Grower Summary

SF 136

Improving water and fertiliser use efficiencies and fruit quality in commercial substrate strawberry production

Final 2013

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

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Read the label before use: use pesticides safely.

Further information

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Project Number:	SF 136
Project Title:	Improving water and fertiliser use efficiencies and fruit quality in commercial substrate strawberry production
Project Leader:	Dr Mark Else
Contractor:	East Malling Research
Industry Representative:	Mr Stephen McGuffie Mr Andrew Chesson
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Headline

- A new ‘closed loop’ irrigation system for substrate strawberry production was developed and evaluated on two commercial grower sites
- Irrigation was triggered irrigation automatically, so that coir volumetric moisture contents were maintained between upper and lower set points, irrespective of changing evaporative demand
- The automated irrigation system was used to control the volume of run-off at different stages of crop development and/or to eliminate run-off completely
- Water and fertiliser savings of 17% and 11% were achieved in experiments at Manor Farm and New Farm, respectively. Class 1 yields were maintained and berry quality was improved
- Using five 1.2 L h^{-1} emitters per 1-m-substrate bag improves the distribution of water and provides more flexibility than using a 6 L h^{-1} emitter with four lateral dripper spikes

Background and expected deliverables

More efficient use of inputs including labour, water and fertilisers is vital to the future success of the UK soft fruit industry. Recent droughts, particularly affecting the south east and east regions (Figure 1) have highlighted the need for growers to use water (and fertilisers) more efficiently. Trickle irrigation has been exempt from legislation until now but it is envisaged that drip irrigators will require an abstraction licence in future and growers must be able to demonstrate an efficient use of water to comply with legislation. There is also concern about the effects of intensive table-top soft fruit production on groundwater quality in the south east and the Environment Agency commissioned ADAS to promote ‘best practice’ in a series of grower workshops in 2012.

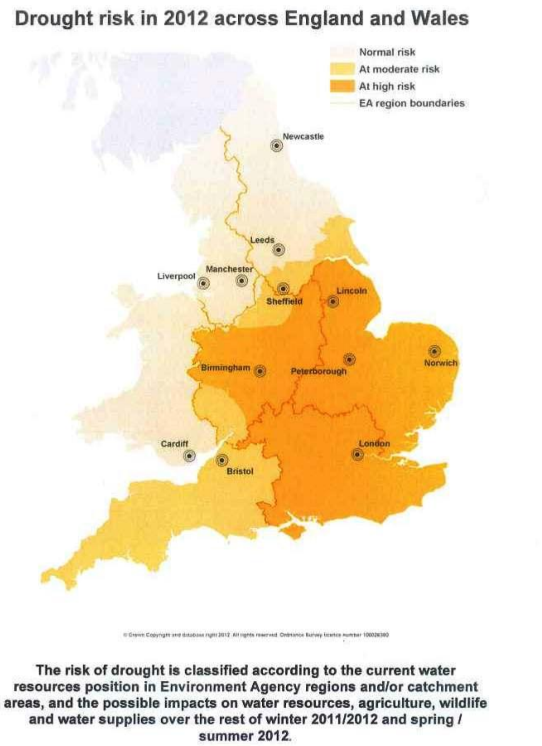

Figure 1. Assessment of drought risk across England and Wales for 2012. Source: the EA.

However, there are few practical guidelines for growers on how best to schedule irrigation, and matching demand with supply can be difficult in changeable summer weather. Many substrate strawberry growers are advised to irrigate to achieve 10-20% run-off, in part to avoid dry spots within the substrate but mainly to prevent the accumulation of potentially damaging ‘salts’. This approach can lead to excessive vegetative growth, increased disease, and fruit with a reduced shelf-life and associated increases in waste fruit. Berry eating quality can also be reduced because key flavour compounds are diluted by the high water content.

If soft fruit growers are to maintain or increase yields against a backdrop of increasing summer temperatures, dwindling water supplies, and governmental demands for greater environmental protection, new production methods that improve water and nutrient use efficiency and utilise ‘best practice’ are needed.

