the use of Terpal as a plant growth regulator for container grown ornamental plant production, applied as a foliar spray.

Bonzi (4 g/L paclobutrazol, Syngenta UK Ltd) has label approval for spray application as a PGR over protected ornamentals in the UK. Bonzi is known to control growth in Poinsettia without phytotoxicity, although suitable rates need to be determined.

Stabilan 750 (750 g/L chlormequat, Nufarm UK Limited) is approved for use for spray application as a PGR over protected ornamentals in the UK under EAMU 1416/17. The maximum individual dose has been reduced to 0.5 ml/L with a maximum of two treatments per year.

Topas (100 g/L penconazole, Syngenta UK Ltd) is a triazole fungicide. Poinsettia are susceptible to powdery mildew, therefore with the current unavailability of Systhane 20EW Topas was included to evaluate any phytotoxic effects. Topas is approved for use on protected ornamentals under EAMU 0169/19.

Stena (polyglycerol based adjuvant, Syngenta UK Ltd, marketed as Stena in the UK and Elasto G5 in the Netherlands) was approved for use as an adjuvant in ornamental plant production in 2019. The product promotes leaf surface wetting and can improve the foliar uptake of an active ingredient. It is most effective when combined with hydrophilic active ingredients, e.g. chlormequat and daminozide. Tests using Stena (in the Netherlands as Elasto G5) with daminozide have demonstrated that addition of this adjuvant can halve the amount of daminozide required to achieve the same amount of growth control. The product is recommended by SURfaPLUS for the following ornamental crops: *Hydrangea*, *Petunia*, *Verbena*, *Sutera*, *Campanula*, Sunflower, *Platycodon*, *Viola cornuta*, potted *Chrysanthemum*, *Dahlia*, *Dahlietta*, *Solanum rantonettii*, *Lavendula* and *Kalanchoë*. Stena has been marketed in the Netherlands since 2006 with no crop damage (phytotoxicity) currently reported. The product does not require a hazard warning label in accordance with EC Directives for Classification. The MSDS (English) can be downloaded at www.surfaplus.com under SURfaPLUS Trading International. Trials of Stena (as Elasto G5) with chlormequat (CCC) were carried out by Beekenkamp in 2017 on Poinsettia 'Astro Red', 'Hera Red' and 'Leona

Red', applied as: 1. CCC 1.0 cc/L; 2. CCC 0.5 cc/L + Elasto G5 0.25 cc/L; and 3. CCC 0.25 cc/L + Elasto G5 0.25 cc/L. All had similar effects on plant height although it should be noted that growth was restricted in 2017 due to general growth conditions.

Control is a seaweed based fertiliser with added calcium chloride. As a relatively new product, limited independent research is available on the effects of this product. Growers report that Poinsettias treated with Control at the recommended rate are shorter than untreated plants (as a side effect), although without causing scorch or similar phytotoxic effects. Calcium chloride is known to reduce plant growth, depending on dose rate. It is also expected that the seaweed element of this product contains plant hormones such as cytokinin; effects include promotion of cell division, leaf expansion, retarded senescence, and increased branching and flower / fruit number and therefore could benefit plant quality. Analysis indicates that Control provides potassium, phosphorus, magnesium, calcium, nitrate-N and minimal ammonia-N. Salts are present in relatively high proportions (chloride, sodium and sulphate). The manufacturer recommends lower application rates (e.g. half the label rate) to soft or sensitive bedding plants, for example, to prevent scorch.

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 two 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; and 2) triazoles e.g. paclobutrazol (Bonzi). The exception is ethephon (a component of Terpal) which breaks down within the plant to produce the plant hormone, ethylene. Of the two groups the triazoles are the most active, although levels of activity varies within this group.

Summary of the 2017 trial results

Regalis Plus caused bleaching at 2.5 kg/ha (single application, observation trial), 1.25 kg/ha and 0.625 kg/ha (three applications, replicated trial). However, in a separate observation trial single plants were treated with a single application at 1.25 kg/ha and 0.625 kg/ha and no phytotoxicity occurred. Treatments achieved height control compared to Stabilan 750 and the untreated control. Continual agitation of the spray solution is required to avoid deposits. The label requirement to leave three weeks between applications meant that only three applications were made within the main trial in 2017.

Severe phytotoxicity occurred in the main trial due to the cumulative effect of the five treatments of HDC P005, both at 2.25 L/ha and 1.125 L/ha and the observation trial (4.5 L/ha, single application). In all cases, plants were shorter than the Stabilan 750 and control plots.

The first application was applied six weeks after pinching, and by three weeks after treatment plants in the untreated control were starting to develop colour. This suggests there may be potential to apply early in the production process at a lower rate to achieve height control without phytotoxicity.

Severe phytotoxicity occurred in the main trial due to the cumulative effect of the five applications of Primo Maxx II, both at 2.0 L/ha and 1.0 L/ha. Phytotoxicity also occurred in the observation trial (4.0 L/ha, single application).

In 2017, Terpal was applied with the authorised non-ionic wetter Activator 90 as indicated on the label (40 ml per 100 L of spray solution). Terpal was the most promising of the products tested. Phytotoxicity occurred in the observation trial at double rate (4.0 L/ha), developing towards the end of the trial. In the main trial, plants had good leaf and bract colour after five applications, but the bracts were slightly small at the rates used (2.0 L/ha and 1.0 L/ha). Good height control was achieved, offering the potential for good control at lower rates.

Summary of the 2018 trial results

A number of recommendations were produced as a result of the 2018 trial:

- **Bonzi:** Good efficacy, no phytotoxicity up to week 44 (0.25 ml/L), good shelf life performance, cost effective.
- **Terpal:** Recommend use at 1.67 ml/L (0.5 L/ha) dose rate or lower. Good efficacy, no phytotoxicity, good shelf life performance, cost effective.
- Consider a programme using Terpal during the growth phase and Bonzi nearer marketing to exploit the relative characteristics of each growth regulator.
- The adjuvant **Stena** (previously coded as HDC P006) effectively halved the dose rate of Stabilan 750 and Terpal required.
- **Regalis Plus** had limited efficacy and was the most expensive of the products tested. Use was restricted as the EAMU required three weeks between applications.
- **Canopy** (previously coded as HDC P005) and **Primo Maxx II** caused severe phytotoxicity and were not recommended for use on Poinsettia.

A range of PGRs and the adjuvant Stena, a fungicide and a seaweed based nutrient were tested on Poinsettia via spray application under UK conditions during the 2019 season. The fungicide Topas and the seaweed based nutrient Control were evaluated for any phytotoxic effects.

Aims and objectives

Objective: To evaluate the efficacy and phytotoxicity of a range of plant growth regulators (PGRs) (either approved in the UK or in other European Countries), a fungicide, a seaweed based nutrient and Stena (adjuvant) on Poinsettia, and their effect on marketability.

Specific objective 1: To evaluate the efficacy of treatment combinations (spray application) of up to three PGRs on Poinsettia.

Specific objective 2: To evaluate any phytotoxic effects of treatment combinations (spray application) of up to three PGRs on Poinsettia.

Specific objective 3: To evaluate the efficacy of up to two PGRs when applied with Stena on Poinsettia.

Specific objective 4: To evaluate any phytotoxic effects of up to two PGRs, in combination with Stena on Poinsettia.

Specific objective 5: To evaluate any phytotoxic effects of one fungicide (spray application) on Poinsettia (single observational plots only).

Specific objective 6: To evaluate any phytotoxic effects of one seaweed based fertiliser (spray application) on Poinsettia (single observational plots only).

Specific objective 7: To produce quality plants for the UK market.

Specific objective 8: To produce plants which sleeve well, are upright and are well furnished with leaves.

Specific objective 9: To carry out a shelf life trial of plants from the most promising treatments.

Specific objective 10: To carry out a financial assessment of the most promising treatments.

Methods and materials

Site and crop production details

A range of plant growth regulators, a fungicide and a seaweed based fertiliser (**Table 5**) were trialled on the Poinsettia variety 'Infinity' (Dummen) at Newey Roundstone Nurseries, Chichester for phytotoxicity (PGRs, fungicide and fertiliser) and efficacy in controlling height (PGRs). Rooted cuttings were potted into 13 cm pots (peat and perlite mix; Peters Excel Grower 15:5:15 + 7 CAO + 3 MgO + TE + calcium nitrate applied to an EC of 2.0) in week 30 and pinched in week 33 (**Figure 1**). The trial was set out on 14 open-mesh benches covered

with capillary matting and mypex prior to the first treatment. Plants were spaced in weeks 36 (9 September 2019) and 43 (22 October 2019).

