

Project title: New Poinsettia Genetics and Controlled Soil Moisture Growing

Project number: PO 021a

Project leader: Dr Chris Bishop, University of Lincoln

Report: Final 2018

Previous report:

Key staff:

Industry Representative: Mike Opperman, Opperman Plants

Date project commenced: June 2017

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 2018. 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.

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

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

Dr Chris Bishop, Reader of Postharvest Technology

The University of Lincoln

Signature Date

Report authorised by:

[Name]

[Position]

[Organisation]

Signature Date

Contents

Grower Summary	1
Project Background and Expected Deliverables	1
Benefits to Industry	2
Benefits of the variety trial.....	2
Benefits of the water deficit trial	3
Summary of the Variety Trial	3
Summary of the Water Deficit Trial	6
Science Report.....	7
Introduction	7
Trial one variety trials.....	7
Trial two water deficit control.....	8
Materials and Methods	9
Trial one.....	9
variety trial	9
Trial two water deficit trial.....	13
Results, Using Deficit Irrigation to Limit Stem Height.....	17
Effects of substrate drying on stem extension.....	17
Point of wilting	18
Substrate	19
Plant material	19
.....	20
Results Harvest	22
Variety Trial	22
.....	24
Water Deficit Trial	25
Results Shelf Life	26

Variety Trial	26
Water Deficit Trial	27
Results - Substrate Analysis	28
Discussion and Conclusions	31
Trial one variety trial	31
Trial two water deficit trial.....	31
Knowledge and Technology Transfer	32
AHDB Poinsettia Open Day 16th November, Neame Lea Nursery	32
Recommended follow-up activities	33
Acknowledgments.....	34
Key Staff.....	34
Appendices	35
Appendix A Shelf life photographs.....	35

Grower Summary

Project Background and Expected Deliverables

Growers within the UK rely upon relatively few poinsettia varieties, with Infinity 2.0 accounting for up to 65% of the current volume. The crop is grown to harvest from mid-November until Christmas as decoration for the domestic market and stringent specifications must be met. The UK market leaders tend to specify a plant 25-30cm high, slightly taller than the EU product, planted into 1 litre pots with a foil of dark green leaves to clean red bracts. The cyathia should be prominent without pollen.

Two trials are reported here:

- 1) Variety assessment
 - 2) Water deficit work for plant growth control
-
- 1) The main objective of this variety trial was to build upon previous work, the plants were benchmarked against the current main commercial variety, Infinity 2.0.

AHDB research in 2015/16 assessed the several new poinsettia varieties which were coming onto the market through growth and shelf life trials, amid industry concerns of reliance upon existing varieties and stock plant maintenance. The results of that trial showed varieties such as Lenora (was No.57), Ferrara, SK148 (now Christmas Sensation) to be promising, and Astro Red, which has continued to show interesting results in 2017/18.

The poinsettia varieties were trialled on three different grower holdings (Pinetops Lymington, Volmary Wisbech St Mary and KRN House plants Louth) across the UK. The crop grown in the northern location was noted at harvest (10 days after the southernmost location assessment date) as still to benefit from an extra week of growing time. The cause of the delay in harvest maturity was unknown, but location and therefore the environmental factors of light and temperature could potentially have had an effect. There were also differences in structure, temperature control and approach to watering and nutrition. (These are reported later in the materials and methods section).
 - 2) A second aspect, the water deficit trial, was based upon industry concern regarding the reduction to two applications of important plant growth regulators (PGRs) such as chlormequat, as early as 2017/18. PGRs have been critical to growers in enabling them to control crop size so attaining product specification. The removal of PGRs may hinder UK growers' ability to meet market specification and so increase vulnerability to competition.

The water deficit trial was carried out by Neame Lea, Spalding. (Details in the materials and methods section). The following was investigated;

- a. The reassessment of the potential of using soil moisture sensing, combined with soil moisture deficit to control stem extension and plant height. This was a continuation of research carried out by Mark Else (NIAB EMR) in a DEFRA funded project (HH3609STX) at Staplehurst Nurseries, Kent (2004-2008). This involved the remote monitoring of three substrate mixes while using Regulated Deficit Irrigation (RDI) during the period of rapid stem elongation in a commercial set up, to see if it controlled plant stem height, and so reducing the reliance on PGRs. The formation of a transferable model of precision irrigation to maintain “optimum” moisture content, capable of being scaled-up to full production and transferable to other crops. Advances in probe technology have increased crop test coverage and robustness of results.
- b. To identify the substrate moisture content at which visible wilting first occurs under a range of Vapour Pressure Deficits (VPDs).
- c. Engagement with the separate, but complementary current Bedding and Pot Plant Centre project led by ADAS on the evaluation of new active ingredients for poinsettia growth and quality.

Benefits to Industry

Poinsettias are the main stay of ornamental pot crops for glasshouse production between July and early December. Approximately 8 million poinsettias were sold within the UK market in 2016, making it one of the most popular seasonal houseplants, predominantly in red bracts on green leaves. UK growers produce approximately half of the retail consumption with the remaining supply produced predominantly in Holland. With changing import markets and euro exchange rates due to Brexit, there are risks to, and opportunities for, the UK industry to develop and expand in this market while maintaining competitiveness. The reduction in distribution distance and time from UK growers should help to improve plant quality in the home market and gain a competitive advantage.

Benefits of the variety trial

This project followed upon the results of the previous trial, reaffirming year-on-year resilience for several of the newer varieties. The trial provided UK growers with knowledge regarding the performance of new and previously tested new varieties against a known benchmark crop (Infinity 2.0). The crops were grown in a variety of commercial operations, conditions and locations, all representative of the industry, so allowing growers to judge consistent varietal

resilience, performance and reliability. The trial also showed that some varieties performed less well and may not be suitable for the UK market, as well as demonstrating how different varieties perform at harvest and then through shelf life. High quality scores at harvest did not always follow through into shelf life, an essential aspect for consumer satisfaction.

Benefits of the water deficit trial

A “dry growing” regime where the irrigation was restricted and monitored using in-pot moisture sensors combined with data logging and remote monitoring (telemetry), was effectively used to achieve plant height control without the use of PGRs. This approach has the potential to significantly reduce the use of PGRs on this and other protected crops in which control of plant height or growth is needed.

Summary of the Variety Trial

Varieties from a number of plant breeders were tested;

Plant breeder	Variety
Beekenkamp	Astro Red
	Lenora Red
	Pon 94 (no longer available)
Dummen	Infinity 2.0
	Ferrara,
	Prima 2.0
Selecta	Christmas Feeling
	Christmas Cracker
	SK148 (Christmas Sensation)
Syngenta	Titan
	Magma

Upon receipt of the plants (17th November) at the University of Lincoln, there were substantial differences in crop height and width between growers. Figure 1. The plants from the water deficit trial were grown with no applications of PGR’s at Neame Lea and the plants from the northern-most nursery could have benefited from a further week of growth before retail.

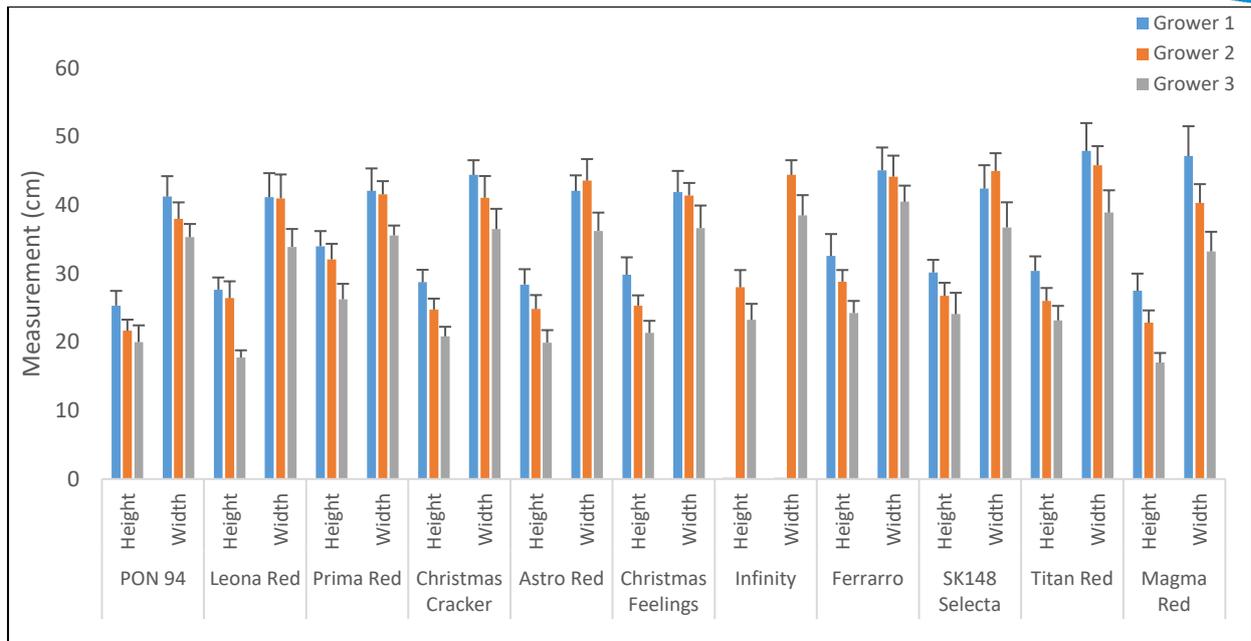


Figure 1. Mean plant height and width at harvest on grower's sites, per variety, showing standard deviation, n=12

At harvest, the varieties showed similar quality scores irrespective of nursery site indicating product resilience across different locations and use of growing techniques; in particular Christmas Cracker and Christmas Feelings. However this scoring consistency across the growing locations did not necessarily relate to high quality scores. The most variable variety across the different grower sites was Lenora Red.