Expected deliverables are:

- Irrigation guidelines to optimise water (and fertiliser) use efficiency in substrate strawberry production;
- Improved economic and environmental sustainability of substrate strawberry production;
- Demonstrable compliance with legislation (Water Framework Directive, The Water Act, The Nitrate Directive);

- The development of a ‘closed loop’ irrigation scheduling tool that triggers irrigation automatically according to plant water use so that water demand can be matched with supply.

Summary of the project and main conclusions

Minimising the daily volume of run-off during changeable summer weather can be challenging, especially when substrate EC levels also need to be managed carefully. In previous HDC-funded work (SF 107) carried out by Dr Else’s team at East Malling Research (EMR), new techniques to save water and fertiliser use in substrate-grown crops of ‘Elsanta’ and ‘Sonata’ were developed. An irrigation scheduling regime that matched water supply to demand, thereby eliminating run-off, was designed using irrigation set points based on plant responses to decreasing substrate moisture contents. In scientific experiments, water and fertiliser savings of 15% for ‘Elsanta’ and 45% for ‘Sonata’ were achieved without sacrificing any Class 1 yield, compared to a commercial regime where run-off averaged 20% over the season. Aspects of fruit quality were also improved, compared to ‘commercial controls’. This irrigation/fertigation strategy needed to be tested in commercial grower experiments to help ensure relevance to the industry and to take account of differences in water quality and background EC.

In HDC SF 136, EMR carried out experiments at Andrew Chesson’s farm (Manor Farm, S.H. Chesson Partnership, Oldbury, Ightham, Kent) and at Stephen McGuffie’s farm (New Farm Produce Ltd, Elmhurst, Lichfield, Staffordshire). The aim of the project was to develop an irrigation scheduling tool that triggers irrigation automatically, according to plant water use so that water demand is matched with supply. By adjusting the irrigation set points, it should be possible to reduce or eliminate run-off of water and fertilisers, without reducing Class 1 yields or quality.

Experimental design

At each of our grower sites, ‘Elsanta’ wase planted into coir bags in late April and early May at Manor Farm and New Farm Produce. There were ten and eight plants per 1-m-long bag at Manor Farm and New Farm, respectively. All plants established well (Figure 2). The experiments compared the growers’ usual methods of irrigation scheduling (Commercial Control - CC) with a Grower Test Regime (GTR) developed at EMR in Defra- and HDC-funded research. Each experiment was set up in a fully replicated randomised block design to ensure statistical rigour; to achieve this, two separate header pipes were installed at each site so that irrigation to the CC and GTR treatments could be applied independently.

Figure 2. All 'Elsanta' plants established wall at Manor Farm, Oldbury, Kent. Photo taken on 25 May 2012

During establishment, all plants were irrigated and fertigated according to usual grower practice. The experiment at SH Chesson Partnership was covered in the last week of May and so the frequent rainfall during May helped to reduce 'blue water' inputs (fresh water from surface or ground water sources). The experiment at New Farm Produce was covered from planting and so irrigation was needed from the outset to aid establishment.

Probes that monitor hourly changes in coir volumetric moisture content (CVMC), bulk EC and temperature (Figure 3A) were installed and connected to data loggers with telemetry so that data from each site could be accessed remotely. Rain gauges were also used to record volumes of irrigation applied and volumes of run-off and in-line water meters connected to data loggers recorded total water use. Irrigation was triggered automatically under the GTR once the coir VMC reached a pre-determined value. This was achieved using GP1 data loggers and SM300 soil moisture probes (Delta-T Devices Ltd) (Figure GS3B). Establishing effective and reliable communication between the GP1 data loggers and the Netafim irrigation rigs at each grower site was carried out by Mr Julian Gruzelier (Eden Irrigation Consultancy Ltd).

