Grower Summary

SF 83

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

Annual 2011

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

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

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

HDC
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

HDC is a division of the Agriculture and Horticulture Development Board.

Project Number:	SF 83
Project Title:	Improving water use efficiency and fruit quality in field-grown strawberry (HortLINK)
Project Leader:	Dr Mark A. Else
Contractor:	East Malling Research (EMR)
Industry Representative:	Mr Peter Vinson, BerryWorld
Report:	Annual 2011
Publication Date:	22 August 2011
Previous report/(s):	-
Start Date:	1 April 2007
End Date:	31 March 2012
Project Cost:	£127,812

Headline

- In commercial field trials, water savings of 40% were achieved compared to the grower's usual method of irrigation scheduling, whilst fruit yields, firmness and flavour were improved.

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.

Summary of the project and main conclusions

EMR field trials

Five irrigation regimes were tested in field trials at EMR during the summer of 2010 (Figure GS1). A Commercial Control (CC) received sufficient water to achieve a Water Productivity (WP) value of around 30-40 (tonnes of water used to produce 1 tonne class 1 berries - industry 'best practice).

Figure GS1. Field trial at EMR. Photo taken on 8 June 2010.

A Grower Test Regime (GTR) was imposed to refine the approach developed in this HortLINK project prior to further testing in field trials at our grower partners' sites in 2011. Three 'deficit irrigation' regimes were also imposed in the field trial at EMR; one Regulated Deficit Irrigation (RDI) treatment and two Partial Rootzone Drying (PRD) treatments of differing severity.

The irrigation trigger values used in each treatment are commercially sensitive and the project consortium has requested that they are not yet disclosed. These values will be included in the Final Project Report in 2012.

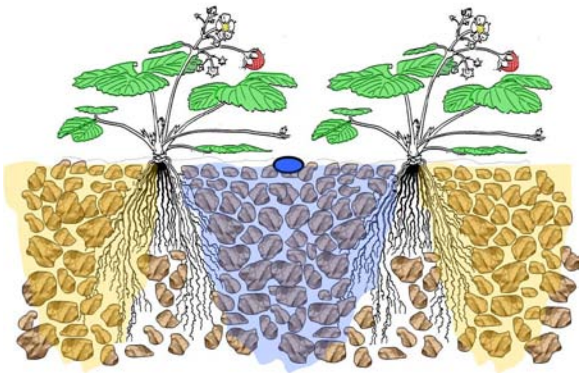

Figure GS2. In the PRD1 regime, irrigation was scheduled frequently to the middle of the bed while the shoulders were allowed to dry.

All treatments were imposed successfully. Having identified soil hydraulic properties at the field site earlier in the project, we were able to modify irrigation strategies (frequency and duration) to ensure that water was applied only to the target volumes of the root zone. Soil remained at or near field capacity in the CC treatment and a significant amount of applied irrigation water (and fertilisers) drained past the rooting zone. Our work with strawberry in this and other projects has repeatedly shown a sudden and sustained demand for water during cropping that occurs despite a relatively constant leaf area. Therefore, the soil moisture content at which irrigation was applied (the irrigation threshold) in the GTR was increased gradually during cropping to try to ensure that fruit expansion rates were not limited by water availability. The irrigation threshold in the RDI treatment was set very low throughout fruit development and cropping to try to identify the soil matric potential beyond which yields were reduced. In the first PRD treatment (PRD1), irrigation was applied only to the centre of the beds so that roots on the outside of the beds were exposed to increasingly dry soil (Figure GS2). This treatment was designed to mimic the situation in many commercial plantings where, although two drip tapes are installed, they often 'migrate' to the middle of the bed. The threshold matric potential at the centre of the bed was maintained fairly high to ensure that irrigation was applied 'little and often' to compensate for the diminishing supply from roots towards the edges of the bed. In the second PRD treatment (PRD2), irrigation was applied either to the centre or to the edges of the bed to determine whether the irrigation switching inherent in many PRD regimes was necessary to deliver maximum benefits in field-grown strawberry.