There were key differences between grower sites in the facilities deployed and growing approaches. The facilities ranged from state-of-the-art modern glass to more traditional structures.

Table 1. Combined quality score at harvest and various stages of shelf life indicating varietal resilience across shelf life.

Variety	Open day grower score	Harvest Score	Nursery	Shelf Life 21 st Dec	Shelf Life 12 th Jan
Pon 94	5.7	6.2		4.1	2.8
Lenora	5.9	5.3		4.4	3.2
Prima	5.7	6.8		4.2	2.9
C. Cracker	6.0	6.8		4.2	2.9
Astro	6.2	7.4		4.6	2.8
C. Feeling	5.1	6.2		4.5	2.9
Infinity 2.0	5.9	6.5		4.5	3.1
Ferrara	5.8	6.8		5.1	3.4
SK148 (Christmas Sensation)	6.0	7.7		4.7	3.5
Titan	6.1	6.4		4.5	2.9
Magma	4.6	4.0		4.0	2.3

The results in Table 1 show Magma had the lowest quality score at all points of assessment, whereas SK148 (Christmas Sensation) performed well in harvest scoring and throughout the shelf life assessment.

At the end of shelf life assessment, the differences in varietal and grower impacts were more noticeable, although most plants survived until this stage with a loss of only five plants out of 210 by the second open day (16th January). The Infinity 2.0 bract colour was true to type prior to shelf life assessment, but it appeared to soften during shelf life; the cause is not known. Figure 2.



Figure 2. Infinity plants, grower 2, shelf life 17th November (left) and 12th January (right) showing colour softening.
Source; Le Grys 2017 & 2018

Summary of the Water Deficit Trial

Water deficit was used in conjunction with graphical tracking to manage stem height, and in doing so plant height control was achieved effectively without use of PGRs. A Substrate Volumetric Moisture Content (SVMC) below 20% by volume was needed to slow stem elongation and this was achieved twice during the “dry growing” regime practised at Neame Lea. Previous DEFRA-funded work EMR (now NIAB EMR) showed that repeated exposure to water deficits over a 3-week period optimised growth control.

The moisture sensors, data loggers and telemetry were reliable, while remote access to real-time data was informative for the grower’s decision-making process on the frequency and duration of irrigation. Data indicated the rate of change in substrate moisture content correlated with daily VPDs as expected.

Three substrate mixes were used in the water deficit trial. The mixes differed in their composition and hence their moisture retention and rewetting characteristics. There were no nutritional limiting factors during crop production. There was an observable difference in the root type and structure between the mixes. The plants all responded to the moisture deficit application and all had very good shelf life.

The open day discussions raised issues relating to relevance and feasibility of “dry growing” for non-ebb and flow bench operations and the need for mobile sensors to allow for bench movement in a commercial operation. It is anticipated that future trials will address these issues.

Science Report

Introduction

Trial one variety trials

The UK poinsettia industry has relied heavily on relatively few genetic lines in recent years. The variety with the largest penetration is Infinity 2.0 (circa. 65% of the UK volume), followed by others such as Titan, Christmas Feeling and Astro Red. There is considerable interest in the use and exploitation of new varieties for the UK market. There are concerns that key varieties which have been in the market for a number of years, are now starting to show non-typical or variable traits and habits. This may be due to issues with stock plant maintenance over a number of years.

Plant breeders in the USA, Germany and Holland are developing new varieties and with improved stock management processes are able to “revamp” existing varieties. Grower variety selection requires knowledge from the industry, other growers, breeders and researchers and customer discussions to make an informed choice. Their own facilities and production techniques need to be taken into consideration. The process of variety selection is very expensive and time consuming, poor decision-making can also have significant negative commercial consequences.

Improved decision making on variety selection can be established by seeing if there are significant grower x genetic interactions, i.e. do all varieties perform similarly on different holdings. If they do perform similarly across different holdings, then it will suggest that varieties are relatively robust between growers. If there are significant interactions, i.e. varieties do not perform similarly, then variety decision-making will be complex.

Varietal selection should also include an assessment of consumer performance. Shelf life trials are difficult and costly to undertake at a grower level.

Given this background, the objectives of this trial were to establish a more rigorous process to underpin the effective selection of poinsettia varieties, in particular;

- Rigorously tested 11 old and new varieties for use by UK growers
- Tested the varieties on three different UK growers' holdings to establish whether any genetic x grower interactions occurred in terms of plant responses.

Trial two water deficit control

The previous EMR (now NIAB EMR) work showed that a RDI treatment applied during the period of rapid stem extension, effectively limited plant height so that the retailer specifications were met at market date, despite a 90% reduction in PGR use. RDI treated plants were also more tolerant to chilling stress, and bract and leaf drop during shelf-life tests were reduced by 90% and 50% respectively compared to well-watered control plants that received the commercial PGR programme.

In 2016, a “dry growing” regime was developed by Neame Lea nursery and used in conjunction with other strategies to achieve plant height control without reliance on PGR’s. This potential to use water deficits to control stem height was tested again at Neame Lea in 2017, and this time moisture sensors were used to provide quantitative data on the rate of change of substrate drying and also the degree of drying needed to achieve effective height control. Sensors were calibrated for each of the three substrates used in the experiment. Three benches were removed from the commercial irrigation system and the crops were watered by hand; the degree with which the crop was allowed to dry between irrigation events was determined by the grower. Changes in the SVMC in the pots were monitored every 15 minutes throughout the growing season and data was uploaded to the DeltaLINK cloud to enable “real time” viewing of the “dry growing” regime developed by Neame Lea.

The degree of the water deficit imposed in the “dry growing” regime was determined by identifying the SVMC at which visible wilting first occurred under a range of VPDs.

Throughout the “dry growing” trials regular compost analysis was conducted.

Preliminary work was also carried out to facilitate scaling-up of the approach across the nursery for poinsettia and other crops where height control is achieved using PGRs.

The report and open days allowed for information and knowledge to be disseminated to the industry and to identify and discuss potential topics for follow-on research.

Materials and Methods

Trial one variety trial

The three experienced poinsettia growers located across England who participated in the previous variety trial agreed to repeat the work in 2017/18

Pinetops Nurseries, 59 Ramley Rd, Lymington, Hants. The Pinetops crop was grown on mobile benches within state of the art glasshouses, with a final spacing of 8 plants per m².

Volmary Ltd, Station Rd, Wisbech St. Mary, Cambridgeshire. The Volmary crop was grown in modern glass on the floor using matting with capillary tubes watering system and spaced at 8.5 plants per m²

KRN Houseplants, Fotherby, Lincolnshire. The KRN crop was grown in a medium sized glasshouse on static benches using a capillary mat irrigation system. Final spacing was 8 plants m².

The growers were selected to represent a broad range of geographical locations and facilities. Their production facilities consist of table and floor production with varying ages of glass. For reasons of commercial confidentiality the results from specific growers are not identified.

The trial covered 11 varieties provided by key breeders who focus on the Northern European markets;

Beekenkamp: Astro Red, Lenora Red, Pon 94 (no longer available)

Dummen: Infinity 2.0, Ferrara, Prima 2.0

Selecta: Christmas Feeling, Christmas Cracker, SK148 (Christmas Sensation)

Syngenta: Titan, Magma Red

In week 30 the plants were despatched directly to the growers; each grower received 128 plants of each of the 11 varieties. The plants were immediately potted up in Peat/Perlite (industry standard) substrate into 13 cm pots and grown in a one block design under standard crop conditions, to ensure adequate guarding of the central experimental plants. The crops were grown under each nursery's site specific standard conditions including nutrition, environmental, irrigation and PGR programmes. Regular nursery visits were undertaken by Mr Kitchener to oversee the trials and provide agronomic advice and support, plus grower liaison.

Compost and tissue analysis was undertaken to understand differences in nutritional uptake and provision between varieties and growers.

At harvest, (21st November to 1st December 2017), measurements of plant performance were assessed on the nurseries. Twelve replicate plants from each variety were randomly selected. Plants were assessed against the same specification by the same scorer, ensuring the measurements were standardised between growers.

Plant performance criteria included;

- plant height
- plant width
- bract number (4 bracts plus 1, in a level arrangement)
- cyathia showing without pollen or stamens showing (on which botrytis may occur)
- 'V' shaped plant for ease of sleeving for retail
- colour typical to the variety with leaves and bracts turgid

Plant quality was scored on a scale of 1-10 where 10 was the highest value. Scores above 4 were considered marketable plants.

Shelf life trial

The shelf life trial was conducted at the University of Lincoln's Holbeach campus, The National Centre for Food Manufacturing (NCFM). The facilities at NCFM, Holbeach were provided with the permission of Poken and Chrysal. After the open day at Neame Lea on 16th November, six replicate plants of each variety from each grower were delivered to The University of Lincoln for comprehensive shelf life assessment, plus four replicate plants from each of the three substrate mixes from the water deficit trial. Figure 3. The plants were transported to site in cellophane sleeves within standard transit boxes. The plants remained boxed for three days to replicate the transportation and depot phase of commercial facilities. Thereafter the plants were randomly placed on benches in pot saucers and remained sleeved for five days to replicate the store phase.

All plants were watered with the same volume of water (mains) three times a week, (to maintain life in the driest plant). The average water consumption was 50 ml every two days.