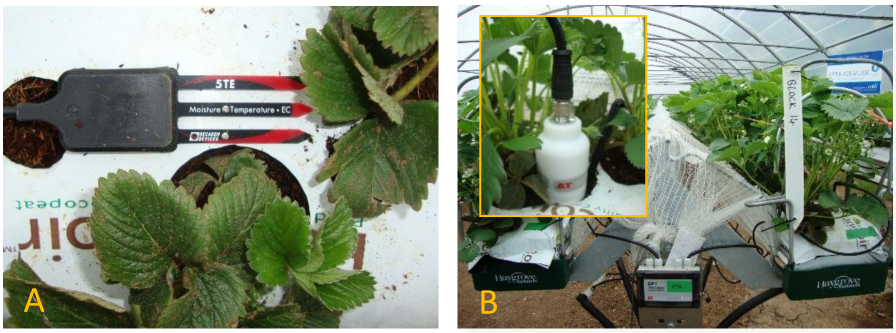

Figure A) The Decagon 5TE sensor used to monitor changes in coir volumetric moisture content, EC and temperature. Photo taken on 15 May 2012. B) The Delta-T GP1 data logger and SM300 probe (inset) used to trigger irrigation automatically once pre-determined values of coir moisture content were reached. Photo taken on 28 June 2012.

At each of our two grower sites, the GTR was imposed at, or just after, 50% full bloom (second week in June 2012). The lower irrigation set points at each site were selected to ensure that although run-off was eliminated, the coir was still sufficiently wet to provide an effective buffer zone to accommodate any unforeseen interruptions in water supply throughout the experiment. During the small green fruit stage, the aim was to control the frequency of irrigation events in the GTR so that run-off volumes of between 1 and 5% were achieved, irrespective of varying daily evaporative demand. Hourly changes in CVMC, bulk EC and temperature were recorded and used in combination with volumes of irrigation applied and volumes of run-off, to inform the GTR irrigation strategy.

Data from the experiment at New Farm over a 7-day period in June are presented in Figure 4. During this time when midday coir temperature varied between 17 and 27 °C, the frequency of irrigation events was adjusted automatically so that water inputs matched evaporative losses, and CVMC was effectively maintained between 0.6 to 0.65 $m^3\ m^{-3}$.

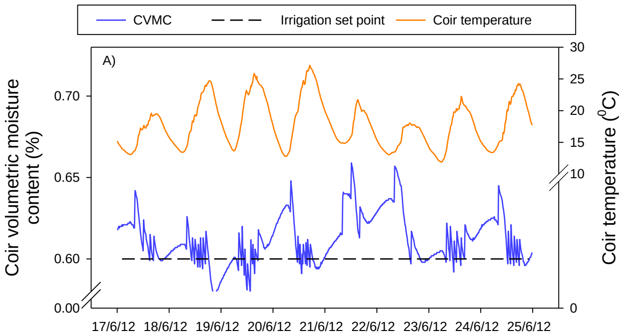

Figure 4. A) Continuous measures of coir volumetric moisture content and temperature during one week in June at New Farm. Irrigation was triggered automatically once the pre-determined value (horizontal dashed line) was reached.

Detailed plant physiological measurements were carried out to determine whether the different irrigation strategies affected plant growth and fruit development.
Changes in CVMC, root zone temperature, dripper inputs and run-off from the experiment at Manor Farm between June and October are presented in Figure GS5.

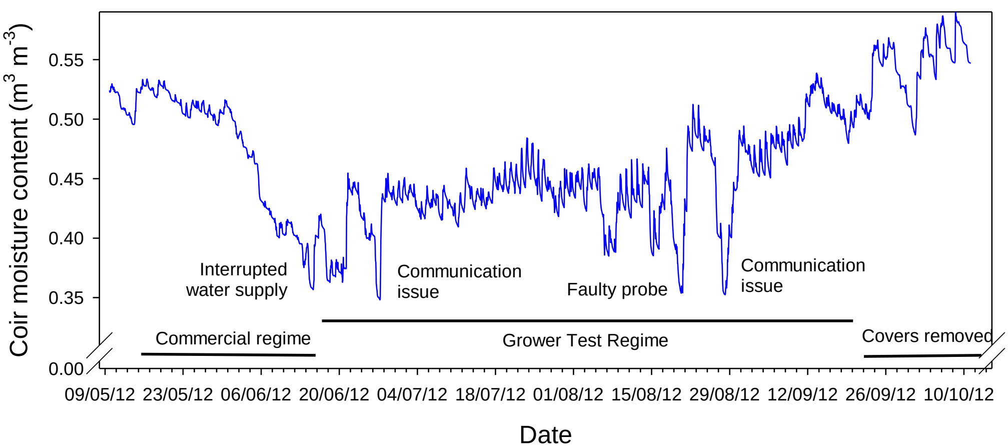

Figure 5. Changes in coir volumetric moisture content and temperature during the experiment at Manor Farm.