Plants were arranged as two trials, the main (fully replicated) trial, treatments 1-13 (**Table 5**); and observation (non-replicated) plots, treatments OBS1-3 (**Table 6**). For the main trial, five treatment applications were applied between weeks 39 and 43, followed by an overspray of Bonzi (0.50 ml/L, 300 L/ha water) to all plots except for the water only control in week 44. Graphical tracking was used to confirm if products would be applied, as used in commercial practice. For the observation plots, either a single treatment application (OBS 1 and OBS 3), or six treatment applications were made. All products were applied under full or EAMU approval (**Table 7**).

Sprays were applied by hand using a backpack and a 1.5 m boom (three 02f110 nozzles) to achieve a fine spray quality, in a water volume of 300 L/ha, except for treatment T10 (Bonzi, 0.35 ml/L) which was applied in 600 L/ha water. All treatments were applied during late afternoon / early evening with shade screens placed over the crop prior to treatment when appropriate. Growing media was moist when treatments were applied, and plants were not watered for 24 hours after treatment.



Figure 1. Poinsettia 'Infinity' rooted cuttings at potting (week 30) and after pinching (week 34)

Table 5. Main trial. Treatment list

Treatment	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	6**
1	Water	Water	Water	Water	Water	Water
2	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
3	Stabilan 750 + Stena. 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Stabilan 750 + Stena. 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
4	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
5	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
6	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
7	Stabilan 750 + Stena. 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Stabilan 750 + Stena. 0.25 ml/L + 2.5 ml/L; 0.075 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Terpal + Stena. 0.83 ml/L + 2.5 ml/L; 0.25 L/ha + 0.75 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
8	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
9	Bonzi, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
10*	Bonzi, 0.35 ml/L, 0.21 L/ha	Bonzi, 0.35 ml/L, 0.21 L/ha	Bonzi, 0.35 ml/L, 0.21 L/ha	Bonzi, 0.35 ml/L, 0.21 L/ha	Bonzi, 0.35 ml/L, 0.21 L/ha	Bonzi, 0.35 ml/L, 0.21 L/ha
11	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Terpal, 1.67 ml/L, 0.5 L/ha	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Stabilan 750, 0.5 ml/L, 0.15 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
12	Topas, 1.67 ml/L, 0.5 L/ha	Topas 1.67 ml/L 0.5 L/ha	Topas 1.67 ml/L 0.5 L/ha	Topas 1.67 ml/L 0.5 L/ha	Topas 1.67 ml/L 0.5 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha
13	Topas, 0.83 ml/L, 0.25 L/ha	Topas, 0.83 ml/L, 0.25 L/ha	Topas, 0.83 ml/L, 0.25 L/ha	Topas, 0.83 ml/L, 0.25 L/ha	Topas, 0.83 ml/L, 0.25 L/ha	Bonzi, 0.35 ml/L, 0.105 L/ha

*Treatment 10 applied in 600 L/ha water rate. All other treatments applied at 300 L/ha. **Final holding treatment

Table 6. Observational plots. Treatment list

Treatment	Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6*
Obs 1	Topas. 3.33 ml/L 1.0 L/ha	-	-	-	-	-
Obs 2	Control 5.0 ml/L 1.5 L/ha	Control 5.0 ml/L 1.5 L/ha	Control 5.0 ml/L 1.5 L/ha	Control 5.0 ml/L 1.5 L/ha	Control 5.0 ml/L 1.5 L/ha	Control 5.0 ml/L 1.5 L/ha
Obs 3	Control 10.0 ml/L 3.0 L/ha	-	-	-	-	-

*Final holding treatment. Treatments applied at 300 L/ha.

Table 7. PGR product list and approval status

T	Product		Active ingredient	Approval status
1	Terpal* (MAPP 16463)	PGR	ethephon and mepiquat (as chloride)	EAMU 0151/18
2	Bonzi (MAPP 17095)	PGR	paclobutrazol	Label approval
3	Stabilan 750 (MAPP 09303)	PGR	chlormequat	EAMU 1416/17
4	Stena (ADJ 0895)	Adjuvant	polyglycerol based adjuvant	Label approval
5	Topas (MAPP 16765)	Fungicide	penconazole	EAMU 0169/19
6	Control	Fertiliser	seaweed based nutrients	n/a

Pesticide applications

Plants were monitored for pests and disease throughout the trial. Insecticides applied during production were as follows:

- Thrips, whitefly: *Beauveria bassiana* GHA (as Botanigard), 0.62 g/L, 1 application 31/07/2019
- Whitefly: flonicamid (as Mainman, EAMU 0045/13), 0.14 g/L, 1 application, 06/08/2019
- Pythium: metalaxyl-M (as Subdue), 12.5 ml/L, 1 application, 10/08/2019
- Thrips: spinosad (as Conserve), 0.475 ml/L, 1 application, 13/08/2019

Shelf life trial

Following the final assessment in week 47, six plants from each of the promising treatments, along with the water control, were sleeved, placed in cardboard boxes which were open at the top, and transferred to ADAS Boxworth, where they were then entered into the shelf life room. The room was set to 20°C, and the plants were kept in the room, in the boxes, for three days, with no light. After three days, three plants from each treatment were removed from the boxes and placed onto the benches in a randomised trial design, with a saucer placed below each pot (**Figure 2**). The temperature remained at 20°C throughout the shelf life period, and the

lights were set to 12 hours light/dark. Plants were irrigated by hand as and when required. The sleeves remained on for a further seven days, and were then removed. Plants remained in the shelf life room until 02 January 2020 (week 1).



Figure 2. Plants removed from their boxes and placed on saucers in week 47 (left), and the sleeves removed in week 48 (right), 2019

Trial design and statistical analysis

Products were applied at various rates (**Table 5** and **Table 6**), singly and in combination.

Treatments 1-13, from the main trial, were arranged in a randomised block design with 13 treatments, three replicate blocks and a total of 624 plants (39 plots, 16 plants per plot; 48 plants per treatment).

Results were examined by ANOVA where appropriate.

Plants in the observation plots were not replicated, and were not subjected to statistical analysis. They were arranged as 16 plants per plot, 1 plot per treatment.

Assessments

Inspections and assessments are summarised in **Table 8 - Table 12** below.

Rooted cuttings were assessed for quality and consistency prior to potting by Newey Roundstone staff.

Table 8. Plant quality (bract development)

Score	Definition
0	Plants mostly green, no bract development. Unmarketable
1	Bracts smaller and less well developed (plants more green) than 2. Unmarketable
2	Bracts smaller and less well developed than 3. Unmarketable
3	Bracts smaller than the water control and 4. <u>Marketable</u>
4	Bracts slightly smaller than the water control. <u>Marketable</u>
5	Bract size and colour fully developed. <u>Marketable.</u>

Table 9. Phytotoxicity scores

Score	Definition
0	Dead
1	Severely damaged / reduced growth / yellow leaves / bracts
2	Severe phytotoxicity
3	Unmarketable, faded bracts, severe crinkling
4	Marginal chlorosis, splash, <5% crinkling
5	No phytotoxicity, all plants marketable

Table 10. Cyathia scores

Score	Definition
0	Cyathia not showing
1	Cyathia juvenile, not showing stamens
2	Stamens visible
3	Stamens visible with pollen
4	Stamens visible but no pollen (i.e. going over)
5	Cyathia drop

Table 11. Shelf life plant quality scores

Score	Definition
0	Dead
1	Severe chlorosis and leaf drop
2	Chlorosis and leaf drop
3	Slight chlorosis and leaf drop
4	No chlorosis or leaf drop

Table 12. Summary of Poinsettia trial actions, inspections and assessments, 2019/20

