Grower Summary

SF 152

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

Final 2017

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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
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Previous report:	Annual Report, June 2016
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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

- Increasing the ratio of ammonium to nitrate nitrogen in substrate grown strawberry feeds can overcome the loss of yield caused by high E.C.

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 the 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 to achieve '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.) has discouraged grower 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 and nitrate ratios. This approach can improve fruit number, berry firmness, soluble solids content and shelf-life potential. Manipulating the ratio of ammonium:nitrate would be of particular benefit in cultivars like '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. Ammonium nitrate is currently used to provide ammonium 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 was tested in Year 3 of this project.

The project aims were:

- To improve consistency of fruit quality and reduce unmarketable/waste fruit in Sonata and Vibrant
- 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 to manipulate N nutrition to improve tolerance to high coir pore E.C.

Summary of the project and main conclusions

In the first two years of the project, experiments were done to establish the coir moisture content at which Sonata and Vibrant plants began to show the first signs of a drought response. The results were used as a basis for irrigation control setpoints in experiments to find out the EC values at which productivity and fruit quality begin to be affected.

In these experiments, three different EC treatments were imposed: in one, the coir EC was kept below 2.5mS/cm; in the second, EC was raised gradually to 3.5 and then maintained between 3.5 and 4.0mS/cm; and in the third, EC was raised gradually to 4.5 and then maintained between 4.5 and 5.0mS/cm.

In Sonata, photosynthesis and the degree of stomatal opening – used as an indication of a plant's stress response – were unaffected by being grown at the higher EC values. In contrast, photosynthesis and stomatal opening were significantly reduced in Vibrant after prolonged exposure to EC levels of 3.5mS/cm and higher, compared with plants where EC was kept below 2.5mS/cm.

For both varieties, however, neither marketable yields nor fruit quality were affected by short-term increases in EC to 3.5mS/cm. Class 1 yields fell when EC exceeded 4.0mS/cm, although

berry quality was unaffected. Some manganese toxicity symptoms were seen in plants at both of the higher EC levels.

In the work's final year, the scientists investigated whether there is an opportunity to improve a crop's tolerance to high substrate EC by manipulating its source of nitrogen – varying the ammonium and nitrate ratios.

2016 experiments

Plants were established during August when they were given a commercial standard vegetative feed. Fertigation was switched to a fruiting feed at the end of August, and that was when the different experimental regimes were imposed.

There were four treatments:

1. The commercial standard, in which the coir EC was maintained at approximately 2.5mS/cm and nitrogen was applied in a 10:90 ratio – that is, 10% of the nitrogen was supplied as ammonium and 90% as nitrate
2. The same ammonium:nitrate ratio as the commercial standard but with the coir EC at the higher level of 3.5mS/cm
3. Coir EC at 3.5mS/cm but with a higher proportion of the nitrogen supplied as ammonium, at 50% ammonium and 50% nitrate
4. Coir EC at 3.5mS/cm but with the proportion of the nitrogen supplied as ammonium further increased, to 75% ammonium and 25% nitrate

The total amount of nitrogen applied was the same for each, only the contribution made by each nitrogen source was varied. All the key micronutrients were kept the same for each treatment, too. The high EC feeds were achieved by altering the concentrations of sodium, chlorine and sulphur – the water leaving the drippers in these treatments was maintained at 3.0 to 3.5mS/cm, enabling the coir EC to climb to the required level. For the commercial standard treatment the fertigation EC, at the drippers, was held at 1.6 to 1.8mS/cm, to limit the build-up of ions in the substrate. The pH of the irrigation water for each regime was kept at 5.8 to 6.2.

Both varieties showed measurable levels of water stress under the high EC regimes, irrespective of the proportion of ammonium in the nitrogen feed.

The Sonata plants grew less well in the high EC regimes, except where the highest ammonium ratio was used, when growth was comparable with plants under the commercial regime.

The situation was less clear for Vibrant. There was no significant difference in growth between the EC regimes, though at the high EC with ammonium and nitrate at equal rates, plants grew

significantly better than in the other treatments. Plants in the trial were not as vigorous as Sonata and had been grown from smaller sized crowns.

Sonata yielded 206g of Class 1 fruit per plant under the standard EC regime. Raising the EC at the standard ammonium:nitrate ratio reduced this by about 20% to 167g, due to fewer Class 1 berries and more at Class 2. In the other high EC treatments, where more of the nitrogen was supplied as ammonium, yields were significantly better. Although there were 5% fewer Class 1 berries, this wasn't statistically significantly different from the standard regime.

Vibrant's yields were generally around half those of Sonata, a direct result of the smaller and less vigorous planting material in this particular trial. The variety produced 102g of Class 1 per plant in the standard commercial regime and, as in Sonata, raising the EC with no change to the ammonium:nitrate ratio significantly reduced yields, by a similar percentage, to 83g at Class 1 – again due to fewer and smaller berries. Both of the higher ammonium regimes largely overcame the EC effect so that Class 1 yields were similar to those under the commercial EC and nitrogen regime.

Fruit firmness didn't vary significantly for either variety between any of the treatments and it was notable that the higher ammonium ratios didn't lead to softer fruit.

Soluble solids content, or Brix, was significantly higher in fruit from both varieties from the high EC and standard nitrogen regime. For Sonata there were also significant differences between treatments in the concentration of malic acid, which was lower in fruit from all the high EC treatments, and total acids, which were reduced by the combination of high EC and high ammonium.

From the yield and quality results – and the tissue analyses which are detailed in the full project report – it looks as if increasing the ammonium rate leads to a better plant nutrient status at higher EC levels, which counteracts the otherwise damaging effects of salinity stress.

Financial benefits

Early work in this project demonstrated that water and fertiliser savings of 34% and 5% can be achieved for Sonata and Vibrant grown under precision 'closed loop' fertigation, where run-off is eliminated and coir kept near water holding capacity.

In the third year trial high E.C. reduced Class I yields by up to 18%. On a 10 ha farm yielding 25 t/ha, this would result in a loss of £157K p.a. However appropriate adjustment of ammonium:nitrate ratio can reduce the impact by 8-100%, eliminating the income loss.

Action points for growers

- A new irrigation scheduling tool has been developed using setpoints based on coir volumetric moisture contents. Combined with the use of substrate moisture and EC sensors, growers can employ it to make significant water and fertiliser savings.
- Water and fertiliser savings of 36% can be achieved for Sonata and 5% for Vibrant.
- Yields of both Sonata and Vibrant are significantly reduced when coir E.C. is maintained above 3.5 mS/cm during cropping.
- For 60-day crops of Sonata or Vibrant, flushing can be triggered at coir EC values of 3 to 3.5mS/cm with no adverse effect on marketable yields or fruit quality.
- In Sonata and Vibrant, increasing the ammonium:nitrate ratio to 50:50 and 75:25 can reduce the adverse impact of high EC above 3.5 mS/cm on yield.
- High ammonium application did not affect fruit firmness in this project.
- Higher ammonium application decreased coir pH.
- Nutrient formulations need to be refined for each cultivar to avoid toxicity, foliar desiccation and yield reduction at higher coir pore E.C. levels.