Following imposition of the GTR on 16 June, water supply to the trial area was interrupted on two occasions (18 and 26 June) which led to CVMC dropping below the lower irrigation set point. The frequent irrigations needed to restore the CVMC on the 27 June resulted in some run-off (between 2 and 4%) over the following two days. However, from the beginning of July onwards, the CVMC was maintained at a constant value, despite fluctuations in root zone temperature and evaporative demand. The different volumes of water applied per substrate bag on each day (Figure 6A) reflect the differences in daily evaporative demand, with more water needed to maintain CVMC on days with higher evaporative demand. During this time, run-off from the substrate bags under the GTR was eliminated (Figure 6B).

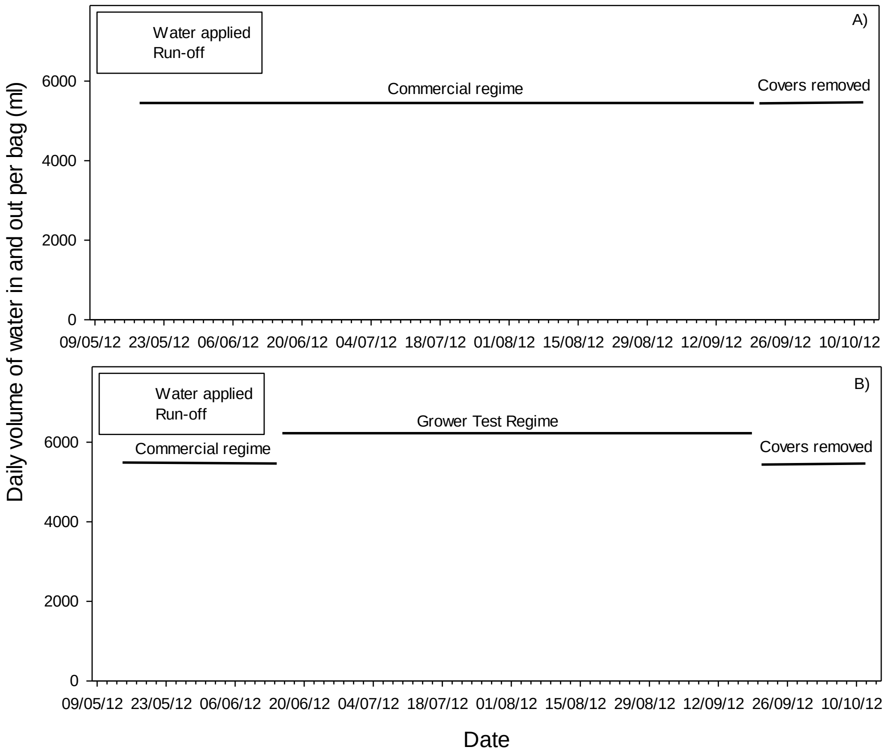

Figure 6. Water inputs and outputs per bag under A) the Commercial Regime and B) the Grower Test Regime at Manor Farm.

Picking began in the first week of July and Class 1, Class 2 and waste fruit were recorded separately from each experimental plot (40 plots at Manor Farm and 32 plots at New Farm). Picking at each of our grower trials continued throughout July until mid-August.

Irrigation water use efficiency

At Manor Farm, from mid-June until mid-August (end of picking), 122 L of water were applied to each substrate bag under the GTR and the volume of run-off was 0.4 L per bag (Table 1). In the Commercial Control treatment, irrigation was scheduled by ‘Rad Sum’ and 146 L of water per substrate bag were applied over the same period; run-off was 9.2 L per bag. Since fertilisers were applied at each irrigation event, a 17% reduction in fertiliser inputs was also achieved under the GTR. Foliar nutrient analysis at the beginning and end of cropping showed no differences between the CC and the GTR treatments.