Date	Week no.	Action	Inspections and assessments
25/07/19	30	Potting date	-
13/08/19	33	Plants pinched	-
06/09/19	36	Plants spaced	-
23/09/19	39	Inspection	Plant height
25/09/19	39	1st spray application. All products	-
30/09/19	40	Inspection	Plant height
02/10/19	40	2nd spray application. All treatments except for OBS1 & OBS2	Phytotoxicity
07/10/19	41	Inspection	Plant height
09/10/19	41	3rd spray application. All treatments except for OBS1 & OBS2	Phytotoxicity
14/10/19	42	Inspection	Plant height
16/10/19	42	4 th spray application. All treatments except for OBS1 & OBS2	Phytotoxicity
21/10/19	43	Inspection	Plant height
22/10/19	43	Plants moved to final spacing	-
23/10/19	43	5th spray application. All treatments except for OBS1 & OBS2	Phytotoxicity
28/10/19	44	Inspection	Plant height
30/10/19	44	Overspray of Bonzi (0.5 ml/L) applied to all treatments except for the water control, and OBS 1-3	Phytotoxicity
04/11/19	45	Inspection. No spray required	Plant height and phytotoxicity
11/11/19	46	Inspection. No spray required	Plant height and phytotoxicity
18/11/19	47	Final assessment at marketing	Plant height, quality, phytotoxicity and cyathia assessments
19/11/19	47	Plants sleeved, boxed and moved to ADAS Boxworth for shelf life trial	-
22/11/19	47	Plants removed from boxes and placed on saucers in shelf life room. Still sleeved	-
29/11/19	48	Sleeves removed	Plant quality, observations on breakages
05/12/19	49	Inspection	Plant quality
19/12/19	51	Inspection	Plant quality
02/01/20	01	Final shelf life assessment	Plant quality

Results

The effect of each PGR treatment on the height, growth and quality was compared with that of the water only control. The effect of the different treatments is presented below. Different to 2018, rather than using Stabilan 750 as the reference product (and applying throughout the trial), only two applications were made, as specified in the EAMU (1416/17).

Temperature and humidity were monitored throughout the trial (**Appendix 1**). Comparative images of treatment effects presented in **Appendices 3, 4 and 5**.

All rooted cuttings obtained for the trial were of good quality prior to potting.

Plant height and growth

All plants in the main trial received five treatments followed by an overspray of Bonzi. Six applications were made of Control (OBS2). A single application was made at double the label / EAMU rate treatments for Topas (OBS1) and Control (OBS3). The Bonzi overspray was not applied to the observation plots or the water control. The decision whether to apply products was based on graphical tracking, aiming to keep plant height within the bounds of the tracks. No treatments caused too strong an effect with insufficient plant growth to require further treatment (i.e. no applications were halted until sufficient growth had been made).

Plant height was measured from the top of the pot to the base of the tallest growing tip. Plant height graphs with graphical tracking are presented in **Appendix 2**. Plant growth between the first PGR application (25 September 2019) and the final assessment (18 November 2019), with a calculation of the percentage height difference compared with the water control is presented in **Table 13**.

For all PGR treatments (treatments 2-11), Poinsettia height was within specification (22 - 28 cm) by the end of the trial (18 November 2019).

Three Bonzi treatments were evaluated, two dose rates (0.35 ml/L and 0.5 ml/L), with the 0.35 ml/L rate applied in 300 and 600 L/ha water. The two water rates were included as growers using Ripa sprayers need a higher water rate to propel pesticides to the furthest reaches of the crop. However, using the higher water rate also increases the volume of active ingredient intercepted by each plant. All three treatments controlled Poinsettia growth below 28 cm, with a greater effect at the higher dose rate than the lower dose rate (300 L/ha water); and at the higher water volume (600 L/ha water) than the lower water volume (300 L/ha water). When translating the recommendations from this trial, growers will need to reduce dose rates when applying in higher volumes of water. Growers should always trial new products and rates on a small number of plants prior to wide scale use.

The fungicide, Topas, had an effect on Poinsettia growth when applied at the two higher rates (treatments 12 and OBS1), with plants shorter than the water control, but there was no effect on height when applied at the lower rate (treatment 13). Growers will therefore need to take into account when applying Topas to control powdery mildew, that it may also reduce plant height. A reduction in plant height was also recorded as a result of the Control treatments (OBS 2 and OBS 3), with lower rate applied at more frequent intervals having the greater impact.

Table 13. Average plant height and growth (height increase between 25 September and 18 November 2019) and average growth relative to the water control at the final assessment (18 November 2019, week 47, 8 weeks after first treatment)

	Treatment	No. of applications	Ave. initial height (cm)*	Ave. marketing height (cm)	Ave. growth (cm)	Growth relative to control (%)
1	Water control	5	14.4	28.3	13.8	-
2	Stabilan 750 / Bonzi	5*	15.3	25.3	10.0	72.3
3	Stabilan 750 + Stena / Bonzi	5*	16.0	25.0	9.0	65.1
4	Terpal	5*	15.6	25.8	10.2	73.5
5	Terpal + Stena	5*	14.3	25.9	11.6	83.7
6	Stabilan 750 / Terpal	5*	15.3	26.4	11.1	80.1
7	Stabilan 750 + Stena / Terpal + Stena	5*	15.7	25.8	10.2	73.5
8	Bonzi 0.35 ml/L	5*	14.3	26.2	11.9	86.1
9	Bonzi 0.5 ml/L	5*	15.3	25.0	9.8	70.5
10	Bonzi 0.35 ml/L 600 L/ha	5*	14.6	24.6	10.0	72.3
11	Terpal / Stabilan 750	5*	15.3	26.3	11.1	80.1
12	Topas 1.67 ml/L	5*	14.8	27.5	12.7	91.6
13	Topas 0.83 ml/L	5*	16.2	28.6	12.4	89.8
OBS1	Topas 3.33 ml/L	1	14.5	25.8	11.3	81.3
OBS2	Control 5.0 ml/L	6	14.3	24.8	10.5	75.9
OBS3	Control 10.0 ml/L	1	14.0	25.8	11.8	84.9

Treatments applied in 300 L/ha water, except for T10 (applied in 600 L/ha water). Plant heights in red did not meet the height specification for Poinsettia (22 - 28 cm) on 18 November 2019. Overspray of Bonzi (0.5 ml/L) applied on 30 October 2019, in addition to tabled treatments. * Height prior to first treatment.

Phytotoxicity

No phytotoxicity was recorded in any plants, either in the main trial or the observation plots (Table 14 and Table 15).

Plant quality

Plant quality was assessed as bract development, in terms of bract size and colouration; where plants / plots achieving higher scores had a higher proportion of red to green. It should

be noted, though, that further bract colour development was expected as the plants progressed into the shelf life assessments.

For the main trial, larger, more developed bracts were present in the water control, and Topas treatments (treatments 1, 12 and 13; $p = 0.036$). Conversely, bracts were smaller and less developed in the Stablan 750, Terpal, and Terpal followed by Stablan 750 treatments (treatments 2, 4 and 11). However, all of the plants were considered marketable (**Table 14** and **Table 15**).

Similarly in the observation plots, Topas (OBS1) scored higher than the water control, and in the Control treatments (OBS2 and OBS3), bracts were well developed and marketable.

Number of heads

In the main trial, the greatest average number of heads per plant was seen in plots treated with Terpal followed by Stablan 750 (treatment 11, 4.3 heads), and the Topas treatments (treatments 12 and 13, 4.3 heads), and this was more than was produced in the water control (4.1 heads). However, none of the treatments produced significantly more or fewer heads than the water control (**Table 14** and **Table 15**).

Cyathia quality

At the time of the final assessment in week 47, there were no differences between treatments for cyathia quality in either the main trial or the observation plots. All cyathia were juvenile (**Table 14** and **Table 15**).

Table 14. Final assessment of treatments 1-13 on Poinsettia 'Infinity', 18 November 2019 (week 47, 8 weeks after first treatment)

	Treatment	No. applications	Ave. phytotoxicity score*	Ave. plant quality / bract development score**	Ave. no heads / plant	Ave. cyathia score***
1	Water control	5	5	4.7 ^b	4.1	1
2	Stabilan 750 / Bonzi	5	5	3.3 ^a	3.8	1
3	Stabilan 750 + Stena / Bonzi	5	5	4.0 ^{ab}	3.7	1
4	Terpal	5	5	3.3 ^a	4.1	1
5	Terpal + Stena	5	5	4.0 ^{ab}	4.1	1
6	Stabilan 750 / Terpal	5	5	3.7 ^{ab}	3.7	1
7	Stabilan 750 + Stena / Terpal + Stena	5	5	4.0 ^{ab}	3.9	1
8	Bonzi 0.35 ml/L	5	5	4.3 ^{ab}	3.7	1
9	Bonzi 0.5 ml/L	5	5	3.7 ^{ab}	4.0	1
10	Bonzi 0.35 ml/L 600 L/ha	5	5	4.0 ^{ab}	3.7	1
11	Terpal / Stabilan 750	5	5	3.3 ^a	4.3	1
12	Topas 1.67 ml/L	5	5	4.7 ^b	4.3	1
13	Topas 0.83 ml/L	5	5	4.7 ^b	4.3	1
	F pr.	n/a	n/a	0.036	0.123	n/a
	s.e.d.			0.4607	0.2581	
	l.s.d			0.9509	0.5327	

***Phytotoxicity score:** Scale of 0 – 5 (0 – Dead; 1 - severely damaged / reduced growth / yellow leaves / bracts; 2 - severe phytotoxicity; 3 - unmarketable, faded bracts; 4 - marginal chlorosis, splash, <5% crinkling; 5 - no phytotoxicity, all plants marketable).

