AHDB

HORTICULTURE

Grower Summary

SF 152

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

Annual 2016

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Read the label before use: use pesticides safely.

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Project title:	Improving the consistency of fruit quality in substrate-grown June-bearer strawberry varieties under precision production systems
Project number:	SF 152
Project leader:	Drs Eleftheria Stavridou and Mark A. Else
Report:	Annual report, June 2016
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Key staff:	Mike Davies, Clare Hopson, June Taylor, Veronica Martinez, Carlos Angulo
Location of project:	NIAB EMR (formerly East Malling Research)
Industry Representative:	Laurie Adams, Hall Hunter Partnership
Date project commenced:	1 April 2014
Date project completed (or expected completion date):	31 March 2017

GROWER SUMMARY

Headline

- Transient rises in coir pore E.C. to 3.5 mS cm^{-1} did not affect marketable yields and fruit quality

Background and expected deliverables

Intensive soft fruit substrate production systems incur high initial financial investments and require careful management to ensure quality is predictable, consistent and controllable. Growers are strongly advised to irrigate to achieve 10-25% run-off to prevent the accumulation of damaging 'salts' or 'ballast ions" within the substrate. Nevertheless, the consistency of supply of high quality berries varies between growers and between successive harvests and more precise management of water and fertiliser inputs is needed to improve consistency of yields and quality.

The removal of the exemption for trickle irrigators, the on-going Abstraction Licence Reform and the UK's recent failure to meet the objectives set out in the Water Framework Directive around achieving 'good quality status' of our water bodies, mean that on-farm water and fertiliser use efficiencies must be improved. AHDB-funded research conducted at EMR (SF 107) and on commercial strawberry grower sites (SF 136) showed that run-off can be eliminated without affecting Class I yields, and aspects of fruit quality were improved. On-going work on precision fertigation in NIAB EMR's IUK projects has confirmed that run-off can be reduced or eliminated whilst maintaining or improving marketable yields and consistency of fruit quality in several proprietary varieties. 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 East Malling. To help growers gain confidence in reducing water and fertiliser inputs, the critical coir pore 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. These values can then be used with the automated 'flushing' technologies being developed in IUK project 101623 to control coir pore E.C. more precisely.

There is an also 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 cultivars 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-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. The potential of altering N nutrition to improve both tolerance to high concentrations of 'ballast' ions in the substrate (high E.C.) and fruit yields and quality will be tested in Project Year 3.

The project aims are:

1. To improve consistency of fruit quality and reduce unmarketable/waste fruit 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 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 pore E.C. / ion' concentrations that limit fruit size and quality
- The potential of manipulating N nutrition to improve tolerance to high coir pore E.C.

Summary of the project and main conclusions

In the second year of the project, coir pore E.C. values that limit marketable yields in 60-day substrate-grown "Sonata" and "Vibrant" were identified.

Experimental design

"Sonata" and "Vibrant" plants were grown in 3 litre coir pots, 2 crowns per pot, in the GroDome (controlled environment) facility at NIAB EMR (Figure 1). Three E.C. treatments were applied: (i) EC2.5 where coir pore E.C. was kept below 2.5 mS cm^{-1}; (ii) EC3.5 where the coir pore E.C. was raised gradually to 3.5 and maintained between 3.5 and 4.0 mS cm^{-1}; (iii) EC4.5 where the pore coir E.C. was raised gradually to 4.5 and maintained between 4.5 and 5.0 mS cm^{-1}.

To control the build-up of coir pore E.C. in the different treatments, two feed solutions were applied; a commercial standard feed in which E.C. was maintained between 1.6 - 1.8 mS cm^{-1}, and a high E.C. feed in which E.C. was adjusted between 2.8 – 4.0 mS cm^{-1} to achieve the desired coir pore E.C. value. During plant establishment, the standard commercial feed was applied to all plants. The EC3.5 and EC4.5 treatments were then imposed on some plants by increasing the E.C. of the feed solution first to 2.8 mS cm^{-1}, then by gradually raising the feed E.C to 4.0 mS cm^{-1} to increase the rate of E.C. build-up during cropping. Once the target coir pore E.C. value was reached, the standard commercial feed was applied to maintain the coir pore E.C. within the desired ranges.