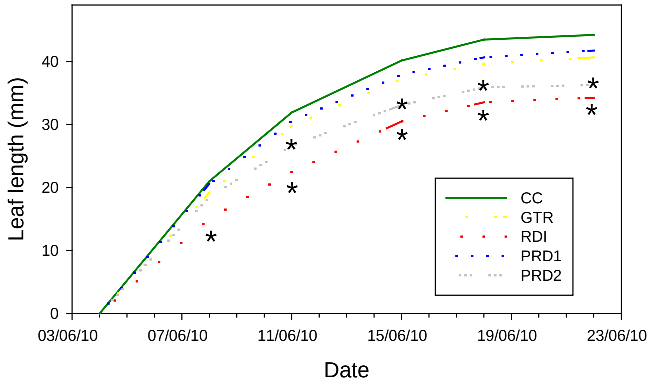

Figure GS3. Leaf growth was significantly slowed under the RDI and PRD2 regimes during fruit development and ripening. Asterisks denote statistically significant differences from CC values.

Rates of leaf extension were slowed during fruit development and ripening under the RDI and PRD2 regimes (Figure GS3); consequently, total canopy areas were reduced by 28% and 19%, respectively, at the end of cropping. Leaf water potentials were significantly lowered during fruit development and ripening in the RDI regime, compared to CC values. Significantly lower leaf water potentials were also detected in the PRD2 regime prior to cropping and in the GTR towards the end of cropping. In RDI-treated plants, rates of photosynthesis were slowed significantly during cropping and this, combined with the shoot water deficit, presumably contributed to the lower yields and reduced quality of fruit from this irrigation regime (see below). Stomatal conductances were reduced significantly towards the end of cropping in all regimes compared to CC values, but no treatment effects on rates of photosynthesis were detected in the GTR, PRD1 and PRD2 regimes.

Foliar nutrient analyses carried out over the season showed reduced phosphorous concentration in RDI-treated plants during cropping; this deficiency has been noted in our previous trials and presumably reflects a reduced capacity for P uptake due to limited root extension growth in drying soils. Careful management of fertigation under the reduced irrigation regimes being developed in this project will be needed to ensure that berry yields, flavour and quality are optimised.

Fruit was first harvested on the 15 June 2010 and ripening was accelerated by the warm weather in late June and early July. Yields of class 1 fruit averaged 799 g per plant under the CC regime; yields from the GTR and PRD1 regimes were 697 and 679 g per plant, respectively. Although yields were reduced under the GTR and the PRD1 treatment, differences were not statistically significant and good commercial yields of 26 and 25 tonnes per hectare, respectively, were achieved with water savings of 57-58%. A water saving of 57% was also delivered by the PRD2 regime but yields of class 1 fruit averaged 649 g per plant (24 tonnes per hectare) and were significantly lower than CC yields. Despite a water saving of 79%, class 1 yields from RDI-treated plants averaged only 543 g per plant (20.4 tonnes per hectare) and were significantly lower than the CC yield. Significantly reduced yields from RDI-treated plants were harvested on only one sampling date, 29 June 2010 when class 1 yields were 33% lower than those from CC plants. Leaf water potentials and rates of photosynthesis were reduced in RDI-treated plants in the preceding days. Values of water productivity (the volume of water needed to produce 1 tonne of class 1 fruit) achieved in the CC, GTR, RDI, PRD1 and PRD2 were 39, 19, 11, 18 and 19 cubic metres of water per tonne of class 1 fruit, respectively. Currently, the more 'water conscious' commercial growers achieve WP values of between 35 and 40.

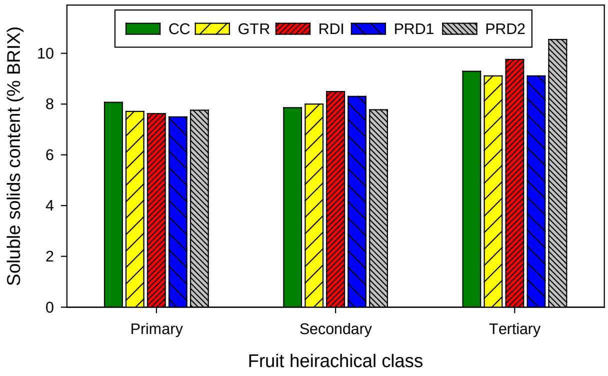

Figure GS4. Berry soluble solids content (% BRIX) was not significantly altered by any of the irrigation regimes.

The firmness and soluble solids content (SSC [% BRIX]) of primary, secondary and tertiary fruit were similar (Figure GS4), irrespective of irrigation treatment and concentrations of glucose, fructose and sucrose were also similar in all berries harvested from each regime. Total organic acid contents were increased significantly in berries from the GTR, RDI, PRD1 and PRD2 regimes but, with the exception of PRD1, treatment effects were not consistent in successive harvests. The sugar-to-acid ratio, an important factor in determining organoleptic (taste/flavour) quality, was generally unaffected except in primary berries from the RDI regime and in tertiary berries from the PRD1 regime where it was reduced significantly. Results from taste tests carried out on two occasions by Waitrose were equivocal due to the lack of consistent treatment effects and the subjective nature of the test, but generally, the panel awarded higher scores to fruit from the CC and PRD2 regimes on the first occasion and to fruit from the CC and GTR on the second occasion.