****Quality Score (bract development):** Scale of 0 – 5 (0 - plants mostly green, no bract development. Unmarketable; 1 - bracts smaller and less well developed (plants more green) than 2. Unmarketable; 2 - bracts smaller and less well developed than 3. Unmarketable; 3 - Bracts smaller than the water control and 4. Marketable; 4 - Bracts slightly smaller than the water control. Marketable; 5 - Bract size and colour fully developed. Marketable).

*****Cyathia score:** Scale of 0 – 5 (0 - cyathia not showing; 1 - cyathia juvenile, not showing stamens; 2 - stamens visible; 3 - stamens visible with pollen; 4 - stamens visible but no pollen (i.e. going over); 5 - cyathia drop).

Indices indicate level of significance. Figures highlighted red are significantly different to the water control ($p=0.036$).

Table 15. Final assessment of observation treatments (OBS 1-3) on Poinsettia 'Infinity', 18 November 2019 (week 47, 8 weeks after first treatment)

	Treatment	No. applications	Ave. phytotoxicity score*	Ave. plant quality score**	Ave. no heads / plant	Ave. cyathia score***
OBS1	Topas 3.33 ml/L	1	5	5	4.6	1
OBS2	Control 5.0 ml/L	6	5	4	4.2	1
OBS3	Control 10.0 ml/L	1	5	4	3.6	1

***Phytotoxicity score:** Scale of 0 – 5 (0 – Dead; 1 - severely damaged / reduced growth / yellow leaves / bracts; 2 - severe phytotoxicity; 3 - unmarketable, faded bracts; 4 - marginal chlorosis, splash, <5% crinkling; 5 - no phytotoxicity, all plants marketable).

****Quality Score (bract development):** Scale of 0 – 5 (0 - plants mostly green, no bract development. Unmarketable; 1 - bracts smaller and less well developed (plants more green) than 2. Unmarketable; 2 - bracts smaller and less well developed than 3. Unmarketable; 3 - Bracts smaller than the water control and 4. Marketable; 4 - Bracts slightly smaller than the water control. Marketable; 5 - Bract size and colour fully developed. Marketable).

*****Cyathia score:** Scale of 0 – 5 (0 - cyathia not showing; 1 - cyathia juvenile, not showing stamens; 2 - stamens visible; 3 - stamens visible with pollen; 4 - stamens visible but no pollen (i.e. going over); 5 - cyathia drop).

Shelf life

Plants from all treatments were placed into shelf life at the end of the trial; three plants from each of the treatments in the main trial, and one plant from each observation plot. The sleeves were kept on for a total of 10 days (three days in the dark in the box, seven days on the bench). When the sleeves were removed, there were no issues with breakages in any of the treatments apart from one plant from the Stabilan 750 + Stena / Terpal + Stena treatment (treatment 7) where one bract became detached. This particular plant had also dropped a lot of leaves compared to the other treatments.

The plants were monitored weekly and there were no issues with wilting or leaf drop in any of the treatments, including the observation plots. By week 51, some of the leaf margins were starting to turn pale and the bracts were beginning to look paler, however this was across all treatments including the water control. A final assessment of plant quality and cyathia quality was completed in week 1, 2020 (**Table 16**). The plants from all treatments were still looking good, with no signs of wilting or severe chlorosis. Images from all treatments at the beginning and end of the shelf life period can be found in **Appendix 6**.

Table 16. Average quality and cyathia scores for plants placed in shelf life. Week 1, 02.01.2020

Trt	Product	Quality score	Cyathia score
1	Water control	2.33	1.00
2	Stabilan 750 / Bonzi	2.00	1.33
3	Stabilan 750 + Stena / Bonzi	3.00	2.33
4	Terpal	2.67	1.33
5	Terpal + Stena	2.00	1.33
6	Stabilan 750 / Terpal	2.00	2.00
7	Stabilan 750 + Stena / Terpal + Stena	2.67	1.33
8	Bonzi 0.35 ml/L, 300 L/ha	3.00	2.00
9	Bonzi 0.5 ml/L	2.67	2.67
10	Bonzi 0.35 ml/L, 600 L/ha	2.67	2.33
11	Terpal / Stabilan 750	3.00	1.67
12	Topas 0.5 L/ha	3.33	1.33
13	Topas 0.25 L/ha	2.67	1.00
s.e.d		0.4152	0.747
l.s.d		0.8569	1.542
F. pr		0.057	0.431

Discussion

None of the treatments included in this trial had a significant adverse effect on the number of heads per plant or cyathia quality, and no phytotoxicity was recorded for any treatment. The target height specification was 22 – 28 cm.

- **Stabilan 750** (0.5 ml/L) is the standard commercial treatment for Poinsettia and it was effective as expected (Treatment 2). In this treatment it was followed by applications of Bonzi (0.35 ml/L) as use of Stabilan 750 is restricted to two applications per crop (EAMU 1416/17). When applied at the lower rate of 0.25 ml/L and combined with the adjuvant **Stena** (2.5 ml/L), height control was comparable to applying Stabilan 750 alone at the higher rate (0.5 ml/L), and bract size was slightly larger. Plants in both treatments scored well in shelf life.
- **Terpal** again proved to be an effective PGR on Poinsettia, producing plants within the height specification with no phytotoxicity (Treatment 4, 1.67 ml/L). This treatment achieved the same bract quality score as Stabilan 750 (/ Bonzi) overcoming issues with small bract size recorded in previous trials. These results indicate that 1.67 ml/L is an appropriate rate for use on Poinsettia. When Terpal was applied at the lower rate of 0.83 ml/L and combined with the adjuvant **Stena** (2.5 ml/L), height control was comparable to applying Terpal alone at the higher rate (1.67 ml/L), and bract size was slightly larger. Plants in both treatments scored well in shelf life.
- **Bonzi** achieved growth control at all rates and water volumes used, without causing phytotoxicity or affecting bract, cyathia or head development compared with the water control. Three Bonzi treatments were evaluated, two dose rates (0.35 ml/L and 0.5 ml/L), with the 0.35 ml/L rate applied in 300 and 600 L/ha water. The two water rates were included as growers using Ripa sprayers need a higher water rate to propel pesticides to the furthest reaches of the crop. However, using the higher water rate also increases the volume of active ingredient intercepted by each plant. All three treatments controlled Poinsettia growth below 28 cm, with a greater effect at the higher dose rate than the lower dose rate (300 L/ha water); and at the higher water volume (600 L/ha water) than the lower volume (300 L/ha water). When translating the recommendations from this trial, growers will need to reduce dose rates when applying in higher volumes of water. Growers should always trial new products and rates on a small number of plants prior to wide scale use.
- **Spray programmes.** Three spray programmes were included in this trial; these were combinations of Stabilan 750 Terpal and Stena and were designed to identify any benefit of early or later applications of Terpal and Stabilan 750 compared with other treatments. The spray programmes were: Stabilan 750 followed by Terpal (Treatment 6), Stabilan 750 + Stena followed by Terpal + Stena (Treatment 7), and Terpal followed by Stabilan 750

(Treatment 11). All of these treatments produced Poinsettia that were within the height specification, with no phytotoxicity, and with comparable cyathia scores and average number of heads per plant. However, bract size was larger in treatments where Stabilan 750 applications (with and without Stena, Treatments 6 and 7) were followed by Terpal; bract size in these treatments was also larger than when Stabilan 750 was followed by Bonzi (Treatment 2).