The shelf life room conditions followed standard trial conditions

- Warm white LED panel lighting - 1000 lux for 12 hours per day
- Temperature maintained at 18 to 22°C
- Relative humidity maintained at 50 to 65%.



Figure 3. Plants as delivered for shelf life room NCFM
Source Le Grys, November 2017

The plants were monitored until 16th January (Figure 4) Visual quality assessments were undertaken on five occasions by the same scorers to ensure consistency. Individual plants were assessed from 0-10 against a range of attributes where: 10 was the highest score, above 4 is acceptable for retail, 4 represented plant deterioration, 3 the plant is unsaleable, 2 represented serious quality defects, 1 indicated plant break down and 0 the plant had died. Quality considerations included:

- Overall balanced shape and colour typical to variety
- Number of bracts and arrangement of bracts, presence of Bract End Burn (BEB)
- Cyathia present, condition of pollen on the stamen
- Leaf and bract fall
- Pest and disease presence

Full photographic records were taken weekly of one replicate plant from each grower and each variety including failures (see Appendix A).



Figure 4. Shelf life room University of Lincoln, NCFM, January 2018
Source; Le Grys, January 2018

Trial two: water deficit trial

Neame Lea Nursery Ltd, Spalding hosted the water deficit trial in their glasshouse facilities, and undertook data collation and collection.

In Week 30 approximately 1,250 (13 cm) plants of Infinity 2.0 were potted in three substrate types to establish the effect of substrate type on sensor accuracy:

- Mix 1, “Industry standard” poinsettia mix of 15 mm peat plus 20% by volume medium grade perlite. To these physical ingredients were added the following; lime to bring the pH into a range of 5.5-6.0, base fertiliser (15-10-20 TE) at 1 g/l, wetting agent at standard rate 0.4 ml/l
- Mix 2, 15 mm peat plus 20% coir and 5% by volume clay, again lime and fertiliser plus wetting agents as per mix 1,
- Mix 3, was the standard bedding type mix as used at Neame Lea, this was a 12 mm peat plus 10% ‘chip N’, a composted wood derived material, with again the lime, fertiliser and wetting agent added as per mix 1.

The plants were grown as a commercial crop pinched during the second week of September (Figure 5). Each ebb and flow bench initially contained 550-600 pots, reduced to 300-350 at first spacing, with further reductions to 100 plants per bench at final spacing. Spacing was carried out on the three benches by hand (normally automated but due to sensor wire connections for the sensors, this was carried out by hand). The cuttings appeared to be a little hard upon receipt and temperatures had been low initially, so rooting out was behind normal crop expectation. Overhead watering was initially done by hand. Neame Lea recorded the following aspects of the trial; potting date, spacing dates and plants per m². The plant watering (by compost type) was recorded, ensuring all benches had the same method, volume and time. Environmental metrics were collated by Neame Lea via the Hoogendoorn PC, recording radiation, compartment temperature and Relative Humidity (RH).

After pinching, one application of calcium nitrate and five applications of 11-42-11(2) fertiliser were applied weekly. From week 38 (approx.) the fertiliser application was changed to 15-5-30, plus a phosphate treatment prior to flower initiation. No PGRs were applied.

Batches of the substrate mixes were sent ahead of the trial to NIAB EMR so that the moisture sensors could be calibrated against the mixes for use in the main trial. This is reported in the results section. Further samples of substrate and foliage were removed at the start of September for analysis.



Figure 5. Water Deficit Trial Neame Lea Nursery
Source; Le Grys, September 2017

At Neame Lea, nine Delta-T sensors (SM150T) per substrate bench were installed into pots connected to a GP2 Advanced data logger and controller, powered by both battery and solar panel, and wired to a modem (Figures 6-8).

The sensors were calibrated for each of the three substrates and set up on benches (21st August), located in close proximity to each other to ensure uniform environment, RH, humidity and light levels for consistency. Telemetry enabled remote access to “real-time” temperature-corrected SVMC data and environmental metrics including air temperature, and RH from which VPD was calculated. Changes in SVMC were recorded every 15 minutes. Information was displayed in the DeltaLINK Cloud. (The collation of environmental data within the glasshouse demonstrated feasibility for the trial assessment).

The “dry growing” regime was first deployed by Neame Lea in mid-late September and SVMC was allowed to fall to 17% at the beginning of Week 39. Following a relatively dry regime throughout much of October, a second water deficit was imposed in Week 43 to limit stem elongation.

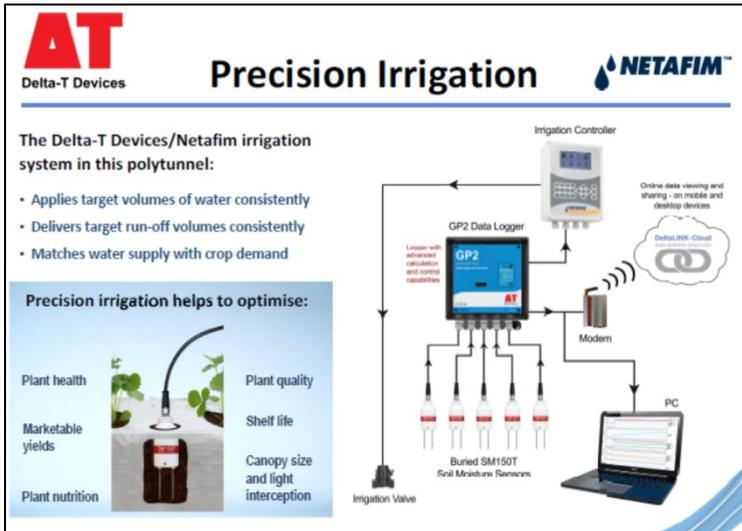


Figure 6. Diagram showing equipment layout
Source; Delta T Devices



Figure 7. Water deficit Trial Neame Lea, bench sensor
Source; Else, September 2017



Figure 8. Water deficit Trial Neame Lea, bench data collection
Source; Else, September 2017

Establishment of wilting point

Nine plants were randomly selected and raised off the bench on to up-turned pots, removing them from the ebb and flow system during October and November. They were then subjected to drying cycles. Monitoring was carried out to determine at what soil moisture value the crop wilts.

The degree of stress perceived by a plant growing in drying substrate depends on the aerial environment, especially air temperature and evaporative demand, therefore the daily VPD from mean RH and temperature within the nursery during the period of water deficit was taken into consideration.

Substrate and plant material

Assessments of substrate and plant samples were carried out at University of Lincoln's Holbeach campus, to determine fresh weights, dry weight and moisture contents. Eight samples (plants) from each substrate mix were randomly selected from the benches containing the moisture sensors, on five occasions. A total of 144 plants were used for destructive sampling. These plants were replaced with those from within the commercial trial to ensure that the water regime was not influenced.

Key actions during the trial were as follows;

- Sensor installation date (21st August 2017) to test the system
- First spacing 19th September
- Second spacing 25th September
- Start of full capacity 2nd October
- End of full capacity 9th October
- Harvest 15th November

Results, Using Deficit Irrigation to Limit Stem Height

Effects of substrate drying on stem extension

The Delta-T moisture sensors were used to monitor the changes in average SVMC in each of the three growing mixes throughout the “dry growing” regime imposed by the production manager at Neame Lea Nursery. Fifteen irrigation events (incl. drenches) were applied during the growing season to each of the three substrate mixes; the rise in SVMC after each of these events is shown in Figure 9 for Mix 1 as an example. The “stepping” during phases reflects differences in rate of plant water use between day and night. As expected, the daily rate of change in substrate SVMC correlated closely with changes in daily evaporation demand i.e. VPD measured in the trial area (data not shown). Higher VPDs resulted in greater rate of water plant loss, reflected in the steepness of stepping shown in Figure 9.

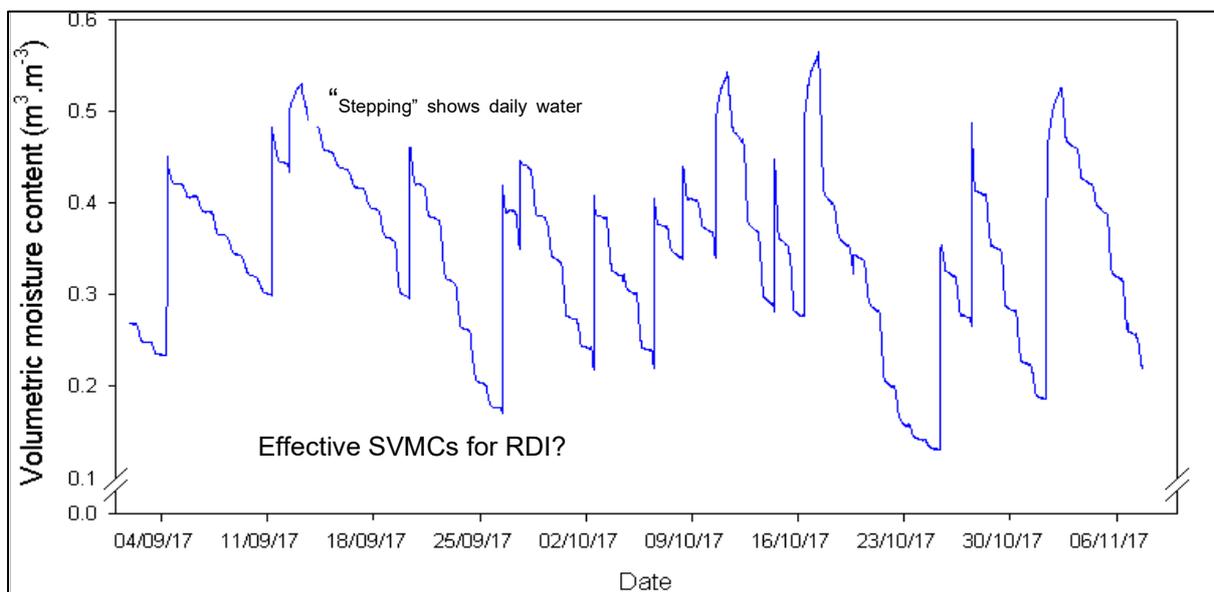


Figure 9. Changes in average SVMC throughout trial Mix 1. The optimum range of SVMC values for effective height control determined in previous trials n=9
Source; Else January 2018

Increases in stem height were tracked and plotted weekly by Neame Lea staff, and compared to “target” values of stem heights that are used by growers to inform decisions about the frequency of PGR applications throughout a typical season. A slowing of stem extension was detected in week 38 and again in week 42 (Figure 10). This coincided with values of SVMC below 20%. The rate of stem elongation was not affected by any other drying episodes e.g. SVMC falling to 23% in Week 40. These results confirm those reported in previous work carried out 2004-2008 with the variety Infinity 2.0 and the standard poinsettia potting mix at a commercial nursery in Staplehurst, Kent. This work showed that a targeted RDI treatment over

the period of rapid stem extension effectively reduced stem extension so that plants met the height specification at simulated market date.