Fertigation to “Vibrant” and “Sonata” was scheduled automatically using the irrigation set points derived in Project Year 1 and the precision fertigation approach developed at East Malling. The frequency of irrigation events was controlled by measuring the average coir volumetric moisture content (CVMC) using three SM150 sensors connected to a Delta-T GP2 Advanced Datalogger (Delta-T Devices Ltd). Once pre-determined values of CVMC were reached, irrigation was triggered automatically. In both “Vibrant” and “Sonata”, the average CVMC in all the treatments was maintained between 48% and 65% throughout the experiment. The duration of irrigation events was adjusted to reduce run-off.

Figure 1. “Sonata” and “Vibrant” plants were grown in a controlled environment in the GroDome at NIAB EMR. Photo taken on 20 May 2016

Spot measurements of CVMC, pore E.C. and coir temperature 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 coir samples were collected and analysed to determine the effects of the different E.C. treatments on plant nutrient status. Routine physiological measurements were carried out on twelve replicate plants per cultivar in each experiment. Stomatal conductance, midday stem water potential, rate of photosynthesis and leaf and fruit growth rate were measured at intervals throughout the vegetative and cropping stages in each cultivar.

Results

Coir Volumetric Moisture Content, pore E.C. and nutrient accumulation

In both “Vibrant” and “Sonata”, the average CVMC in the treatments was maintained between 48% and 65% throughout the experiment.

In the EC2.5 treatment, coir pore E.C. was maintained below 3.5 mS cm^{-1} throughout development and cropping in both cultivars. In “Vibrant”, the coir pore E.C. in the EC3.5 treatment reached the target value on 20 April 2016, and coir pore E.C. was generally maintained between 3.0 and 3.5 mS cm^{-1} throughout cropping. In the EC4.5 treatment, the highest coir pore E.C. value that could be achieved was 3.9 mS cm^{-1} on 4 May 2016.

In “Sonata”, the coir pore E.C. in the EC3.5 treatment reached the target value on 13 April 2016, and was maintained between 3.5 to 4.0 mS cm^{-1} until measurements made on 3 May 2016 indicated that the coir pore E.C. had risen to 4.5. Pots were then flushed with the commercial feed solution to reduce coir pore E.C.; values fell temporarily to 2.5 mS cm^{-1} and returned to target values by 13 May 2016. In the EC4.5 treatment, the coir pore E.C. reached the target value on 27 April 2016 and was maintained between 4.0 and 5.0 mS cm^{-1} for the remainder of the experiment.

Effect of E.C. treatments on plant physiological responses

Midday stem water potential is a sensitive indicator of limited substrate water availability and other forms of plant stress and can be used to detect the very early stress-induced changes in shoot water balance. 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 slight but statistically significant decrease in midday stem water potential in both cultivars was detected in plants receiving the EC4.5 treatment on 22 March 2016. At this time, the coir pore E.C. of the EC2.5 plants was below 2.0 mS cm^{-1}, but the coir of those in the 3.5 and 4.5 treatments had only reached 2.5 mS cm^{-1} (Figure 2). In both cultivars, values of midday stem water potential continued to diverge in the EC3.5 and EC4.5 treatments. In “Sonata”, photosynthesis and stomatal conductance were unaffected by the coir pore E.C. values that were reached in these experiments. In “Vibrant”, photosynthesis and stomatal conductance was not affected by transient increases in coir pore E.C to 3.5 mS cm^{-1} but after prolonged exposure to this and higher coir pore E.C. values, both parameters were reduced significantly compared to values measured in plants receiving the EC2.5 treatment. Fruit and leaf extension rates were not affected by the E.C. treatments in either cultivar.