Table 1. The effects of the two irrigation regimes on yields, fruit quality and water productivity values at Manor Farm.

Irrigation regime	Class 1 yields (g per plant)	Average % BRIX	Average firmness (N)	Volume of water applied per bag (L)	Water Productivity
CC	442	9.2	5.2	146	33
GTR	452	9.5	5.3	122	27

Table 2. The effects of the two irrigation regimes on yields, fruit quality and water productivity values at New Farm.

Irrigation regime	Class 1 yields (g per plant)	Average % BRIX	Average firmness (N)	Volume of water applied per bag (L)	Water Productivity
CC	352	8.8	4.2	115	41
GTR	342	9.1	4.4	102	37

New Farm Produce, from mid-June until mid-August (end of picking), 102 L of water were applied to each substrate bag under the GTR and the volume of run-off was 1.6 L per bag (Table 2). In the Commercial Control treatment, irrigation was scheduled by a combination of ‘Rad Sum’ and changes in evaporative demand; 115 L of water per substrate bag were applied over the same period. The volume of run-off was 23 L per bag. These figures corroborate the view of Stephen McGuffie that the CC was ‘run a little wetter’ than the GTR. Since fertilisers were applied at each irrigation event, an 11% reduction in fertiliser inputs was also achieved under the GTR. Foliar nutrient analysis at the beginning and end of cropping showed no differences between the CC and the GTR treatments.

Class 1 yields and fruit quality

Class 1 yields from the CC and GTR regimes at Manor Farm were similar and averaged 442 g and 452 g per plant, respectively (Table 1). Class 2 and waste fruit were slightly lower under the GTR but in the trial overall, 97% Class 1 fruit was achieved. Fruit firmness was also similar in berries sampled at the beginning, middle and end of cropping from each irrigation regime. Average berry soluble solids contents were also similar but tended to be higher under the GTR towards the end of cropping (GTR = 11.7, CC = 10.7).

Class 1 yields from the CC and GTR regimes at New Farm were similar and averaged 352 g and 342 g per plant, respectively (Table 2). Yield of Class 2 fruit was slightly higher under the GTR. Fruit firmness was also similar in berries sampled at the beginning, middle and end of cropping from each irrigation regime, although values were consistently higher in fruit from the GTR. Average berry soluble solids contents were also similar but were always higher under the GTR.

Water productivity

The efficiency with which irrigation water is used on-farm can be estimated by calculating the Water Productivity (WP) value (the volume of water used to produce 1 kg of Class 1 fruit); a lower value indicates a more efficient use of water. For the GTR at Manor Farm, the WP value calculated from 16 June to 14 August was 27 while for the CC regime, a WP value of 33 was achieved. If the volumes of water used during establishment and after cropping (until the covers were removed in early September) are included, WP values were 50 and 57 for the GTR and CC, respectively. At New Farm Produce the WP value calculated from 16 June to 8 August 2012 for the GTR was 37 while for the CC regime, a WP value of 41 was achieved. The WP values including water used after cropping could not be calculated at New Farm since several large irrigation/fertigation events were applied separately and at different times to plants in the two experimental treatments.

Conclusions

- The aim of this work was to develop and evaluate a system that could be used in commercial substrate production to trigger irrigation automatically, so that coir volumetric moisture contents are maintained between upper and lower set points, irrespective of changing evaporative demand.
- The automated irrigation system was also used to control the volume of run-off at different stages of crop development and/or to eliminate run-off completely.
- The results to date suggest that significant water and fertiliser savings can be achieved in commercial substrate production without affecting berry size, Class 1 yields or fruit quality if irrigation is scheduled to match demand with supply. Water and fertiliser savings of 17% and 11% have been achieved in our experiments at Manor Farm and New Farm Produce respectively, and aspects of berry quality were improved.
- More information is needed on the critical coir EC levels that limit fruit size so that water- and fertiliser-savings can also be achieved on sites where irrigation water has a higher background EC.