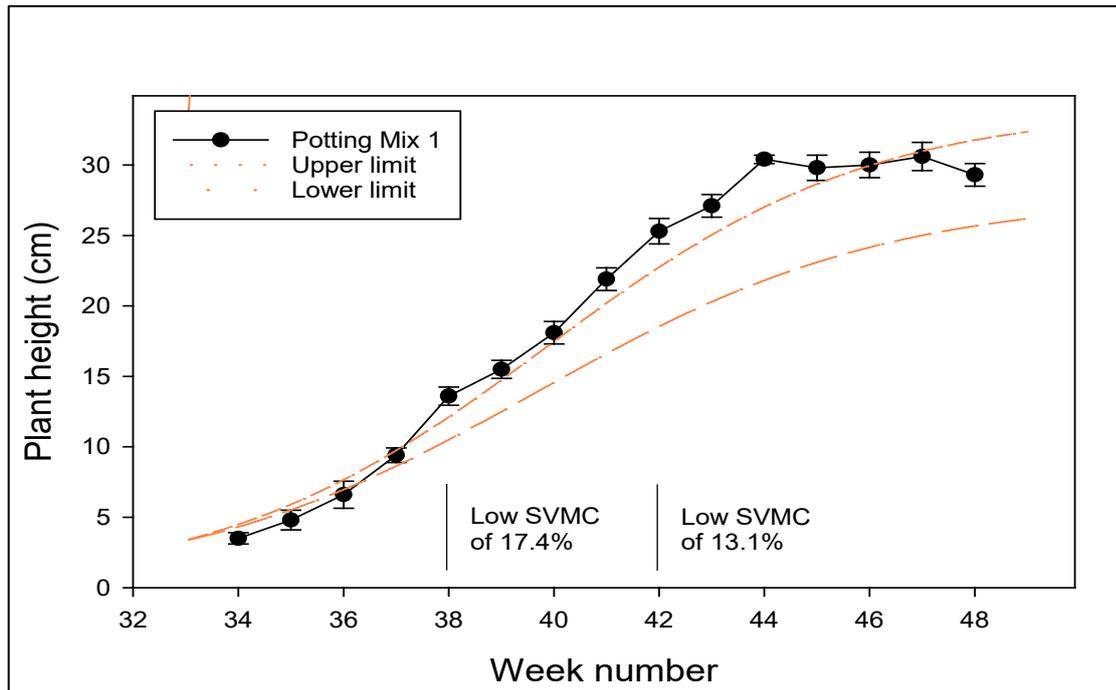


Figure 10. Changes in average stem height of plants grow in in Mix 1 (perlite –bulrush, potted wk 30, 13 cm pot) and subjected to the “dry growing” regime. The upper and lower ranges of stem height needed to ensure that height specs are met at market date are also shown. The substrate volumetric moisture contents (SVMC) that slowed extension growth in Weeks 39 and 43 are also shown.

Source; Else January 2018

Point of wilting

In plants where irrigation was withheld, visible wilting of the leaf tips first occurred nine days after the SVMC value that showed stem extension (7% SVMC), in a plant-plus-pot weight of 250 g. Results were similar in each of the three substrate mixes and over each of the three drying episodes. This data confirmed that there is a reasonable buffer zone between the degree of substrate drying that will effectively control stem height and that which could lower plant visual quality and shelf life potential. This should help to allay grower concerns that the RDI approach is too risky. Sustained wilting occurred at circa. 6% SVMC, with a 220 g plant-plus-pot weight

Substrate

The plants were graded out a second time after 19th September (Figure 11). The mean standard deviation between pots of the same sample after the 19th September decreased and remained consistent between 1.8-3.6% SVMC.

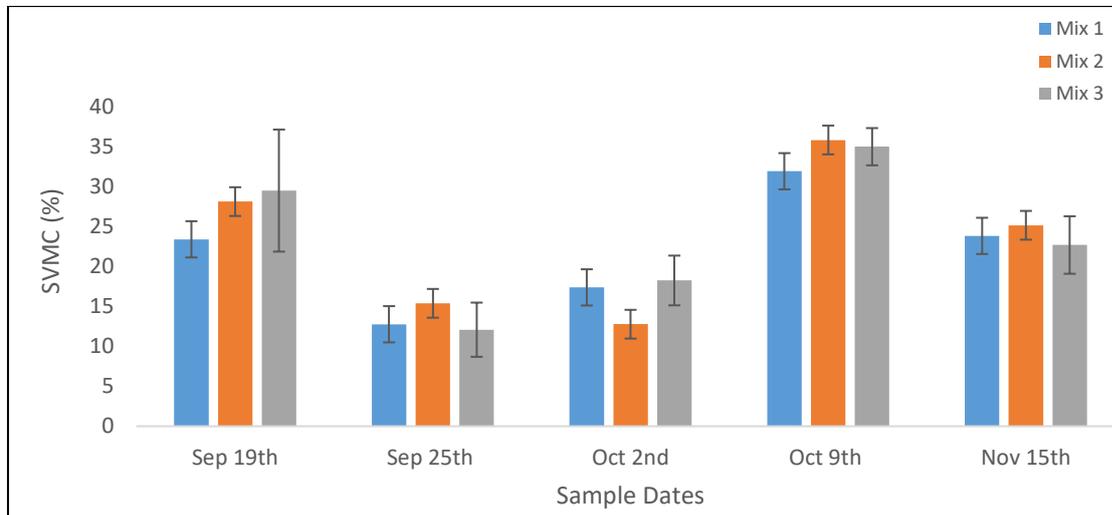


Figure 11. SVMC showing mean and S.Dev. n= 8

The mean percentage difference of SVMC between composts on the same sample date was between 2% (15th November) and 7% (19th September). With the exception of the 19th September and 2nd October, Mix 2 had the highest SVMC per 1 litre pot, indicating slightly higher water retention.

Plant material

Figure 12 shows mean leaf moisture content and dry matter. There was a steady increase in root and plug weight for all substrate mixes as expected (Figure 13). Substrate Mix 3 root material had lower weights after drying which is in line with visual observations, where the roots were less substantial than in the other two substrates at each test date, and there was less root system towards the top of the pot (Figure 14). These findings were supported by earlier root growth observations by Bulrush.

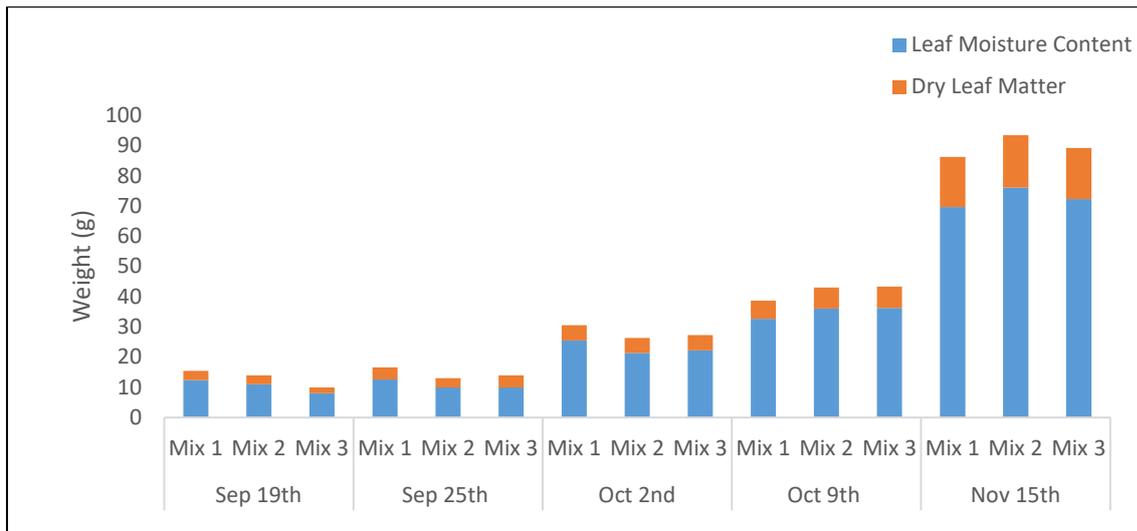


Figure 12. Leaf Moisture content and Dry Matter, showing mean. n= 8 Mix 1= industry standard, Mix 2=Mix 1 plus coir and clay, Mix 3=Neame Lea standard

