Grower Summary

Developing precision and deficit irrigation techniques to reduce reliance on PGRs and to optimise plant quality, uniformity, and shelf-life potential in commercial protected pot and bedding plant production

PO 022

Final report

Project title:	Developing precision and deficit irrigation techniques to reduce reliance on PGRs and to optimise plant quality, uniformity, and shelf-life potential in commercial protected pot and bedding plant production
Project number:	PO 22
Project leader:	Dr Mark Else, NIAB East Malling
Report:	Final Report, March 2023
Previous report:	Annual Report, January 2021
Key staff:	Mike Davies, NIAB East Malling
	June Taylor, NIAB East Malling
	Hilary Papworth, NIAB
	Dr Paul Alexander, Bulrush Horticulture Ltd
Locations of project:	NIAB East Malling, New Road, East Malling, Kent ME19 6PR, UK.
	NIAB, Lawrence Weaver Road, Cambridge CB3 OLE, UK.
	Staplehurst Nurseries Ltd, Clapper Lane, Staplehurst, Kent TN12 0JT, UK.
	Neame Lea Ltd, Horseshoe Lane, Spalding, Lincs. PE11 3JB, UK.
	Volmary Ltd, Station Rd, Wisbech St. Mary, Cambridgeshire, PE13 4RY, UK.
Industry Representative:	NA
Date project commenced:	1 August 2019

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.

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.

Mike Davies

Scientific Support Specialist

NIAB East Malling

Signature Date 30 May 2023

June Taylor

Scientific Support Specialist

NIAB East Malling

Signature Date 30 May 2023

Report authorised by:

Mark Else

Head of Department, Crop Science and Production Systems

NIAB East Malling

Signature Date 30 May 2023

GROWER SUMMARY

Headlines

- Poinsettia plant height and quality specifications at dispatch were fully met when Regulated Deficit Irrigation (RDI) was used as a non-chemical method of growth control on a commercial nursery;
- Shelf-life potential of RDI-treated plants was improved compared to plants sprayed with PGRs;
- RDI should only be applied to plants with well-developed root systems;
- Objective criteria to assess the quality of poinsettia at dispatch and after shelf-life have been developed;
- The combined use of crop co-efficients and vapour pressure deficits can inform commercial decisions on irrigation scheduling and application of RDI.

Background

In scientifically robust Defra-funded work carried out by NIAB EM and Staplehurst Nurseries Ltd between 2004 and 2008, we showed that Regulated Deficit \irrigation (RDI) applied during the period of rapid stem extension effectively limited plant height so that retailer specifications were met at market date, despite a 90% reduction in PGR use. RDI-treated plants were also more tolerant of chilling stress, and leaf and bract drop during shelf-life tests were reduced by 50% and 90% respectively, compared to well-watered control plants under the commercial PGR programme. Once the RDI technique had been optimised, these benefits were delivered over two consecutive seasons in 2006 and 2007.

Further work funded by the AHDB, led by the University of Lincoln, and carried out at Neame Lea Nurseries in 2017/18 and 2018/19, demonstrated that Deficit Irrigation (DI) could be successfully deployed as a non-chemical means of growth control at scale on a commercial poinsettia crop. However, despite this and earlier successes, several barriers to the widespread commercial uptake of DI and RDI remain, and the industry felt that more convincing evidence of the potential benefits of using these approaches as a non-chemical method of growth control was needed.

In PO 022, our results from statistically robust experiments carried out on a commercial nursery provided unequivocal evidence of the benefits of RDI for height control, quality at dispatch and shelf-life potential of key pot and bedding species. At the outset, we recognised that new approaches were needed to facilitate non-chemical growth control in commercial production systems, and so we assessed and developed tools and technologies that would deliver RDI reliably and consistently in a range of production systems currently used by small-, medium- and large-scale protected pot and bedding growers.

A key aim in PO 022 was to develop objective criteria for the assessment of plant quality at dispatch, following transport and during shelf-life tests to ensure that quality attributes are viewed consistently across the industry. This was achieved for poinsettia and the criteria are available to growers and researchers.