- **Topas** (fungicide), produced no phytotoxic effects on Poinsettia at any of the dose rates used in this trial. However, when applied at the two higher rates (Treatments 12 and OBS1), it did have an effect growth, producing shorter plants than the water control. At the higher rate (OBS1), the effect on growth was due to a single application at double the EAMU rate. Growers will therefore need to take into account when applying Topas to control powdery mildew, that although it is safe to use on Poinsettia, it may reduce plant height at higher rates.
- The seaweed-based fertiliser **Control** applied at label rate (6 applications, 5.0 ml/L) and at double the rate (1 application, 10.0 ml/L) did not cause phytotoxicity and achieved comparable quality and cyathia scores to other treatments. Slightly fewer heads were produced per plant in at the higher dose rate (OBS3, 10.0 ml/L, average 3.6 heads per plant) compared with the lower dose rate treatment (OBS2, 5.0 ml/L, average 4.2 heads per plant) and the water control (average 4.7 heads per plant). However, application may affect plant height, particularly at the lower application rate (5.0 ml/L).
- The adjuvant **Stena** (previously coded as HDC P006) again proved effective in reducing the PGR dose rate require to achieve comparable height control when used at the label rate (2.5 ml/L) in combination with Stabilan 750 and Terpal.

Conclusions

- All PGR treatments were effective in controlling Poinsettia growth to achieve the height specification, with no phytotoxicity.
- The adjuvant Stena can be applied at the label rate with Terpal and Stabilan 750 enabling the PGRs to be reduced by 50% while still achieving the height specification.
- The order of Terpal and Stabilan 750 in spray programmes has minimal effect on Poinsettia growth, but bract size was slightly smaller when Terpal was followed by Stabilan 750.
- Bonzi provided effective growth control, but has a stronger effect when applied in water volumes greater than 300 L/ha.
- Topas and Control are safe to use on Poinsettia to control powdery mildew, but may affect plant height.

Acknowledgements

Our thanks to:

- Stuart Whiteman, Nick Nolan and the team at Newey Roundstone Nursery for their support and for hosting the trial.
- Newey Young Plants, Syngenta, GrowDesign, Nufarm UK Ltd, and BASF for the provision of plants and materials.
- The Scientific Support Team at ADAS.
- The Bedding and Pot Plant Centre Management Group for steering the project.

References

Brough, W. (2011) Assessment of a number of new growth regulator products to control growth on commercial crops of bedding plants. Project PO 004. AHDB.

Hartvig, P., and Hjelmroth, L. (2016). Vækstregulering af pryddplanter – effektivitet af Regalis Plus, Moddus M, Alar 85 SG, Bonzi and Terpal I julestjerner. Forsøg 2016-764. Aarhus Universitet.

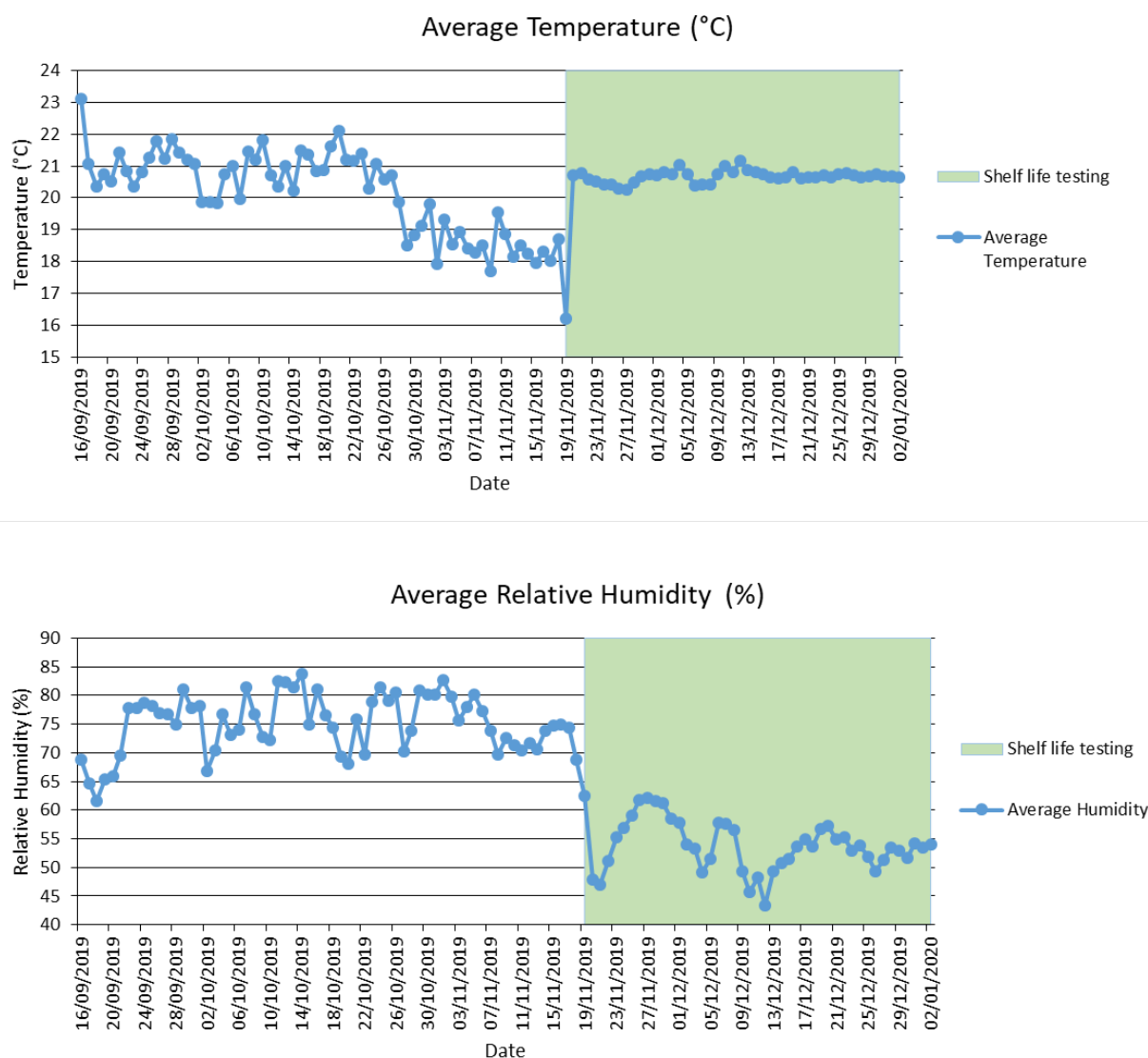
Paaske, K. (2010). Vækstregulering af margeritter. Forsøg 2010-765-1. Aarhus Universitet.

Paaske, K. (2013). Vækstregulering af *Argyranthemum* og *Osteospermum*. Forsøg 2013-765-2. Aarhus Universitet.

Paaske, K. (2015). Growth regulation using Caryx og HDC P005. Aarhus Universitet.