- The water savings achieved so far in this project are encouraging given that the two growers, Andrew Chesson and Stephen McGuffie, are already ‘water conscious’ and use irrigation water very efficiently.
- New developments in substrate moisture sensor and data logger technology are being developed and will be included in a proposal to continue this work next year on ‘Elsanta’ main season crops at our two grower partner sites.

Knowledge Exchange and Technology Transfer activities

- Project aims, objectives and results were presented in a series of six articles published in the Fruit Grower magazine from May to October 2012.
- The project aims, objectives and results were presented to BIFGA during a visit to EMR, 25 April 2012.
- The potential of using this approach to schedule irrigation automatically to substrate-grown soft fruit crops so that run-off is eliminated was discussed at two Grower Days held at Manor Farm and New Farm Produce, 8 and 11 July, 2013.
- The project aims, objective s and results were presented at the Fruit Focus Forum 2012 at EMR, 25 July 2012.
- The project aims, objectives and results were presented at the Kent Water Summit: Water security for Farmers and Growers, 12 November 2012, EMR.
- The project aims, objective s and results were presented at the HDC / EMRA Soft Fruit Day at EMR, 22 November 2012.
- The project aims, objectives and results were presented during a visit to FAST Ltd 30 January 2013, Faversham, Kent.
- The project aims, objectives and results were presented during a visit to Angus Soft Fruit Ltd, 7 February 2013, Dundee.
- The project aims, objective s and results were presented at the HDC Agronomists’ Day at EMR, 5 March 2012.

Financial benefits for growers

The project aimed to develop practical ways to improve the economic sustainability of soil-less strawberry production by improving both water and fertiliser use efficiencies. We have demonstrated that a ‘closed loop’ system can deliver water and fertiliser savings in commercial production systems. However, current industry ‘standard’, ‘best’ and ‘better’ practice must be first established before the water and fertiliser use efficiencies delivered in this project can be assessed in a commercial context.

In both commercial trials, five 1.2 L per hour drippers per 1-m substrate bag were used. Some growers are beginning to switch to this system instead of using a 6 L per hour dripper with four irrigation spikes per 1-m bag since water would still be supplied to the majority of the substrate should individual drippers become blocked; these could then be readily and inexpensively replaced. Clearly, the economics of this approach are feasible for commercial production systems.

The reduction in fertiliser use of 17% achieved by one of the participating growers under the GTR could be expected to save around £300/ha/annum. The Rural Business Research (RBR) 2008/2009 Farm Business Survey for Horticulture Production in England reported average annual fertiliser costs (across all specialist glass businesses including soft fruit) of £3,250-£4,500/ha. On this basis, a 20% reduction in fertiliser used could on average therefore save £650-£900/ha. This would cover the costs of the Delta-T GP1 data logger and an SM300 probe; additional one-off costs to cover the connection of the hardware to the commercial fertigation rig would also need to be met.

The RBR 2008/2009 survey reported average annual water costs (across all specialist glass businesses including soft fruit) of £530-£630. This confirms that on average the savings in expenditure on water do not justify expenditure on irrigation scheduling tools. Growers using mains water would be expected to pay significantly more for water and there may then be a significant financial benefit to using less water. The growers involved in this project do not use mains water.

The economic feasibility of installing and running the 'closed loop' system developed in this project in commercial production systems would need to be assessed on a case by case basis. Scaling up the relatively small-scale scientific experiments carried out by EMR to several hectares of high value substrate strawberry will require new developments in substrate moisture sensor and data logger technology. The aim is to develop a wireless system capable of controlling multiple zones of different crops or crops at different stages of growth.

Action points for growers

- Employ an irrigation consultant to ensure that current and new irrigation systems are designed correctly to achieve accurate and precise delivery of water and fertilisers.
- Monitor run-off at different times throughout the day to establish which irrigation events can be reduced to save water and fertilisers.
- Consider using vapour pressure deficits (VPD) to help inform irrigation decisions.

- Use substrate moisture and EC probes to help inform irrigation decisions.
- Consider using five individual 1.2 L h^{-1} drippers per substrate bag to improve the lateral spread of irrigation water and to reduce the impact of blocked emitters on Class 1 yields.

Acknowledgements

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