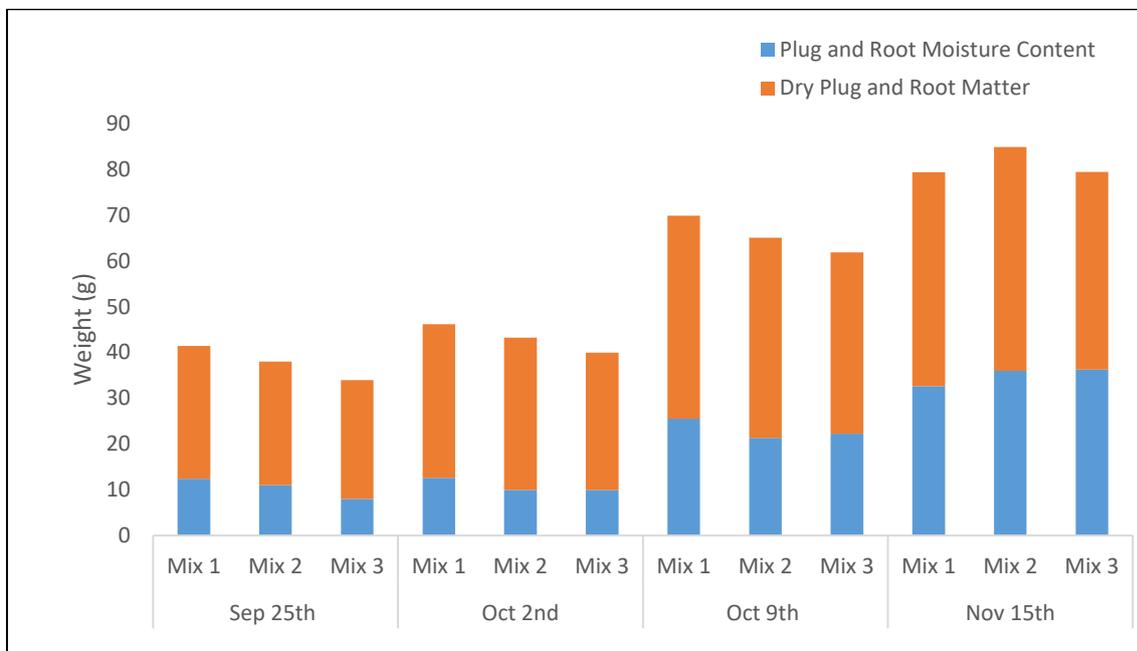


Figure 13. Plug and root moisture content and dry matter, showing mean. n= 8 Mix 1= industry standard, Mix 2=mix 1 plus coir and clay, Mix 3=Neame Lea standard

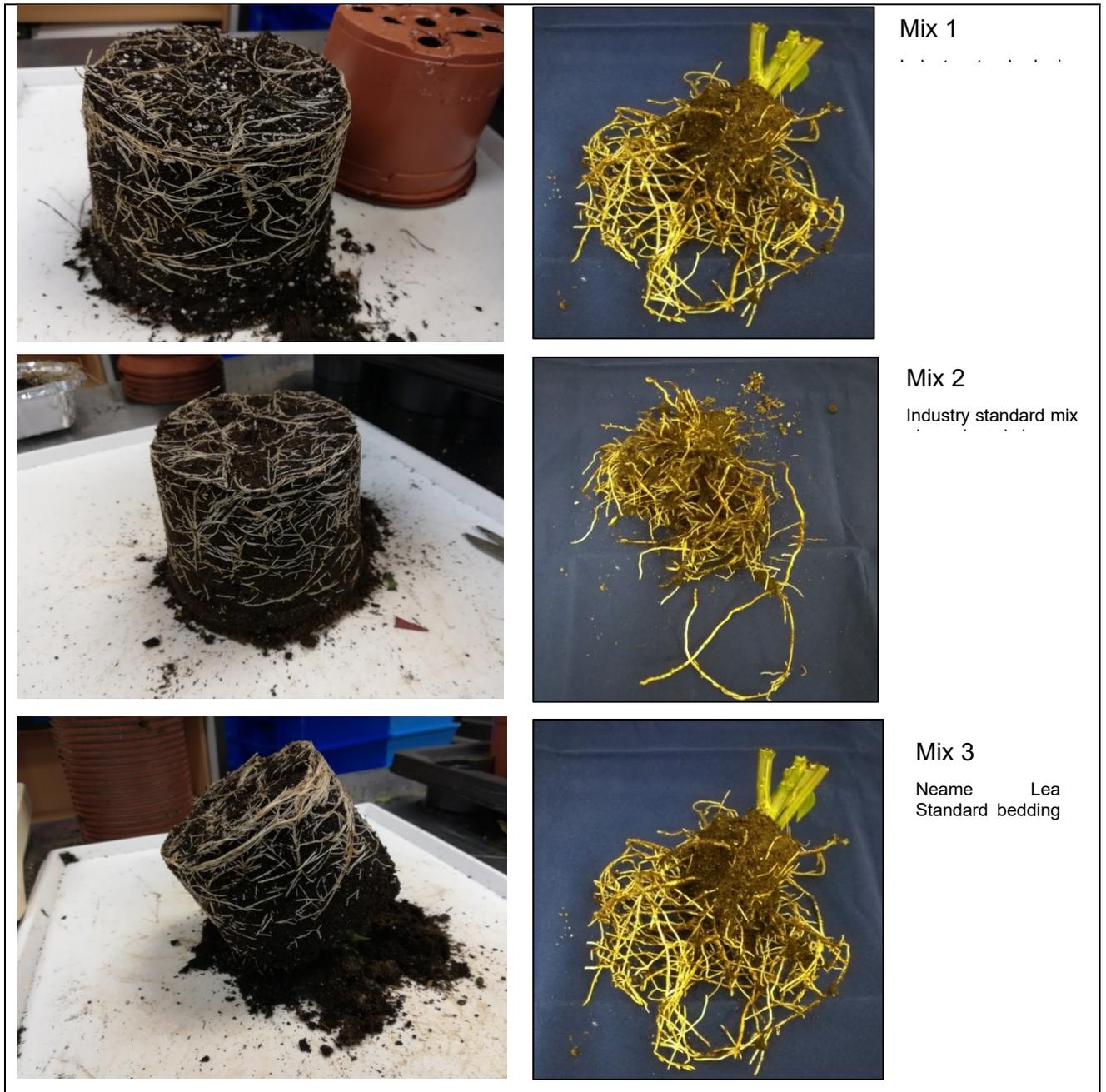


Figure 14. Comparison of substrate Mixes 1, 2 and 3 with relevant plug and roots November 15th Water Deficit Trial
 Source: Le Grys November 2017

Results Harvest

Variety Trial

During the AHDB open day delegates were asked to score each of the varieties to provide a grower focussed assessment of overall quality (33 data sets were received) where 10 was the highest score, 3 had no commercial value and 0 was dead. The results from the Open Day (16th November) assessment by growers of plants from the individual three nurseries are shown in Figure 15. No plants were available from grower 1 for Infinity 2.0. The results indicate Magma Red was the least popular variety and the most inconsistent results between growers showed for Lenora Red (7.2 – 4.5). The combined nursery scores from the Open Day assessment of three growers showed Magma Red as the least popular variety and Astro Red performed the best (Figure 16).

