Horticultural Development Company

Grower summary

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Improving water use efficiency and fruit quality in field-grown strawberry

Annual Report 2009

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Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

Water savings of up to 75% compared to current industry 'best practice' can be achieved without compromising yields or quality of class I fruit by scheduling irrigation effectively.

Background and expected deliverables

The project aims to provide the potential to increase water use efficiency (WUE) in UK field-grown strawberry production by 40% thereby saving water and improving fruit quality.

Irrigation of the UK crop is now essential to ensure the yields and quality demanded by retailers and consumers. However, strawberry growers, Defra and the Environment Agency are all becoming increasingly concerned about the future availability of abstracted water for trickle irrigation. Current abstraction rates in the major strawberry-growing regions are unsustainable and growers must now comply with legislation designed to safeguard these resources (The Water Act 2003). Recent research at EMR and elsewhere has provided major opportunities to use water more efficiently while continuing to meet consumer demand for sweet fruit with good flavour and shelf-life.

There are two aims to this project:

1) To devise irrigation scheduling tools to deliver irrigation water when and where it is needed.
2) To use the improved irrigation scheduling tool to implement deficit irrigation techniques that deliver further water savings whilst maintaining yields, improving fruit quality and reducing waste.

Expected deliverables from this work include:

- Increased water productivity (WP) and improved fruit quality that will, in turn, increase sustainability and profitability of this sector.
- Practical ways to use water more efficiently that will enable growers to comply with new legislation while continuing to meet consumer demand for high quality, healthy fruit with good shelf-life potential.
- Reduced water usage (by 30-40%), waste and diffuse pollution.

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Summary of the project and main conclusions

The progress made in relation to individual milestones is summarised below.

1.3 Complete physiological measurements, yield assessments and WUE estimates in second cropping year (month 18)

- 'Misted tips' (cv. 'Elsanta' – supplied by Edward Vinson Ltd) were planted out on 2nd August 2007. All plants established well and had produced 7-8 trusses by late May 2008.
- Three different approaches to irrigation scheduling were compared: scheduling using an Evaposensor to estimate crop evaporative demands; scheduling in response to changes in the vertical profile of soil moisture content measured by EnviroSCAN probes; scheduling in response to changes in soil moisture integrated horizontally across the rooting zone using ECH2O probes (the closed loop system).

Figure GS 1. Polytunnel A of the experimental field plot at EMR. Photo taken on 30 June towards the end of cropping

- Two treatments where irrigation was set for fixed times each day (30 and 60 min) were chosen to represent the arbitrary approach to irrigation used by some growers.
- Measurements of pre-dawn and midday leaf water potential and stomatal conductance indicated that soil water availability in all of the three scheduling regimes was becoming limiting at times during cropping.
- Yields of class 1 fruit averaged between 580-680 g fresh weight which equates to 8.7-10.3 tons of class 1 fruit per acre (21.5-25.5 t/ha) (Table GS 1).
- Yields of marketable fruit were improved by all scheduling regimes compared to the 'Arbitrary-30' control value. However, the yields in the 'Aribtrary-30' and 'Arbitrary-60' treatments may have been influenced by their position at the edges of the polytunnels. A different experimental design that eliminates 'edge effects' will be used in 2009.

Figure GS 2. Commercially relevant yields were obtained from the trial this year. Photo taken on 6 June 2008

- Scheduling irrigation by the 'Evaposensor' approach improved water productivity by 2.5-fold over a regime typically used by some growers (Table GS 1). Significant

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improvements in water productivity were also delivered by the 'Closed loop' regime.

- The 'Evaposensor' approach delivered water savings of 75% compared to recommendations in the ADAS current 'best practice' guide (ADAS 2003)[1]

Table GS 1. Yields of class I fruit and water productivities (WP) from each of the five irrigation regimes. WP was calculated from the total irrigation volume applied during each regime between 2 May and 11 July 2008 and the yield of class 1 fruit from each of the treatments.

Scheduling regime	Class 1 yield (Tons per acre)	Water productivity (Cubic metres of irrigation water used to produce 1 tonne class 1 fruit)
Evaposensor	9.4	9.1
EnviroSCAN	9.0	16.1
Closed loop	10.3	10.5
Arbitrary-30	8.7	18.1
Arbitrary-60	8.7	36.3

3.2 Identify the chemical signals that interact to control leaf gas exchange under deficit irrigation (month 23)

- Detached leaf tests are being used to determine the effects of changes in the delivery of these putative signals on stomatal conductances. The interaction of the gaseous plant hormone ethylene and ABA in the regulation of stomatal response to PRD and RDI will determine photosynthetic rates and the availability of essential precursors for flavour compounds.
- The low sensitivity of the detached leaf test has been accepted for many years but has not been satisfactorily explained. We have shown, for the first time, that foliar ethylene production rates increase during detached leaf tests. This may help to explain the relatively high concentrations of ABA needed to close stomata in these tests compared to those needed in intact plants. Further tests are being carried out to elucidate the role of ethylene in ABA-induced stomatal closure.

4.2 Complete sensory and analytical tests to determine effects of irrigation scheduling on fruit quality and shelf-life in second cropping year (month 23)

- A taste test carried out by Waitrose did not detect any differences in appearance, aroma, texture or flavour in berries harvested from the different irrigation treatments. A taste test by Marks and Spencer suggested that fruit from the 'EnviroSCAN' regime had the best aroma and flavour. This may have been due to the small size of the tertiary berries from this regime at the time of tasting, smaller berries often being more flavoursome.

