Grower Summary

SF 152

Improving the consistency of fruit quality in substrate-grown June-bearer strawberry varieties under precision production systems

Annual 2015

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Contractor:	East Malling Research
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GROWER SUMMARY

Headline

- Water and fertiliser savings of 34% and 5% were achieved for ’Sonata’ and ’Vibrant’grown under the Irrigation Test Regimes.

Background and expected deliverables

The UK strawberry industry is a vital part of the UK's rural economy and the market continues to grow at a rate of 2.1% by volume and is estimated to sell 106,606 tonnes per annum, worth c. £454 million. The UK portion of the market was worth £218 million in 2013. Irrigation and the addition of fertilisers (fertigation) is essential to produce the high quality berries demanded by retailers and consumers. Modern intensive substrate production systems incur high initial financial investments and require careful management to ensure quality is predictable, consistent and controllable. Nevertheless, the consistency of supply of high quality berries varies between growers and between successive harvests and 32,000 tonnes of fruit picked each year is unmarketable due to small size, skin crazing and unacceptably soft fruit that is predisposed to bruising, rots and diseases. More precise management of water and fertiliser inputs could be expected to reduce fruit waste by at least 30%.

Growers are currently advised to irrigate to achieve 10-25% run-off to prevent the accumulation of damaging ‘salts’ within the substrate. However, AHDB Horticulture-funded research conducted at EMR (SF 107) and on commercial grower sites (SF 136) has shown that run-off can be eliminated without affecting Class I yields and aspects of fruit quality improved. Despite the obvious benefits of our research, concern over perceived problems associated with increased substrate electrical conductivity (E.C.) is limiting growers’ uptake of the new water- and fertiliser-saving techniques developed at EMR. To help growers gain confidence in reducing water and fertiliser inputs, the critical coir E.C. values and the contributory ions that limit fruit size and quality in modern commercial cultivars (cvs) such as ’Sonata’ and ’Vibrant’ need to be determined.

There is an opportunity to improve tolerance to high substrate E.C. by manipulating ammonium-N ($N\text{-}NH_4$) and nitrate-N ($N\text{-}NO_3$) ratios and this approach can also improve fruit number, berry firmness, soluble solids content and shelf-life potential. Manipulating the ratio of $N\text{-}NO_3$ to $N\text{-}NH_4$ would be of particular benefit in cvs such as ’Sonata’ where berries can be soft and vulnerable to bruising. Despite positive reports in the scientific literature, the UK soft fruit industry is wary of using ammonium nitrate as a major source of N. Currently, ammonium nitrate is used to provide $N\text{-}NH_4$ during fruit development, but is usually eliminated two weeks before picking as it can lead to unacceptable softening and subsequent poor shelf-life.

Strategic research is needed to test whether altering N nutrition has the potential to improve both tolerance to high concentrations of ‘ballast’ ions in the substrate (high EC) and yields and quality.

The project aims are:

1. To improve consistency of fruit quality and reduce unmarketable/waste fruit by 30% in ’Sonata’ and ’Vibrant’
2. To develop precision fertigation techniques to increase resource use efficiency and environmental performance in substrate soft fruit production

Expected deliverables from this work will include:

- The effects of over-watering and over-feeding on consistency of fruit quality in ’Sonata’ and ’Vibrant’
- New grower guidelines for the precision production of substrate-grown ’Sonata’ and ’Vibrant’
- Identification of coir E.C. / ion’ concentrations that limit fruit size and quality
- To test the potential of manipulating N nutrition to improve tolerance to high coir E.C.

Summary of the project and main conclusions

In this project, irrigation set points for 60-day substrate-grown varieties ’Sonata’ and ’Vibrant’ that optimise marketable yields, berry quality and resource use efficiency were identified and tested against typical commercial fertigation regimes. ’Sonata’ established more slowly than ’Vibrant’ and Class I yields were lower than expected, due to a low number of flowers and fruit.

Experimental design

’Sonata’ and ’Vibrant’ plants were grown in 3 L coir pots in a compartment of the GroDome facility at EMR (Figure 1). Three irrigation regimes were applied:

(i) commercial control treatment (CC) in which run-off of water and fertilisers averaged 20% over the growing season;

(ii) a precision ‘closed loop’ fertigation (ITR), where run-off was eliminated and coir kept near water holding capacity; and

(iii) a drying down treatment (DD), where coir was allowed to dry to the point that triggered a range of physiological responses.