Summary

To quantify the effects of deficit irrigation on poinsettia growth, quality, and shelf-life potential

The potential of using RDI to control stem extension, meet retailers' quality specifications at dispatch, and extend shelf-life potential was investigated on a commercial crop of "Hera" poinsettia at Staplehurst Nurseries, Kent, planted in Week 29. Six irrigation blocks each consisting of four flood-and-drain benches were randomly allocated to either a Commercial Control treatment or an RDI treatment . Decisions on when to apply PGRs and irrigation events to the Commercial Control plants were scheduled by the Staplehurst grower team. Following a single application of PGR at pinching, no further sprays were applied to the RDI crop. RDI was applied during a specific development stage (see below) and during this period, the frequency of irrigation events to the RDI-treated plants was determined by NIAB EM staff. Otherwise, irrigation events to the RDI-treated crop were scheduled by the grower team.

In early September 2019, moisture sensors were placed into nine pots sited across a bench within an irrigation block in both the Commercial Control and RDI treatments. Substrate moisture content averaged every 15 min within treatments was monitored remotely from these sensors with weather station data allowing for calculation of real-time estimates of glasshouse Vapour Pressure Deficits. The NIAB EM team used these real-time data sets to impose the RDI treatment from 16 September 2019 to 10 October 2019. Frequent manual measurements of plant height, substrate moisture content, pore E.C. and plant-and-pot weights were also taken. During this time, four drying cycles were imposed on the RDI crop, with a target lower substrate moisture content of 10-12% before pots were rewetted. Nine fertigation events were applied to the Commercial Control during this period; the duration of irrigation events was the same in both treatments.

Figure GS 1. RDI-treated plants (background) developed paler leaves during the drying down cycles, and bract colouration was delayed compared to Commercial Control plants (foreground). Photo taken on 7 October 2019.

Height data were plotted using a poinsettia growth model used by the nursery. When measured after the end of the RDI treatment on 10 October 2020, the average height of RDI-treated plants was 26.5 ± 0.6 cm, compared to an average Commercial Control plant height of 27.7 ± 0.9 cm.

To establish criteria to objectively assess quality at dispatch, after distribution and during shelf-life

Criteria for the assessment of quality at dispatch were agreed with the Project consortium (see below) and were used by the Staplehurst grower team to ascribe an overall plant quality score. At dispatch, several parameters were measured on randomly selected plants from each treatment, including plant height, canopy width, number of primary and secondary bracts, vertical distance between uppermost and lowermost primary bracts, widths of the largest and smallest bract star, the stage of cyathia development, and the number of leaves on the basal 5 cm of stems.

The only statistically significant treatment difference was the number of primary heads in the Commercial Control plants (5.6) compared to the RDI-treated plants (4.8). Overall, plant quality at dispatch was similar in the two treatments. Average plant heights in the two treatments were similar (CC = 30.2 cm, RDI = 28.9 cm) and these results confirm that effective height control can be achieved using RDI, despite a reduction in PGR use of 85% (1 vs 7 sprays) compared to the Commercial Controls.

After assessment at the nursery, twelve plants from each treatment were selected by the Staplehurst grower team for shelf-life tests.

Figure GS 2. A) RDI-treated and B) Commercial Control plants on the day before dispatch. Photos taken on 7 November 2019.

Criteria for the assessment of plant quality during shelf-life tests were developed by Hilary Papworth (NIAB) and Harry Kitchener (consultant) following discussions with the grower partners. The nomenclature and scoring system to be used to try to ascribe objective quality scores were agreed and used to assess whether RDI impacted on the deterioration of plant quality during an eight-week shelf-life test. The quality criteria are given in the Science Section.