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- Taste tests at EMR detected increased sweetness in fruit from the 'Evaposensor', 'EnviroSCAN' and 'Closed loop' treatments, compared to the two arbitrary treatments.
- Berry firmness and soluble solids content (BRIX) were measured on freshly picked fruit throughout the cropping season. BRIX values were improved in tertiary fruit harvested from the 'Evaposensor', 'EnviroSCAN' and 'Closed loop' treatments, compared to the two arbitrary treatments.
- Sugar and organic acid profiles were not affected by any of the irrigation regimes in primary, secondary or tertiary fruit. Consequently, berry sugar to acid ratios were similar, irrespective of irrigation regime.
- Concentrations of ellagic acid, an important bioactive compound, were increased by the 'EnviroSCAN and 'Closed loop' regimes compared to 'Arbitrary-30 values. Berry total antioxidant capacities of primary, secondary and tertiary berries from each of the scheduling regimes are being determined.
- Flavour volatile production was measured on two occasions to determine the effects of the irrigation treatments on fruit aroma. The irrigation regimes did influence the production of key flavour volatiles but these differences were not detected by the taste panels.
- Effects of the irrigation regimes on shelf-life potential were not consistent. In one test on fruit stored at 5 ºC for six days, fruit from the three scheduling regimes had significantly lower keeping quality than fruit from the arbitrary regimes. A second test at 5 ºC revealed no significant differences in the shelf-life potential of fruit from each of the irrigation regimes. At 20 ºC, the percentage of rots was greatest in fruit from the three scheduling regimes (70-87%) while only 37% of fruit from the 'Arbitrary-60' regime developed rots by day six of the shelf-life test. In a second test at 20ºC, rots were present in 70-87% of fruit, irrespective of irrigation regime.
- Berry BRIX values were unchanged after six days storage at 5 ºC.

6.1 Collate and analyse results from completed questionnaires received from KG and BW growers (month 21).

- A grower questionnaire on water use efficiency was distributed by KG Growers Ltd and BerryWorld. Twenty seven completed forms were received.
- Thirty seven percent of the growers surveyed did not know how much water they used.
- The average volume of water used by growers to produce 1 tonne of class 1 fruit (water productivity) in 2008 was 78 m^3. The minimum volume was 30 m^3 and the maximum volume 161 m^3.
- Ninety three percent of growers received advice from consultants and 52% scheduled

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irrigation according to neutron probe measurements. Only 3% scheduled irrigation by intuition or experience without monitoring changes in soil moisture content.

Conclusions

- If irrigation is unscheduled and applied irrespective of weather conditions or the soil moisture content, a large proportion of the applied water may percolate through the rooting zone and be lost. Consequently, values of water use efficiency and water productivity will be low with this strategy.
- Significant improvements in water use efficiency and water productivity were delivered when irrigation was scheduled using the Evaposensor' and 'Closed loop' treatments. Water savings of up to 75% were delivered compared to current 'best practice' (ADAS 2003)[1], without reducing yields.
- The frequency and duration of the fertigation events throughout the season was dictated by the frequency of irrigation events *i.e.* plants could only be fertigated during irrigation events. Consequently, although the same volume of fertiliser had been applied to all treatments by the end of cropping, foliar concentrations of some nutrients were deemed to be 'low' or 'deficient' in some of the treatments. These deficiencies may have affected fruit quality and shelf-life potential. Both irrigation and fertigation regimes will be optimised in the 2009 season.
- Canopy areas were reduced by the 'Evaposensor' and 'EnviroSCAN' regimes which may help to increase light penetration to the developing fruit thereby improving some components of berry quality. The improvement in the visibility of fruit afforded by the smaller canopy may also help to reduce picking costs.
- Yields of class 1 fruit were highest in the 'Closed loop' and 'Evaposensor' treatments and were typical of those expected from a commercial main season crop. The lower yields in the two arbitrary treatments may have resulted from over irrigation or they may have been due to edge effects.
- When expressed in terms of tons of class 1 fruit per acre, yields ranged from 8.7 to 10.3 (21.5 – 25.5 t/ha)
- Berry firmness and soluble solids content of primary and secondary fruit were largely unaffected by the irrigation regimes. However, soluble solids content of tertiary fruit was enhanced by the three scheduling treatments, but berry firmness was reduced at the end of the season, compared to the 'Arbitrary-30' value.
- Although the irrigation regimes did influence the production of key flavour volatiles, the changes were apparently insufficiently large to be detected by the taste panels.

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- The results highlight the increased demand for water during cropping to drive fruit expansion. Insufficient water availability at this time could reduce fruit size and therefore jeopardise economic yields and components of fruit quality may also be compromised.

Financial benefits

A full cost-benefit analysis will, in due course, enable growers to make informed decisions about the financial benefits to be gained from irrigation scheduling and deficit irrigation.

Action points for growers

- Adopting an effective irrigation scheduling strategy will often improve water productivity.
- Existing irrigation scheduling strategies can be further refined to increase water productivity.
- Fertigation regimes must be tailored with effective scheduling regimes to ensure that soil nutrient availabilities do not become limiting during fruit development and cropping.

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