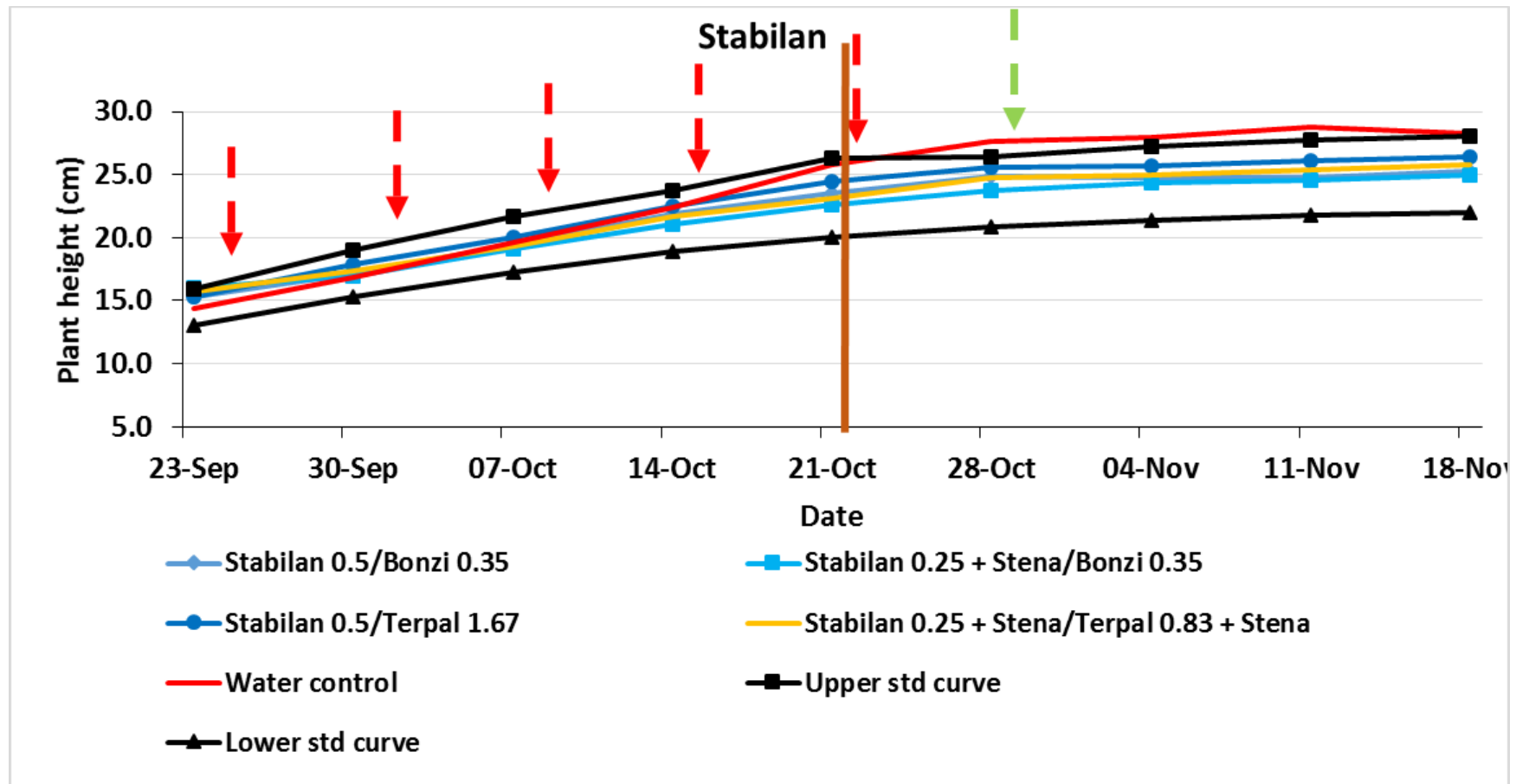
Appendix 1

Glasshouse daily average temperature and humidity. Average daily temperature was between 17°C and 23°C during the spraying and 20°C and 21°C during shelf life testing. Average humidity was between 61% and 83% during the spraying and 43% and 62% for the shelf life testing.

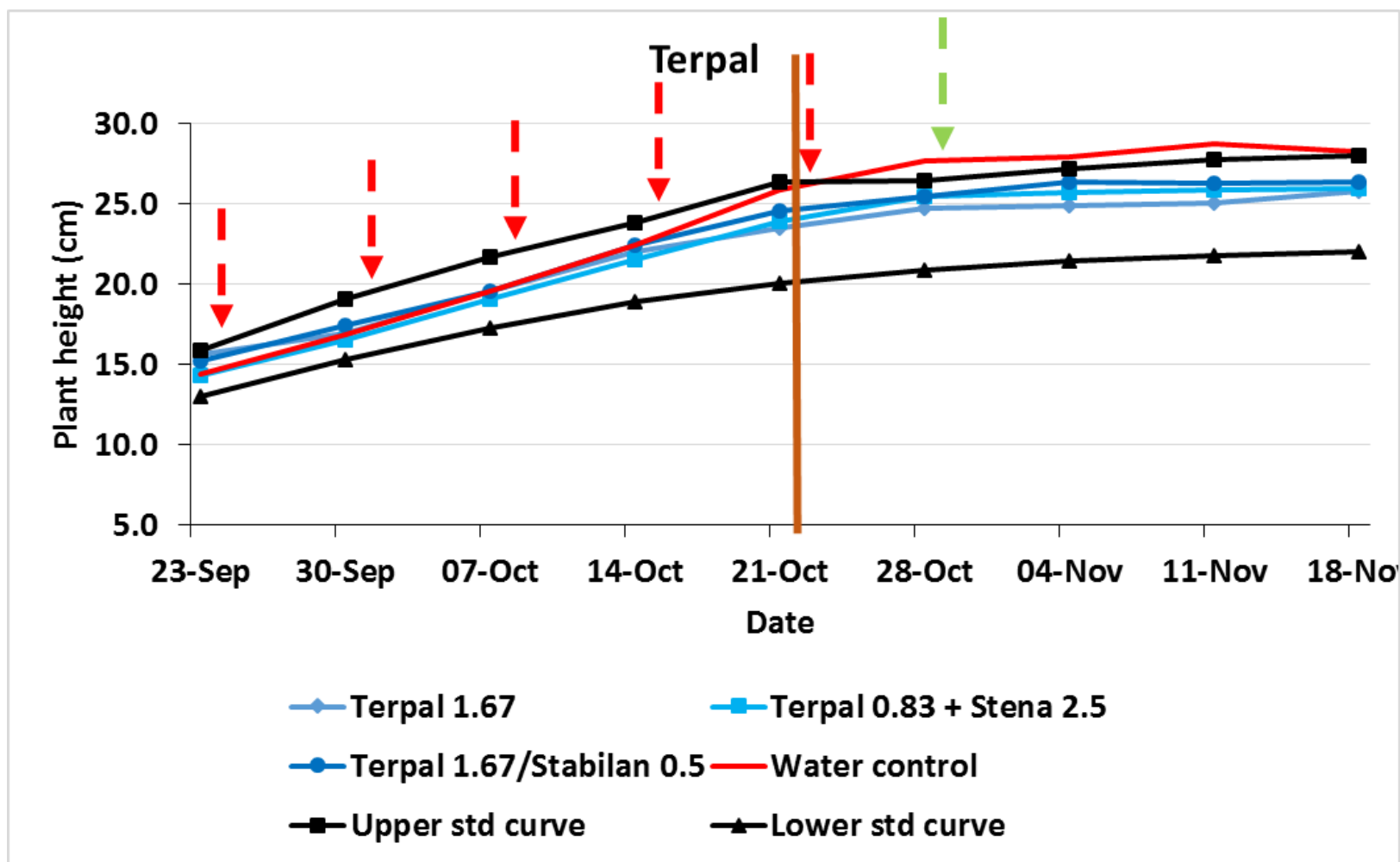


Appendix 2 A.

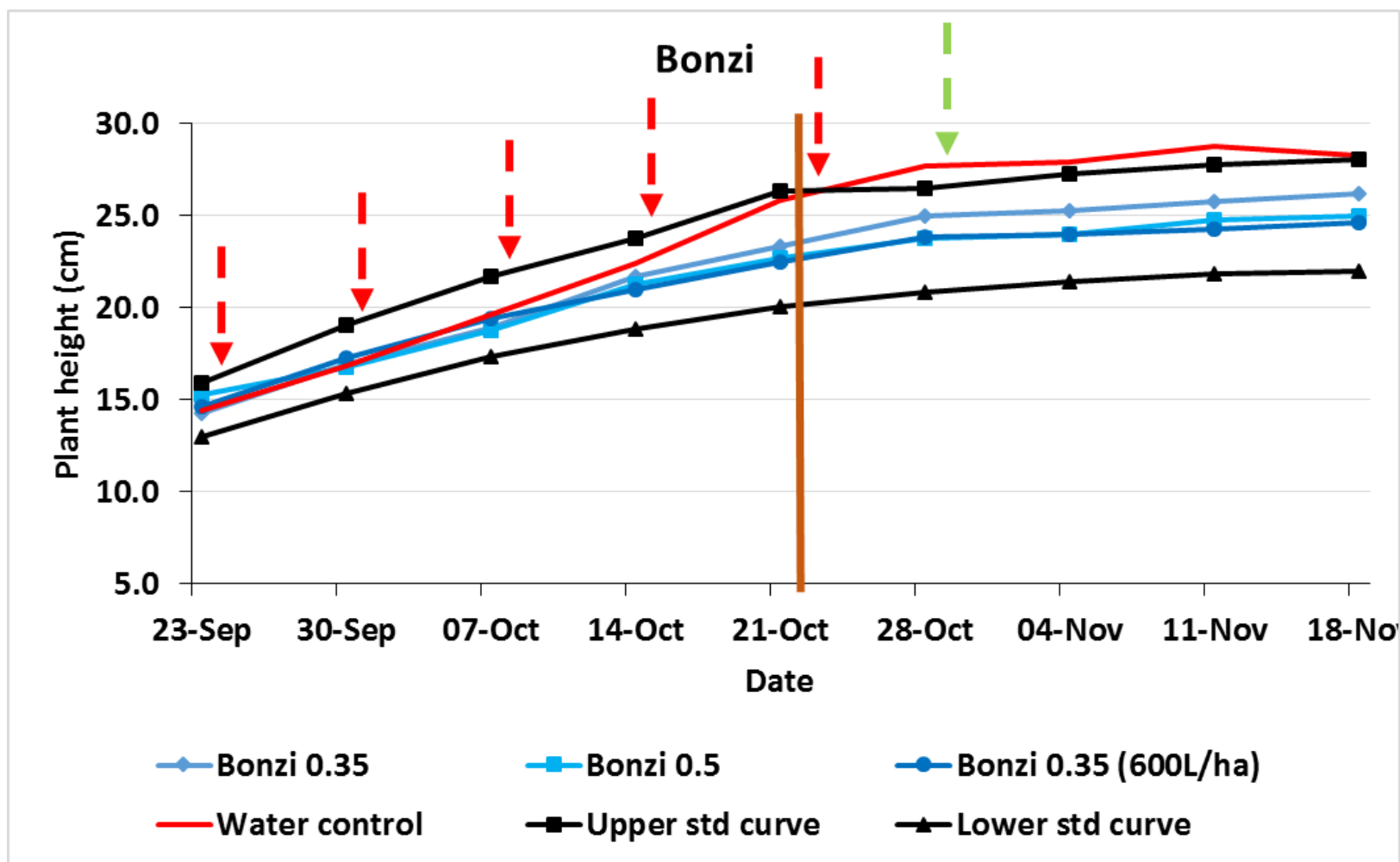
Poinsettia height graphs. Stabilan 750 treatments: average plant height. Arrows indicate application dates; red arrows are the treatment application, green arrows are a Bonzi overspray. The vertical brown line indicates date of final spacing. Treatments applied in 300 L/ha water. Height specification for Poinsettia = 220 - 280 mm.