Figure 1. 'Sonata' and "Vibrant" plants were grown in a controlled environment in the GroDome at EMR.

The frequency of irrigation events was determined by measuring coir volumetric moisture content (CVMC) using three SM150 sensors connected to Delta-T GP2 Advanced Dataloggers (Decagon Devices Ltd). Once pre-determined values of CVMC were reached, irrigation was triggered automatically. The duration of irrigation events was adjusted to achieve the desired volume of run-off. Irrigation water was delivered to each pot via a dripper stake connected to a 1.2 L $hour^{-1}$, non-return, dripper.

In addition, coir VMC, E.C. and temperature were monitored continuously using WET sensors attached to GP2 (Decagon Devices Ltd); 'spot' measurements were made using a WET sensor and a hand-held HH2 unit (Delta-T Devices Ltd). Irrigation water inputs and run-off were measured with rain gauges connected to EM50G data loggers with telemetry (Decagon Devices Ltd). Leaf and substrate samples were analysed to determine the effects of the different irrigation treatments on plant nutrition. Routine physiological measurements were carried out on twelve replicate plants per cv. in each experiment. Stomatal conductance, midday stem water potential, rate of photosynthesis, and leaf and fruit growth rate were measured at intervals throughout vegetative and cropping stages in each variety.

Coir Volumetric Moisture Content, EC and nutrient accumulation

In 'Vibrant', the average CVMC in the CC treatment was maintained between 47 and 55% throughout the experiment, in the ITR treatment between 44 and 47%, while in the DD treatment, irrigation was withheld until the average value fell to 20% (Figure 2). In 'Sonata', in the CC treatment CVMC was maintained between 52 and 60%, in the ITR treatment between 46 and 54%, while in the DD treatment, irrigation was withheld until the average value fell to 23% (**Error! Reference source not found.**).

The coir pore E.C. rose to 2.2 mS cm^{-1} at the end of cropping in both cvs under the DD treatment, but compared to values from the CC and ITR treatments, these differences were not statistically significant.

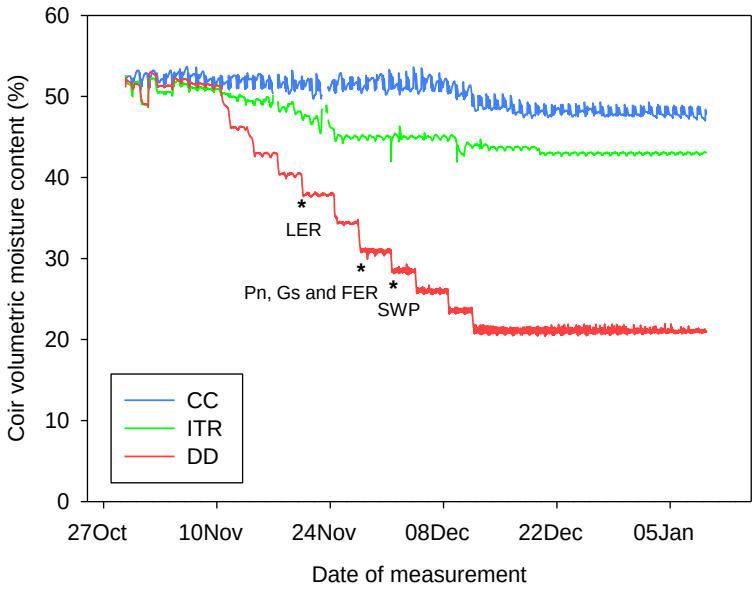

Figure 2. Average coir volumetric moisture contents in the three irrigation regimes of "Vibrant" measured using SM150 moisture probes inserted in the rooting zone

Nutrient analyses of coir and leaf samples collected from each of the three irrigation treatments at the end of cropping indicated that the DD treatment affected nutrient uptake and / or availability. 'Vibrant' plants under the DD treatment had lower phosphorus, zinc, boron and copper leaf concentrations, but a higher calcium concentration. Coir available phosphorus, ammonia and boron were lower in DD-treated 'Vibrant' plants. There were no significant effects of irrigation treatment on leaf and coir nutrient concentrations in 'Sonata'.