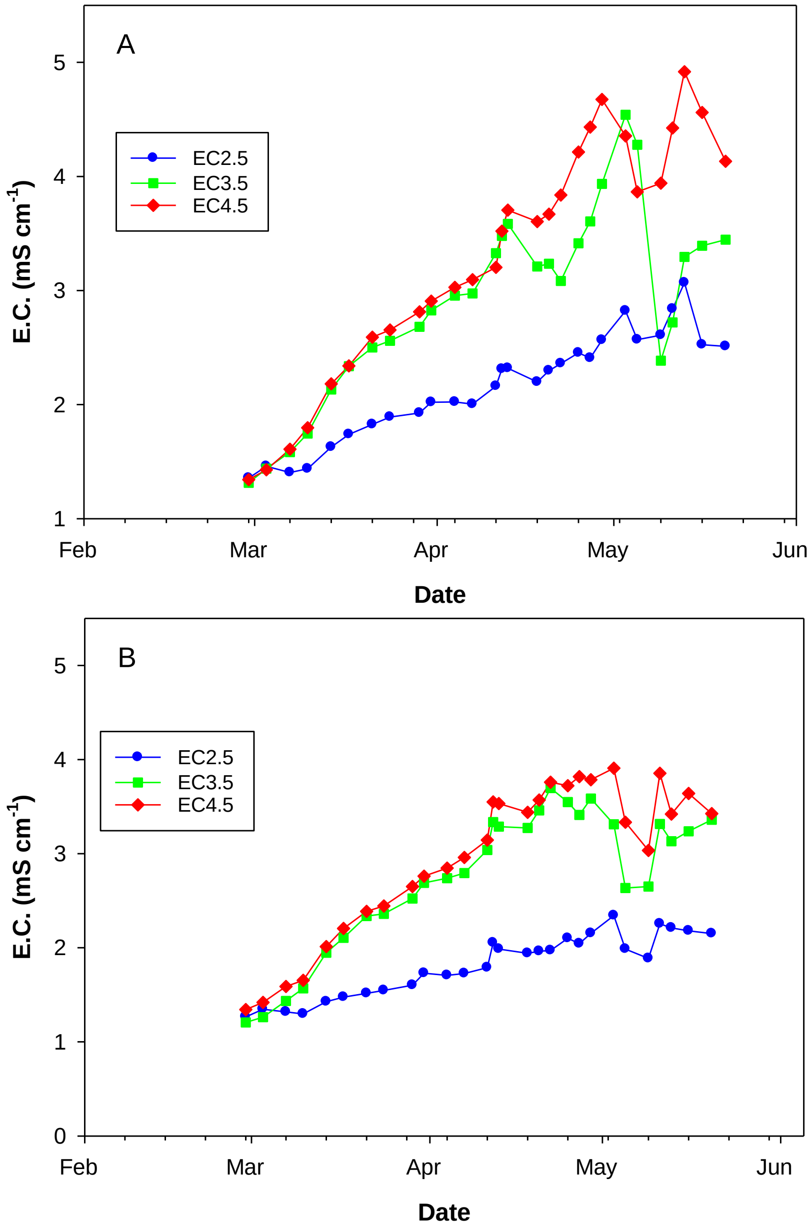

Figure 2. Coir pore E.C. built-up in 'Sonata' (A) and 'Vibrant' (B) plants under the three E.C. treatments

Effects of E.C. treatments on marketable yield and fruit quality

High E.C. levels decreased the total and Class I yields. The reduction was attributable to fruit size as well as a decrease in berry number (Table 1). No statistically significant differences in berry quality attributes including firmness and soluble solids content (SSC [% BRIX]) were detected (Table 1).

Table 1. The effects of the three E.C. treatments on Class I yields and fruit quality components of "Sonata" and "Vibrant".

Treatment	"Sonata"			"Vibrant"		
	Class I yield (g plant^{-1})	Average BRIX (%)	Average Firmness (N)	Class I yield (g plant^{-1})	Average BRIX (%)	Average Firmness (N)
EC2.5	529.4a*	7.9a	2.6a	315.8a	7.4a	3.5a
EC3.5	476.1ab	8.1a	2.7a	295.0ab	8.0a	3.7a
EC4.5	419.3b	7.9a	2.9a	197.0b	8.1a	3.9a

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

Leaf fresh and dry weight

In both "Sonata" and "Vibrant", leaf fresh weight (F.W.) and dry weight (D.W.) at the end of the experiments were reduced in plants under the EC3.5 and EC4.5 treatments when compared to those in the EC2.5 treatment. This reduction was most marked in "Vibrant" with a 22% and 49% reduction in DW of plants in the EC3.5 and EC4.5 treatments, respectively. In "Sonata", reductions in DW of 13% and 23% were recorded for plants in the EC3.5 and EC4.5 treatments, respectively, compared to those in the EC2.5 treatment.

Financial benefits

The project aims to improve the economic sustainability of substrate strawberry production by improving both water and nutrient use efficiencies and improving tolerance to higher core pore E.C. values. 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 conducted 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

- Use substrate moisture and E.C. sensors to help manage coir pore E.C.
- For "Sonata" and Vibrant" 60-day crops, flushing events can be triggered at coir pore E.C.

values of 3 – 3.5 mS cm^{-1} without reducing marketable yields or fruit quality.

- More precise management of coir pore E.C. will help to deliver on-farm improvements in water and fertiliser use efficiencies, and demonstrate compliance with new and impending legislation.
- Adjustment of manganese inputs is needed to avoid foliar toxicity at coir pore E.C values above 3.5 mS cm^{-1}.