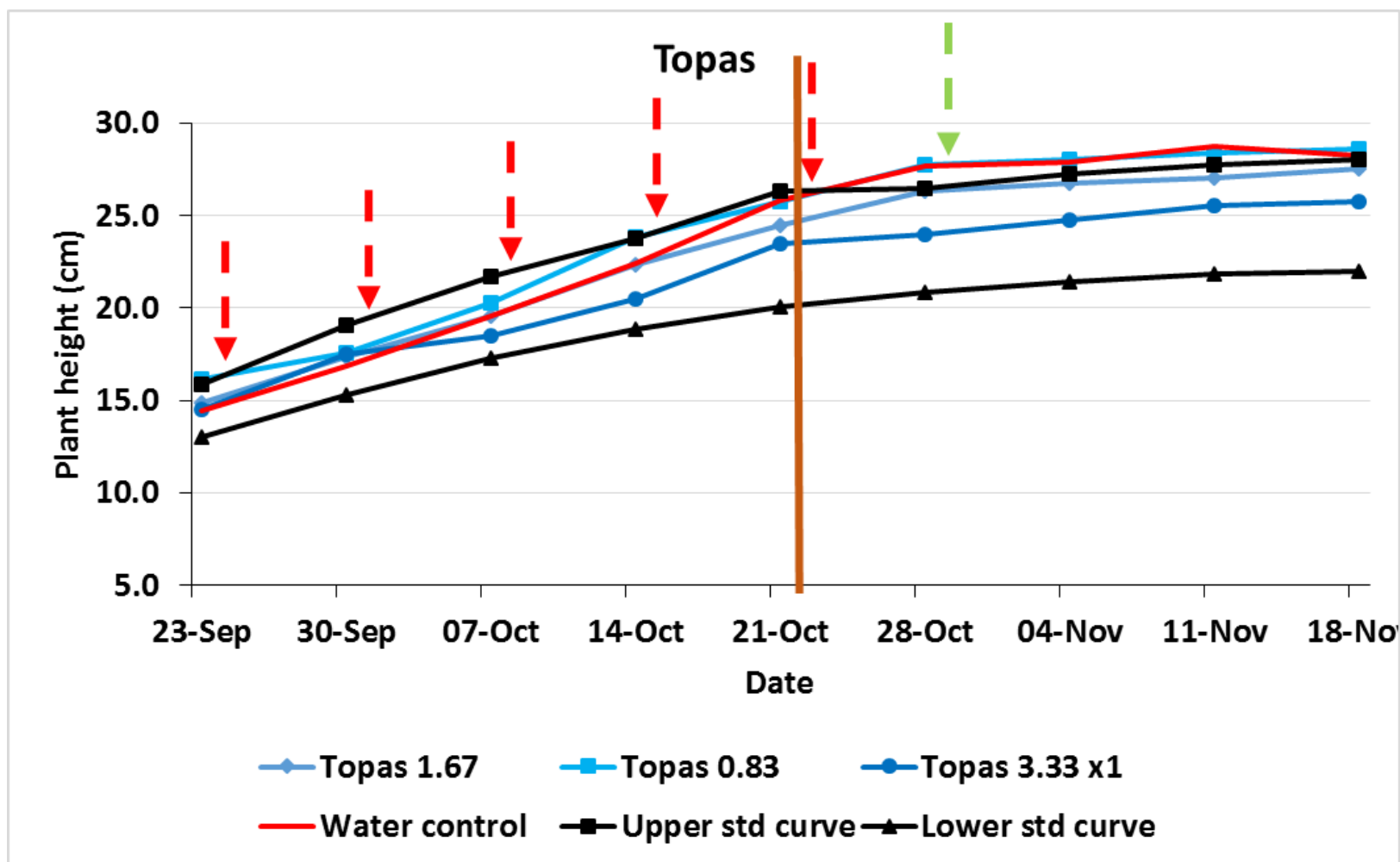
Appendix 2 B. Terpal treatments: average plant height. Arrows indicate application dates; red arrows are the treatment application, green arrows are a Bonzi overspray. The vertical brown line indicates date of final spacing. Treatments applied in 300 L/ha water. Height specification for Poinsettia = 220 - 280 mm.



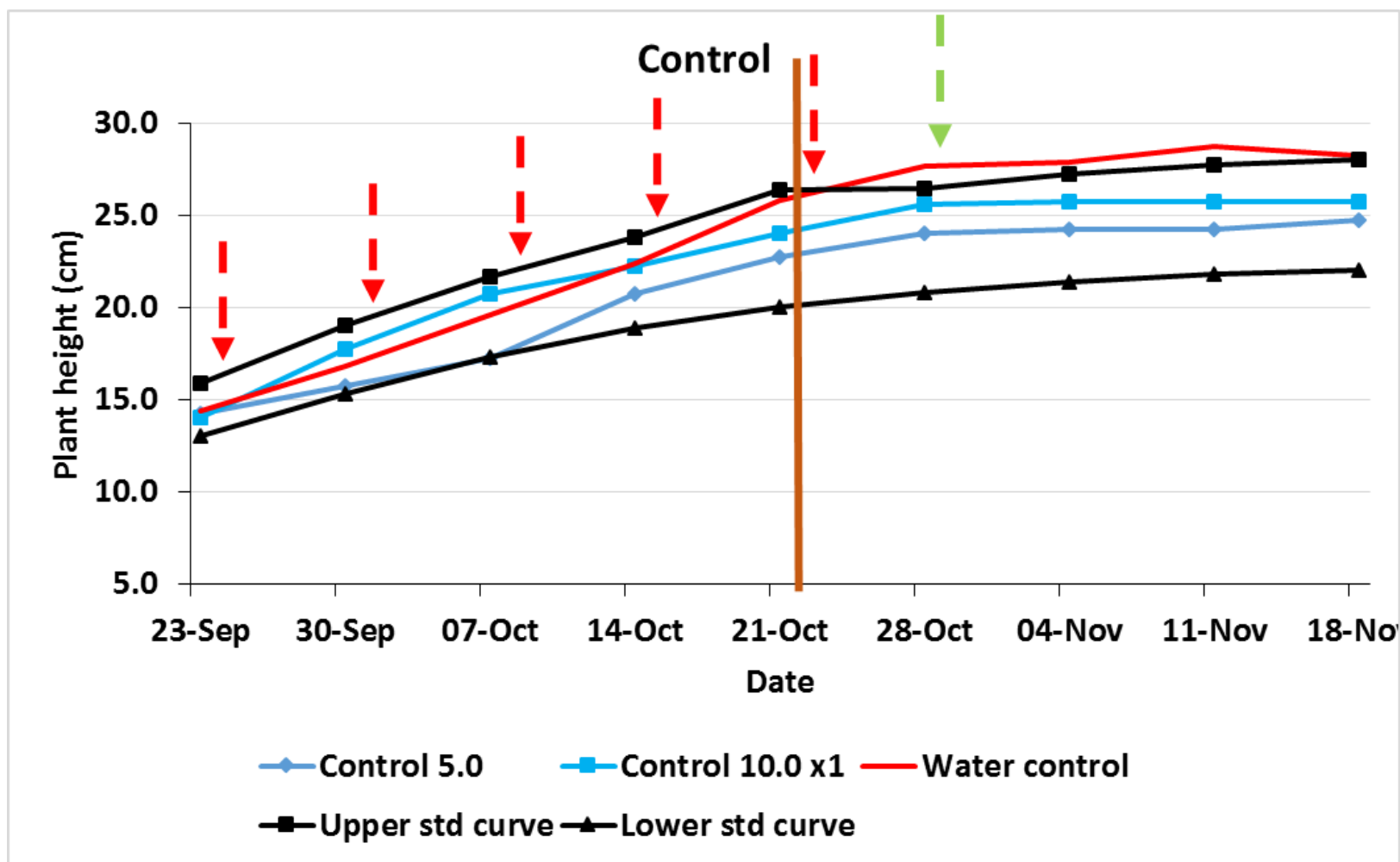
Appendix 2 C. Bonzi treatments: average plant height. Arrows indicate application dates; red arrows are the treatment application, green arrows are a Bonzi overspray. The vertical brown line indicates date of final spacing. Treatments applied in 300 L/ha water, except for Treatment 10 (Bonzi 0.35 ml/L in 600 L/ha) water. Height specification for Poinsettia = 220 - 280 mm.