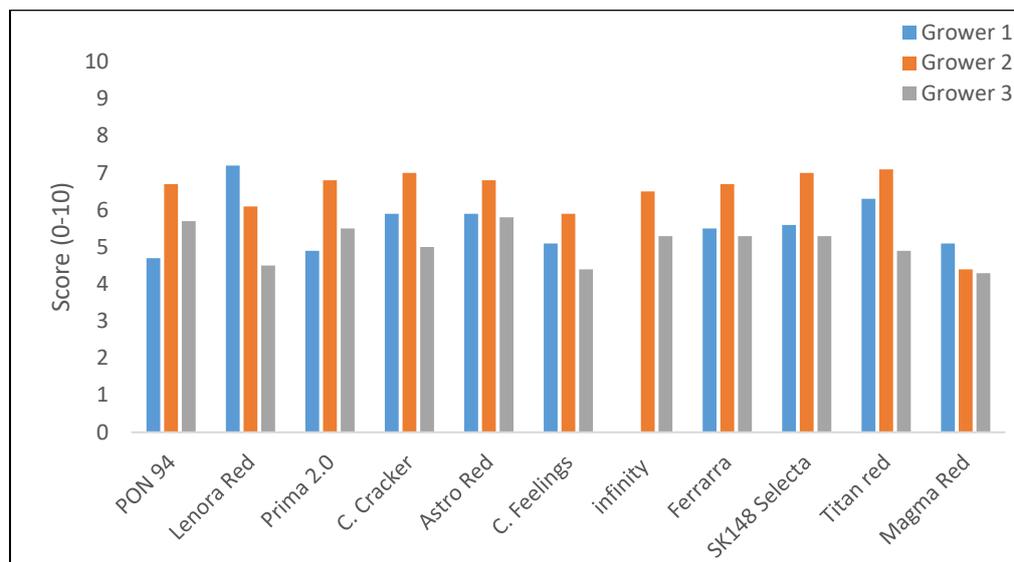


Figure 15. Grower Assessment Open Day 16th November Neame Lea. n=6

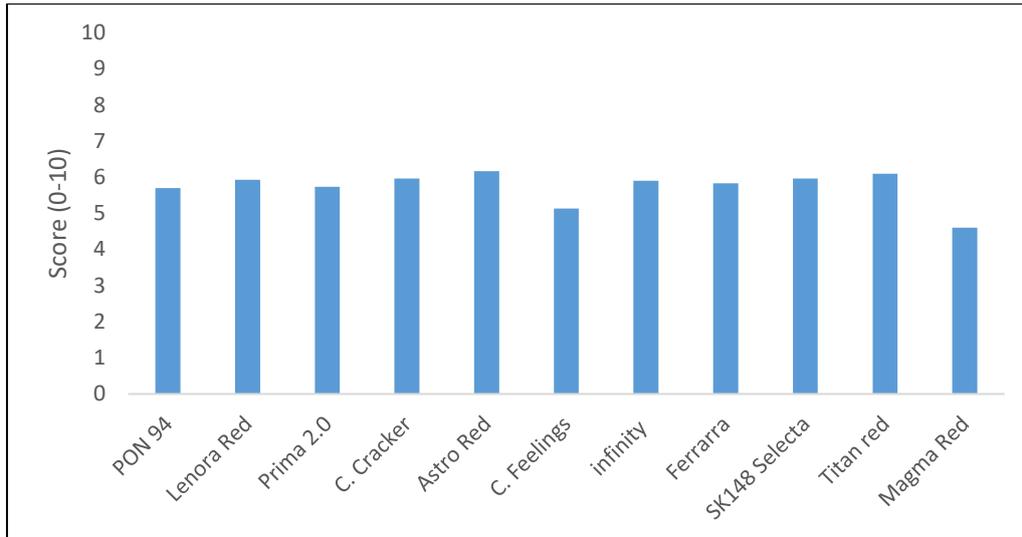


Figure 16. Combined scores by growers Grower Assessment Open Day 16th November Neame Lea. n=12 for Infinity 2.0 and 18 for all other varieties

The combined grower scores were generally similar to the trial assessor’s value, although for most varieties they scored lower for the same varieties than the assessor. This demonstrates that both the individual assessor and the growers had similar opinions on quality. While SK148 (Christmas Sensation) scored the highest assessor score, (7.7), Astro Red scored the second highest (7.4). Both Assessments indicated Magma Red performed the worst (Figure 17).

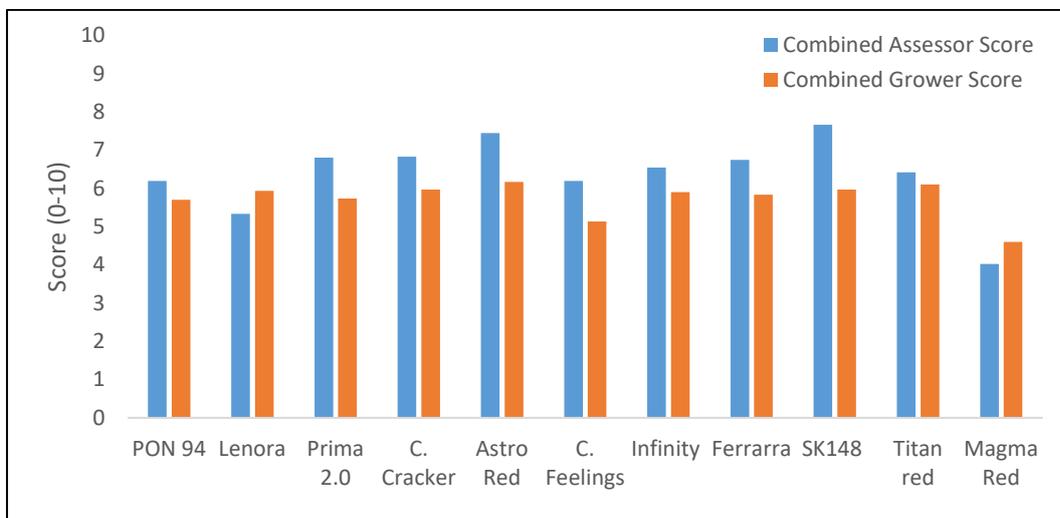


Figure 17. Mean Harvest Plant Quality. Combined grower scores at Open day 16th November compared with combined assessor scores on nursery results (21st November – 1st December) 2017. n=12 for Infinity 2.0 and 18 for all other varieties

The smallest plants at harvest when the nurseries’ results were combined, was Magma Red in both height and width followed by PON 94 and Lenora Red (Figure 18).

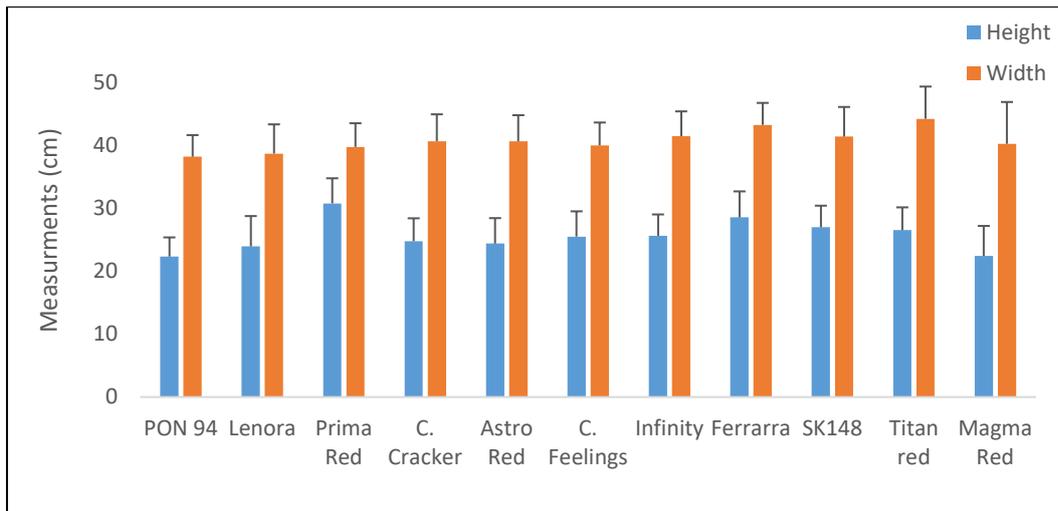


Figure 18. Harvest Plant height and width showing mean and S.Dev. Combined grower results (21st November – 1st December) 2017. n=12 for Infinity 2.0 and 18 for all other varieties

The highest number of secondary bracts at harvest on nursery results was on Magma Red. (Figure 19).

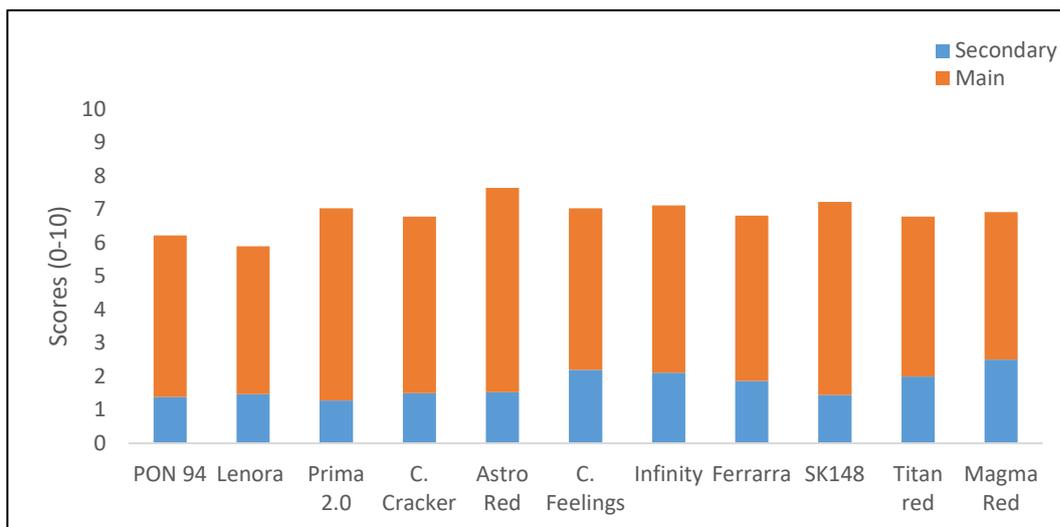


Figure 19. Harvest, mean number of main and secondary bracts. Combined grower results (21st November – 1st December) 2017. n=12 for Infinity2.0 and 18 for all other varieties

Water Deficit Trial

The mean height difference in the nine plants used in the water deficit trial differed by 2.8 cm and the mean width differed by 2.3 cm, while the standard deviation between the pots was similar.

Despite the plants from all substrate mixes and the variety trial plants being of similar height and width, the number of main and secondary bracts for all the substrate plants were less than in the variety trial plants (Tables 2 and 3). This difference in bract numbers was reflected in a lower quality score for the substrate mix plants. There was very little difference in *Cyathia* status with regard to substrate mix.