Effect of irrigation regimes on plant physiological response

Midday stem water potential is a sensitive indicator of limited substrate water availability and can be used to detect the very early changes in shoot water balance that occur in response to mild substrate drying. Although such values may be significantly lowered, important agronomic traits such as fruit expansion and the accumulation of precursors for important flavour compounds are often only detected as the stress intensifies. A decrease in midday stem water potential was the first physiological response detected in DD-treated 'Sonata', statistically significant reductions were triggered at an average CVMC of 38%. In DD-treated 'Vibrant' plants, statistically significant reductions in stomatal conductance and photosynthetic rate were first triggered at an average CVMC of 30%, while midday stem water potential was lowered at 28%. As expected, no physiological responses were detected in plants grown under the ITR treatment in either cultivar.

Effects of irrigation regimes on fruit marketable yield and quality

Fruit size, fruit number, total and Class I yields (**Error! Reference source not found.**) were not affected by the irrigation treatments in either cultivar. Likewise, no statistically significant differences in berry quality attributes including firmness and soluble solids content (SSC [% BRIX]) (**Error! Reference source not found.**) were detected. Concentrations of organic acids (citric, malic, oxalic, ascorbic) and sugars (fructose, glucose, sucrose), the sugar:acid ratio and total anti-oxidant capacity were similar in all treatments detected (data not shown).*Water*

Table 1. The effects of the three irrigation regimes on Class I yield and quality.

Irrigation regime	cv. Sonata			cv. Vibrant		
	Class I yield (g plant^{-1})	Average BRIX (°)	Average Firmness (N)	Class I yield (g plant^{-1})	Average BRIX (°)	Average Firmness (N)
CC	112.5a*	7.8a	278.5a	159.4a	7.4a	232.2a
ITR	122.4a	7.3a	292.6a	169.7a	7.1a	233.2a
DD	114.0a	8.1a	291.2a	161.1a	7.8a	256.5a

*means followed by the same letter are not significantly different (p=0.05)

and fertiliser inputs

During the cropping period of 'Sonata', 11.9, 7.7 and 6.5 L of irrigation water were applied to each plant grown under the CC, ITR and DD treatments, respectively. 'Vibrant' plants grown under the CC, ITR and DD treatments received a total of 9.0, 8.5 and 5.8 L pot^{-1}, respectively. Therefore, water and fertiliser savings of 36% and 5% were achieved under the ITR treatment, compared to the CC treatment for 'Sonata' and 'Vibrant', respectively. For 'Sonata' the total volume of run-off for the duration of the experiment, excluding flushing events, was 2.4 and 0.5 L per plant for CC and ITR treatments, respectively; while for 'Vibrant' run-off volumes were 2.3 and 0.2 L, respectively.

Main conclusions from the first year's work

- The coir volumetric moisture contents that limit important agronomic traits in 'Sonata' and 'Vibrant' plants were identified.
- This information will be used to inform the irrigation set points to be used in experiments to identify the critical pore E.C values that limit productivity and quality in 'Sonata' and 'Vibrant'.
- Water and fertiliser savings of 34% and 5% were achieved for 'Sonata' and 'Vibrant' grown under the Irrigation Test Regimes.
- Class I yields and berry quality of 'Sonata' and 'Vibrant' were not affected by the irrigation treatments.

Financial benefits

The project aims to improve the economic sustainability of substrate strawberry production by improving both water and nutrient use efficiencies and manipulating the form of nitrogen nutrition. Savings associated with a 30-40% reduction in mains water and fertiliser costs are likely to be increasingly significant, provided that yields, quality, and shelf-life are either maintained or improved. Evidence from other on-going projects suggests that avoiding large variations in CVMC through precision irrigation can improve the consistency of fruit quality. Managing the accumulation of ions in the coir and improving plant tolerance to rising pore E.C values will also help to reduce the need for irrigation flushing events, and the subsequent negative impacts on fruit firmness, flavour, and shelf-life potential. A partial cost/benefit analysis will be carried in Year 3 in which the investment and returns associated with deploying the irrigation treatments and manipulating the form of N nutrition will be compared.

Action points for growers

- Monitor run-off at different times throughout the day to establish which irrigation events can be reduced to save water and fertilisers.
- Use substrate moisture and EC probes to help inform irrigation decisions.
- Consider using the coir volumetric moisture content set point developed in the project to optimise water and fertiliser inputs and reduce or eliminate run-off without affecting marketable yields or fruit quality.
- Consider adjusting water and fertiliser inputs to meet the demands of each variety.