Over the 8-week shelf-life test, leaf abscission was reduced by 50% in plants previously treated with RDI compared to Commercial Controls, and bract abscission was reduced by 90% in RDI-treated plants. Cyathia development was delayed by RDI until week 4 after which values were the same in each treatment. Overall plant quality was higher in RDI-treated plants on five of the seven measurement dates, and plants previously exposed to RDI were aesthetically superior to the Commercial Controls when viewed by the attendees of the AHDB Open Day on 15 January 2020.

To scale-up the DI approach to deliver non-chemical growth control to a commercial poinsettia crop.

Deficit Irrigation was applied to blocks of *ca.* 2,000 "Astro Red", "Freya Red" and "Infinity Red" plants on flood-and-drain benches at Neame Lea's Horseshoe Road site. Sensor technologies were installed on 10 September 2020, and real-time data sets were used to schedule the imposition of DI to the three varieties. Irrigation decisions during the period of DI were made in conjunction with the grower team who were monitoring the crops regularly. Plant heights were recorded using tracker software.

The DI treatment was imposed from 5 October until 4 November 2020 during which time up to six drying and re-wetting episodes were applied. A target lower substrate volumetric moisture content of *ca.* 12-13% was used for each variety. At the beginning of November, some plants were still wilting despite the substrate moisture content having been returned to well-watered values. In follow up, it was apparent that the DI treatment had caused significant lower leaf fall in Freya Red, and the quality of the Astro Red and Infinity Red was also lowered. Upon examination, it was noted that the root systems in each of the varieties were not well developed, and were especially poor in Freya Red. Although height specifications were met at dispatch, the grade-out of DI-treated plants was higher than expected. Reasons for the relatively poor root development in some commercial crops at the Neame Lea Horseshoe Road site in 2019 were not known.

To develop tools to deliver Precision and Deficit Irrigation in different growing systems

To date, most sensor-led approaches have been developed for bench ebb-and-flood systems where irrigation is often uniform, and so the variability of pot-to pot-moisture content is low. Capillary matting is viewed as a less expensive alternative method for irrigation control, but variability in pot-to-pot moisture content can be higher. This variability was mapped and quantified in two commercial nurseries growing potted poinsettia on either capillary matting on benches, or on the floor, by multiple sampling of substrate moisture contents before and after irrigation events.

Variability in the bench-top crop was low immediately after an event (1 h) suggesting that the uniformity of irrigation supply and subsequent uptake of water from the capillary matting was good. Subsequent measurements (72 and 120 h after irrigation) showed that the rate of evapotranspiration across the growing area was also even. These results suggest that the use of capillary matting on level benches offers relatively consistent pot-to-pot substrate moisture control, and that this system would be suitable for sensor-based RDI management with relatively few sensors needed. Unfortunately, pandemic-related delays and disruptions meant that our follow-on work to implement RDI in this system could not be started.

Measurements made on the floor-grown poinsettia crop showed a greater degree of variability, and this persisted even after various interventions made by the grower. The largest source of variability was the limited spread of irrigation water along the length of the bays. With this set-up and inherent variability, it would not be economically viable to consider using RDI as a means of non-chemical growth control, as the extent of substrate drying could not be controlled satisfactorily.

To develop approaches and technologies to apply RDI to pack bedding crops

Following extended delays with access to reliable wireless weighing units, two 30Mhz units were received in November 2022, and one was immediately tested at NIAB East Malling on a potted strawberry selection growing in a Controlled Environment room. The second unit was installed at Staplehurst Nurseries in a crop of primrose in December 2022. Both units generated reliable data over several weeks and provided detailed measurements of water lost by evapotranspiration once irrigation to the measurement pots had been withdrawn. The rate of water loss over a 24 h period correlated strongly with ambient vapour pressure deficit (VPD) at each location, and deviations in these rates indicated when plants first perceived a substrate water deficit *i.e.,* the onset of RDI. Crop coefficients were calculated at different developmental stages for each crop, and these will be used post-project - firstly to schedule irrigation to match demand with supply, and secondly to impose RDI to improve resource use efficiency, consistency of plant and fruit quality, assure and extend shelf-life potential, and reduce emission to land, air and water.