Table 2. Showing the mean data for various features of Infinity 2.0 plants used in the water trial (15th November) n=4

	Substrate Mix 1	Substrate Mix 2	Substrate Mix 3
Main Bracts	3.4	3.7	4.1
Secondary Bracts	1	0.7	0.9
Height	30	27	30
Width	43	43	45
Quality Score	2.8	2.2	3.1

Table 3. Showing the mean data for various features of Infinity 2.0 plants from two growers at variety trial harvest stage (24th November and 1st December). n=12

	Variety trial (harvest stage)
Main Bracts	5
Secondary Bracts	2
Height	26
Width	41
Quality Score	7

Results Shelf Life

Variety Trial

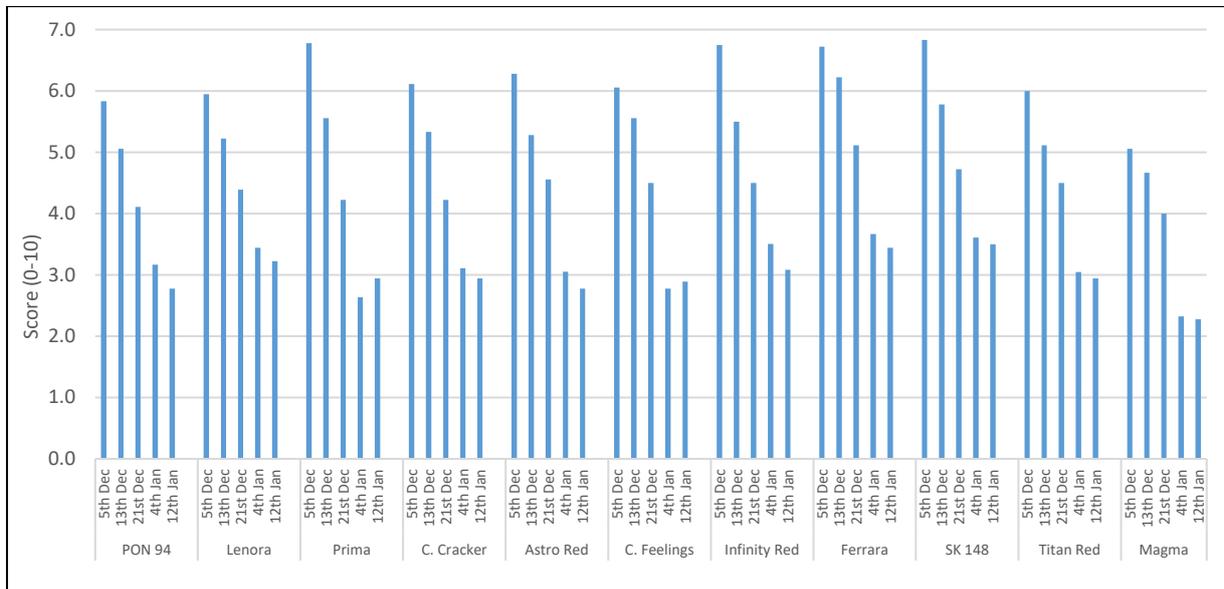


Figure 20. Shelf Life Variety Trial, UoL. Showing quality scores across five assessment dates n= 18

Figure 20. shows a comparison for all varieties of the quality of the plants throughout post-harvest shelf life. This indicated that for overall quality, Magma consistently performed the lowest throughout the assessment period.

At the closest assessment date prior to Christmas, 21st December, there was only a 1.1 difference in mean quality scores between all the varieties with Ferrara showing the highest score of 5.1.

SK148 (Christmas Sensation), Ferrara and Lenora show the highest scores at the end of shelf life, with 3.5, 3.4 and 3.2 respectively. All varieties showed a smaller change in scores between 4th and 12th January compared with previous assessment dates prior to 21st December. Each assessment gap was 8 days apart.

Water Deficit Trial

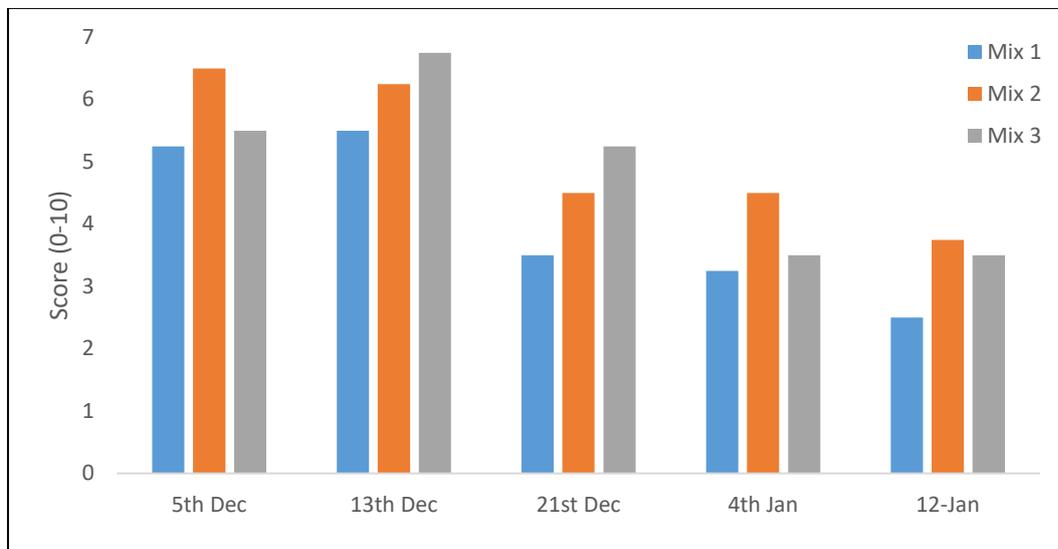


Figure 21. Shelf life Trial, Water deficit UoL showing quality scores across five assessment dates n= 4

The water deficit scores on each assessment date, with the exception of the first date, showed the same range of scores as the variety trial plants for Infinity 2.0 (Figure 21), the stress of water deficit did not show a notable impact on quality score (Table 4).

Substrate Mix 1 showed consistently the lowest quality score across all assessment dates.

Table 4. Showing mean quality scores of three water deficit substrate Infinity 2.0 plants and combined variety trial Infinity 2.0 plants, for five shelf life assessment dates. (Score range 0-10, where 10 is high).

Plants	5 th Dec	13 th Dec	21 st Dec	4 th Jan	12 th Jan
Mix 1	5.25	5.5	3.5	3.25	2.5
Mix 2	6.5	6.25	4.5	4.5	3.75
Mix 3	5.5	6.75	5.25	3.5	3.5
Variety Trial Infinity 2.0	6.8	5.5	4.5	3.5	3.1

Results - Substrate Analysis

Table 5. Illustrates the substrate analysis gathered during the production phase of the crop.

Mix 1 =20% perlite, Mix 2= 20% coco + clay, Mix 3 Bedding +10%CHIP-N

	Sample Name		DENS	pH	COND	NH4-N	NO3-N	TON	P
			g/l		us/cm	mg/l	mg/l	mg/l	mg/l
27/07/2017	20% Perlite	Unused	321	5.8	277	55.7	84.1	139.8	27.6
21/08/2017	20% Perlite		440	5.8	295	17.3	121.2	138.5	20.9
06/09/2017	20% Perlite		436	5.3	680	7.3	306	313.3	36.9
19/10/2017	20% Perlite		649	5.4	297	14.4	108.9	123.3	113.5
27/07/2017	20% Coco+Clay	Unused	396	5.6	292	28.4	113	141.4	8.4
21/08/2017	20% Coco+Clay		438	5.9	245	15	97.1	112.1	9.3
06/09/2017	20% Coco+Clay		486	5.7	496	7.8	208.6	216.4	14.1
19/10/2017	20% Coco+Clay		638	6	317	13.2	97.4	110.7	140.3
27/07/2017	Bedding + 10% CHIP-N	Unused	327	5.2	254	51.2	84.3	135.5	28.5
21/08/2017	Bedding + 10% CHIP-N		415	5.5	230	24.6	95.5	120.1	20.3
06/09/2017	Bedding + 10% CHIP-N		491	5.3	498	6.9	203.2	210.1	34.1
19/10/2017	Bedding + 10% CHIP-N		781	5.4	379	16.5	132.4	149	191.9

Table 5 shows the analysis data for those characteristics which are deemed critical to production. There was little nutritional difference between the samples – other than the apparently low phosphorus (P) values in Mix 2. In fact this would not reflect plant available P. Mix 2 contained clay and therefore it would be reasonable to expect adsorption of the P onto the clay. The method of analysis used was based on a water extract so only recovers immediately available nutrients.

Also note that the pH of Mix 3 was consistently lower than the other two mixes, it would probably have been considered as not ideal for poinsettia as lower pH's can make available higher amounts of elements such as Manganese (Mn) which can be accumulated in the plants to the detriment of growth. Fortunately no symptoms of excessive leaf accumulation of Mn were observed in the crop. This would have manifested itself as lower leaf brown spotting and stunting of the plants.

Table 6. Illustrates the leaf tissue analysis results for the crop during production:

	SAMPLE	Cl	N	P	K	Mg	Ca	Mn	Cu	Zn	Mo	B
	NAME	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
06/09/2017	Peat + 20% Perlite	0.28	4.83	1.06	1.44	1.14	2.92	170	4.16	29.4	6.86	21.3
19/10/2017		0.13	5.27	1.41	3.2	0.64	1.08	90	2.26	21.1	1.6	23.3
06/09/2017	Peat + 20% Coco + Clay	0.24	4.75	0.62	1.61	1.14	2.91	138	3.54	26	4.81	17.5
19/10/2017		0.15	5.73	1.33	3.16	0.72	1.13	85	2.42	21.6	1.26	22.1
06/09/2017	Peat + 10% Chip N	0.33	4.66	0.69	1.63	0.99	2.30	93	3.15	21.3	3.35	16.7
19/10/2017		0.14	5.56	1.46	3.23	0.76	1.21	112	2.16	23.8	1.13	24.1

Table 6 illustrates the leaf tissue data collected for the trial plants at Neame Lea. The major concern with regard to leaf tissue data was to monitor the P levels in the tissue especially at or around the beginning of September. The monitoring scheme, run since the late 1990s, has provided evidence that if the P levels in the leaves drops below 0.6% of the dry matter, then in the flower initiation phase in September, the plant will remobilise P from older leaf tissue to ensure that the apical growth points are well supplied. Generally a combination of leaf tissue levels at or around 0.6% and substrate values below 20 mg/l trigger the recommendation for boosting fertiliser input levels of P. This is normally achieved by using either Mono ammonium phosphate (MAP) or a commercial compound such as 10-52-10 feeds for the first two weeks of September. In the results in Table 5, it was clear that the boosting of the P levels was successful as leaf tissue values were raised well above the 1% mark, which supports other work demonstrating P remobilisation (Whipker *et al.*, 2011). The symptom was normally seen on the oldest leaves as interveinal chlorosis, but this can in severe cases lead to lower leaf abscission. Infinity 2.0 is a variety particularly prone to the condition.