Appendix 2 D. Topas treatments: average plant height. Arrows indicate application dates; red arrows are the treatment application, green arrows are a Bonzi overspray. The vertical brown line indicates date of final spacing. Treatments applied in 300 L/ha water. Height specification for Poinsettia = 220 - 280 mm.



Appendix 2 E. Control treatments: average plant height. Arrows indicate application dates; red arrows are the treatment application, green arrows are a Bonzi overspray. The vertical brown line indicates date of final spacing. Treatments applied in 300 L/ha water. Height specification for Poinsettia = 220 - 280 mm.



Appendix 3

A. Overhead photographic record of treatment effects, 18 November 2019, week 47. Treatments 1-13 (T1-13), after five treatment applications followed by a Bonzi overspray (**Table 5**)

		
T1. Water only	T2. Stabilan 750 0.5 ml/L; Bonzi 0.35 ml/L	T3. Stabilan 750 0.25 ml/L + Stena 2.5 ml/L; Bonzi 0.35 ml/L
		
T4. Terpal 1.67 ml/L	T5. Terpal 0.83 ml/L + Stena 2.5 ml/L	T6. Stabilan 750 0.5 ml/L; Terpal 1.67 ml/L
		
T7. Stabilan 750 0.25 ml/L + Stena 2.5 ml/L; Terpal 0.83 ml/L + Stena 2.5 ml/L	T8. Bonzi 0.35 ml/L	T9. Bonzi 0.5 ml/L
		
T10. Bonzi 0.35 ml/L (600 L/ha)	T11. Terpal 1.67 ml/L; Stabilan 750 0.5 ml/L	T12. Topas 1.67 ml/L



T13. Topas 0.83 ml/L

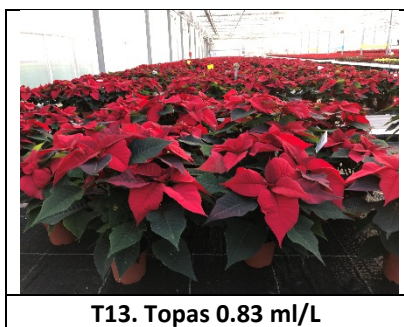
B. Overhead photographic record of treatment effects, 18 November 2019, week 47. Observation plots (OBS1-3). OBS 1 and OBS 3 after a single treatment application; OBS2 after six treatment applications programmes (**Table 6**)



Appendix 4

A. Comparative plot photographic record of treatment effects, 18 November 2019, week 47. Treatments 1-13 (T1-13), after five treatment applications followed by a Bonzi overspray (**Table 5**)

		
T1. Water only	T2. Stabilan 750 0.5 ml/L; Bonzi 0.35 ml/L	T3. Stabilan 750 0.25 ml/L + Stena 2.5 ml/L; Bonzi 0.35 ml/L
		
T4. Terpal 1.67 ml/L	T5. Terpal 0.83 ml/L + Stena 2.5 ml/L	T6. Stabilan 750 0.5 ml/L; Terpal 1.67 ml/L
		
T7. Stabilan 750 0.25 ml/L + Stena 2.5 ml/L; Terpal 0.83 ml/L + Stena 2.5 ml/L	T8. Bonzi 0.35 ml/L	T9. Bonzi 0.5 ml/L
		
T10. Bonzi 0.35 ml/L (600 L/ha)	T11. Terpal 1.67 ml/L; Stabilan 750 0.5 ml/L	T12. Topas 1.67 ml/L



T13. Topas 0.83 ml/L

B. Comparative plot photographic record of treatment effects, 18 November 2019, week 47. Observation plots (OBS1-3). OBS 1 and OBS 3 after a single treatment application; OBS2 after six treatment applications programmes (**Table 6**)



OBS1. Topas 3.33 ml/L (1 app)



OBS2. Control 5.0 ml/L



OBS3. Control 10.0 ml/L (1 app)

Appendix 5

A. Comparative image of treatments: T1 - Water only; T4. Terpal 1.67 ml/L; T6. Stablan 750 0.5 ml/L; Terpal 1.67 ml/L; T7. Stablan 750 0.25 ml/L + Stena 2.5 ml/L; Terpal 0.83 ml/L + Stena 2.5 ml/L; T11. Terpal 1.67 ml/L; Stablan 750 0.5 ml/L (left to right)



B. Comparative image of treatments: T1 - Water only; T9. Bonzi 0.5 ml/L; T2. Stablan 750 0.5 ml/L, Bonzi 0.35 ml/L; T3. Stablan 750 0.25 ml/L + Stena 2.5 ml/L, Bonzi 0.35 ml/L (left to right)



C. Comparative image of treatments: T1 - Water only; T4. Terpal 1.67 ml/L; T5. Terpal 0.83 ml/L + Stena 2.5 ml/L (left to right)



D. Comparative image of treatments: T1 - Water only; T8 - Bonzi 0.35 ml/L (300 L/ha water); T9 - Bonzi 0.5 ml/L (300 L/ha water); T10; Bonzi - 0.35 ml/L (600 L/ha water) (left to right)



E. Comparative image of treatments: T1 - Water only; T12. Topas 1.67 ml/L; T13. Topas 0.83 ml/L; OBS1. Topas 3.33 ml/L (1 app) (left to right)




F. Comparative image of treatments: T1 - Water only; OBS2 - Control 5.0 ml/L; OBS2 - Control 10.0 ml/L (1 application) (left to right)



Appendix 6

Comparative images of treatment effects at the start and end of shelf life

Week 48 – sleeves removed	Week 01, 2020
	
Water; Stabilan 750 / Bonzi	Water; Stabilan 750 / Bonzi
	
Water; Stabilan 750 + Stena / Bonzi	Water; Stabilan 750 + Stena / Bonzi
	
Water; Terpal	Water; Terpal
	
Water; Terpal + Stena	Water; Terpal + Stena

	
Water; Stabilan 750 / Terpal	Water; Stabilan 750 / Terpal
	
Water; Stabilan 750 + Stena / Terpal + Stena	Water; Stabilan 750 + Stena / Terpal + Stena
	
Water; Bonzi 0.35	Water; Bonzi 0.35
	
Water; Bonzi 0.35 (600 L/ha)	Water; Bonzi 0.35 (600 L/ha)

	
Water; Terpal / Stablan 750	Water; Terpal / Stablan 750
	
Water; Topas x1	Water; Topas x1
	
Water; Topas x0.5	Water; Topas x0.5