Summary of project outputs

1) We have established that wireless substrate moisture sensors and weighing balances can be operated in real-time in commercial glasshouses reliably, and that the data can be easily viewed remotely on various devices;
2) We have investigated the use of substrate moisture sensors in several growing systems, and have highlighted their respective advantages and limitations;
3) The use of such sensors to measure and map variability in substrate moisture content has been demonstrated in ebb-and-flow and capillary mapping irrigation systems;
4) For longer-term pot crops, the control of growth via RDI can be informed and guided by the real-time substrate moisture data;
5) To decide whether RDI could be applied effectively in any growing system, the degree of variability within each irrigation block should be determined. This is best done by measuring plant-and-pot weights or substrate moisture contents across the growing area before and after an irrigation event. Over-wet or dry areas will reduce the success and benefits of applying RDI;
6) To optimise the quality, and therefore usefulness, of the data sets, more attention should be paid to irrigation system installation and maintenance, for example, bench levelling and irrigation uniformity;
7) More consistency is needed at the pot-filling stage to ensure that the volume/weight of substrate added is similar so that bulk densities are similar in each pot;
8) The use of wireless weighing balances to derive development stage- and variety-specific crop co-efficients is explained;
9) The benefits of using vapour pressure deficit readings and forecasts combined with variety-specific crop co-efficients to improve irrigation scheduling are explained;
10) Advice is available on how to impose RDI on potted and pack bedding using deviations in the rate of change of water loss or substrate moisture content.

Financial Benefits

Cost savings in the purchase and application of PGRs would be realised if RDI was implemented in commercial crops. Reduced fertiliser inputs during the period of RDI imposition would also deliver cost savings. The improved consistency of quality and lower grade-outs resulting from RDI would reduce on-site waste and lower costs and emissions associated with rejections, and the assured shelf-life potential would reduce in-store waste.

Taking active steps to transition to net zero emissions goals would also enhance grower businesses' reputations.

Action Points

For growers wishing to reduce plant variability at dispatch by optimising irrigation scheduling:

- Check that your benches are level – using either a laser levelling system or water on the benches;
- Check that bench trays and channels are clean – to ensure an even distribution of irrigation water;
- Check that drainage holes are clean, with mesh grids in place – to avoid blockages and over wetting the substrates;
- Carry out annual irrigation system performance audits - to identify and resolve issues
- Measure the volume of water delivered at each irrigation event - to calculate minimum irrigation durations;
- Deploy pressure regulated irrigation inputs wherever possible - to ensure that target irrigation volumes are accurate and precise;
- Understand the different phytoclimates in your growing areas - use the information to inform decision-making on irrigation scheduling:

For growers considering testing the potential of using RDI as a means of non-chemical growth control in potted poinsettia crops:

- Before imposing RDI, inspect the root system on several plants to confirm that it is fully developed;
- Aim to impose RDI during the exponential phase of stem extension;
- Avoid applying RDI after week 42-43 when bracts are beginning to expand;
- Reduce substrate moisture contents gradually over 2 weeks to allow plants to adapt to the drying rootzone conditions;
- During RDI, withhold irrigation until some plants begin to wilt;
- Use an inexpensive electronic balance to inform irrigation scheduling under RDI;
- Try to avoid imposing RDI during very hot weather;
- Be prepared to see some wilting plants, and a temporary change in leaf colour;
- After the RDI phase, aim to return substrate moisture content to pre-stress values within 1 week.

For growers considering testing the potential of using RDI as a means of non-chemical growth control in spring pack bedding:

- Avoid applying RDI until plants have established and root systems are well developed
- Reduce substrate moisture contents gradually over 2 weeks to allow plants to adapt to the drying rootzone conditions;
- Use an inexpensive electronic balance to inform irrigation scheduling under RDI;
- Be prepared to see a temporary change in leaf colour, or temporary wilting in some varieties;
- Return substrate moisture content to pre-stress values one week before dispatch to make sure that the substrate is thoroughly rewetted for the distribution/retailing phase.