The other element looked at was boron (B). In the past the 'book' values quoted for sufficient Boron in poinsettia leaf tissue, ranged around the 30 ppm mark. During monitoring of modern cultivars, values around the 18-20 ppm are more representative of well-supplied plants showing no deficiency symptoms. In the case of this trial, the results indicated that the plants were all well supplied with B from each of the substrates and so there was no limiting of growth potential.

During the monitoring of the plants at the nursery, observations showed that there were distinct differences in the root architecture between the three mixes. The photographs below illustrate the differences which were observed: Figure 22



Mix 1- Peat+Perlite

Mix 2- Peat + coir & clay

Mix 3, Peat plus Chip N

Figure 22. Root architecture in three substrate mixes
Source; Bragg November 2017

The important observation was that in Mix 3 the roots produced were much more like ‘water’ roots (a white fleshy fragile / brittle root, unlike a normal developed finer and more robust root found generally in substrate) suggesting that they had been holding much more water for longer times between irrigations. The other observation was that such roots were found to be much more fragile during any handling. There was however no suggestion that the observed root architecture had made any difference to the plants performance.

The peat and perlite Mix 1 was probably the best and will continue to be used for trial projects, all plants performed well with no leaf symptoms. The monitoring of the crop helped with avoiding phosphorous levels and the associated leaf marking.

Discussion and Conclusions

Trial one variety trial

The objective of the variety trial was to establish which varieties are a suitable crop across a range of growers and facilities. The findings of this trial indicate that the highest performing varieties at harvest and during shelf life were SK148 (Christmas Sensation), Ferrera, Astro Red, while the benchmark Infinity 2.0 was in the top section of scores, and Magma Red performed the least well throughout grower assessment, harvest assessment and shelf life assessment. Magma Red were the smallest plants, but with the most secondary bracts.

Some of the varieties were new to the market from the previous trial and performed well, others have repeated the high performance at shelf life in this trial (Astro Red and Lenora Red) showing year on year resilience.

One grower's plants were smaller in size resulting in possible overshadowing during shelf life assessment and therefore their quality score may have been influenced, although the plants were scored in the same overall pattern of quality among varieties, indicating variety robustness. Astro Red was unusual again in this trial in that it had a relatively high bract count, (especially main bracts) although the plant was comparable in height and width to other varieties.

The grower assessment quality scores were comparable to the nursery harvest quality results with Astro Red and SK148 (Christmas Sensation) scoring well. Lenora Red did not perform especially well at the harvest assessment or grower assessment, it showed as a small plant. Although its overall performance during shelf life assessment was good.

At the 21st December assessment, there was almost no difference in quality scores across varieties.

Shelf life scores indicated SK148 (Christmas Sensation), Ferrera and Lenora Red performed well. Astro Red performed well at harvest and well in shelf life until Christmas but declined in average scores by end of shelf life. All trial plants with the exception of five plants (2%) achieved full shelf life.

Trial two water deficit trial

The aim of the water deficit trial was to demonstrate that poinsettia plant height could be controlled without reliance on PGRs by imposing substrate drying at critical phases during the growing season. Earlier research (funded by DEFRA) carried out on a commercial nursery using Infinity 2.0 grown in a standard poinsettia mix, identified that SVMC (soil volumetric

moisture content) values at or below 17%, imposed during the phase of rapid stem elongation, could be used to control stem height effectively. The results from the 2017 trial carried out at a different location indicate that water deficit irrigation could be considered an effective and reliable means of height control.

The water deficit Infinity 2.0 plants were comparable in quality scores during shelf life with the combined Infinity 2.0 plants used in the variety trials, although more research is required to provide confidence that water deficit is not detrimental to plant quality. It is proposed to test this idea more thoroughly in work planned for 2018.

The three substrates used in the trial were initially calibrated for their response to moisture release. During the trial, the substrates were monitored for their nutritional status and plant leaf analysis was completed; this shows that the plants were in no way limited in growth via nutrition. The results show that the plants in the trial were all adequately supplied with nutrients and there was no limitation to plant growth because of the nutrition applied.

The fact that the physically different mixes produced quite different rooting habits in the plants was of interest but did not appear to have any limiting effect on the plants.

Knowledge and Technology Transfer

AHDB Poinsettia Open Day 16th November, Neame Lea Nursery

Plant samples were assembled at Neame Lea Nursery; six replicates of each variety from the three growers were labelled and placed on show for growers to assess and to score.

The open day included

- The work and findings to date of the water deficit trials at Neame Lea
- A variety plant display from growers
- The work and findings to date of PGR work carried at Roundstone.(Separate BPPC work)

The open day discussions raised issues relating to relevance and feasibility of “dry growing” for non-ebb and flow bench operations and the need for mobile sensors to allow for bench movement in a commercial operation.

The trial results and especially the open days have given growers informative guidance on varietal selection. Growers were asked to judge at the open days to confirm and re-affirm their choice of varietal selection for the coming 2018 season. The open day discussions allowed

for issues to be raised regarding current concerns and potential varietal options for further research, especially into non-red varieties.

Recommended follow-up activities

- Continue work on variety assessment both in different locations and growing regimes. Only using the standard potting mix.
- Continue shelf life trials from harvest through the Christmas period into January.
- Use the precision irrigation technology to schedule irrigation automatically to an irrigation block
- Determine the timing and frequency of water deficits needed to control stem height effectively
- Compare Neame Lea's "dry growing" regime with RDI implemented automatically using the precision irrigation technology
- Quantify the impact of RDI on plant quality, shelf-life potential and stress resilience
- Derive crop co-efficient for three key varieties to enable scaling-up
- Evaluate the use of new sensors that measure substrate matric potential to improve the ability to manage plant stress (perhaps explain that SVMC are affected by changes in bulk density and so the values at which stem height control was achieved may differ in different substrates, whereas the matric potential value should be the same)
- To analyse whether imposing RDI on a commercial scale can deliver added value in terms of plant quality and shelf-life potential
- Preliminary work was carried out in 2017 (not reported here) on deriving crop coefficients for Infinity 2.0 to develop a low-cost approach to scaling-up the precision irrigation and the RDI approach across the nursery, this needs developing.
- Understand how these approaches can be deployed across nurseries that use capillary matting. Much work has been done on optimising irrigation scheduling in Hardy Nursery Stock crops using capillary matting in the past, but needs future development with poinsettia.

Acknowledgments

The authors would wish to thank the AHDB Horticulture team for funding the project work. The authors wish to express gratitude the nursery teams for their support, time and dedication in growing the crops for both trials, especially to Vasile and Kinga at Neame Lea Nursery and to thank Mr Kitchener for his support and guidance throughout the trials. Acknowledgement for the team at Bulrush for their technical assistance and knowledge during the water deficit trials and the technical team at University of Lincoln for their work on the substrate and plant material and shelf life trials. Acknowledgment of the use of the Pokon and Chrysal shelf life room at NCFM.

We thank all those associated with the organisation of the open days, and the industry's attendance which showed support for the trials.

Key Staff

Harry Kitchener, HMK Ltd

Neil Bragg, Bulrush Horticulture Ltd

Wayne Brough, AHDB horticulture

Martin Squire, Pokon and Chrysal

Andrew Fuller and Vasile Agache, Neame Lea Nursery

Francis Mizuro, Volmary Ltd

Ian Paton, Pinetops Nurseries Ltd

Paul Firth, KRN Plants Ltd

Mark Else and Mike Davies, NIAB EMR

Simon Pearson, Chris Bishop and Nicole Le Grys, University of Lincoln

References

Whipker, B., McCall. I., Barnes, J. (2011) Greenhouse Product News (July) pages 32-3, [www.GPNMAG.com]

Appendices

Appendix A Shelf life photographs

Photographs of replicates of the same grower and same variety at start and end of shelf life trial. The photograph on the top row shows replicate (a) taken 27th November 2017, the photograph on the bottom row shows replicate (f) taken 8th January 2018.

PON94; Grower 1

Grower 2

Grower 3



Lenora Red; Grower 1

Grower 2

Grower 3



Prima; Grower 1

Grower 2

Grower 3



Christmas Cracker; Grower 1

Grower 2

Grower 3



Astro Red; Grower 1

Grower 2

Grower 3





Christmas Feelings; Grower 1

Grower 2

Grower 3



Infinity 2.0; Grower 1

Grower 2

Grower 3

No plant available		
No plant available		

Ferrara; Grower 1

Grower 2

Grower 3

SK148; Grower 1

Grower 2

Grower 3



Titan; Grower 1

Grower 2

Grower 3

Grower 1 (f) died by end date so (e) shown on 8th January 2018



Magma Red; Grower 1

Grower 2

Grower 3

Grower 2 (f) died by end date so (e) shown on 8th January 2018