Berry concentrations of vitamin C and ellagic acid (important anti-oxidants) were increased by the GTR, RDI, PRD1 and PRD2 regimes, but with the exception of RDI, not consistently across primary, secondary and tertiary berries. Berry total anti-oxidant activity was improved in primary, secondary and tertiary fruit from the GTR and the RDI regime and in primary and secondary fruit from the PRD regimes.

In shelf-life tests, rates of water loss from punnets of fruit from the GTR, RDI and PRD2 regimes were significantly lowered, compared to those from CC fruit. Susceptibility to bruising and the rate of development of rots in primary berries were significantly reduced from Day 2 onwards in all treatments compared to fruit from the CC regime. At the end of the 6-day test, only 15% of primary fruit from the GTR regime showed rots whilst 52% of berries from the CC regime had rots.

In summary, significant water savings were achieved under the GTR and PRD1 regime and although yields of class 1 fruit were reduced, differences from CC yields were not statistically significant. The lower than expected class 1 yields harvested from the GTR may have resulted from inconsistencies in the outputs from the limited number of soil moisture probes used to schedule the irrigation to this treatment; it is likely that this regime was run a little too dry during cropping. Nevertheless, components of fruit quality remained unchanged or were improved under the GTR and PRD regimes. Our results suggest that irrigating only the centre of the bed and allowing the 'shoulders' to dry was an effective water-saving strategy, provided that the soil in the centre of the bed was maintained fairly 'wet'. However, the typical physiological responses to PRD (*e.g.* slowed leaf extension, partial stomatal closure) were not detected under this regime, presumably due to relatively high average root water potentials. These responses were detected under the PRD2 regime but the degree of soil drying needed to invoke production of the causal root-sourced signals also limited fruit expansion and class 1 yields. Marketable yields and fruit quality were reduced under the RDI regime when the lower irrigation threshold was set so that significant soil drying was achieved. On-going work at EMR will establish the irrigation threshold (soil matric potential) to use in grower RDI trials in 2011 to help ensure that yields are maintained and berry quality is improved. This irrigation threshold will be suitable for use on all soil types.

Grower partner trials

The GTR was trialled on one of our grower partners' farms in 2010 to test the potential of our approach to deliver water savings whilst maintaining yields and quality (Figure GS5). Three polytunnels were irrigated with the GTR and three were irrigated according to the grower's usual irrigation practice informed by neutron probe data and visual inspection (dibbing).

Plant physiological responses were similar under the two regimes; this was anticipated since the irrigation threshold was set above the point at which physiological responses to drying soil are first triggered and so development of plant 'stress' was avoided. Compared to the grower's usual irrigation practice, the GTR regime delivered water savings of 40%; significant savings in fertilisers were also achieved. Total class 1 yields from the GTR were 19% higher than those from the grower's usual regime although the increase was not statistically significant due to variable yields from tunnels under the grower's regime.

Components of fruit quality (*e.g.* berry firmness, flavour) were improved under the GTR and this was achieved without reducing average fruit size or fresh weight. Other aspects of fruit quality including SSC, concentrations of sugars and organic acids, the sugar to acid ratio and total anti-oxidant capacity were unchanged. Susceptibilities to bruising and rots during shelf-life tests were also similar in fruit from the two irrigation regimes.

Soil moisture (MPS1 and 10HS) probes were also placed in crops of 60-day 'Elsanta' at our other grower partners' sites to monitor current irrigation practices throughout the 2010 season. These data sets, and the irrigation managers' decisions on when and how often to irrigate, are currently being discussed during farm visits to our four grower partners; this information is helping to inform and finalise our irrigation scheduling strategies for the grower trials later this year.

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.

Figure GS5. The GTR was tested for the first time in a commercial grower trial. Photo taken on 5 May 2010.

Action points for growers

- Setting up systems to record the volumes of water applied to 60-day, mainseason and everbearer crops will help growers to establish their irrigation water requirements throughout the year.

- The data would also help to determine baseline water use efficiencies for each grower; this information will be required by the EA to support future abstraction license applications for drip / trickle irrigation.

- Scheduling irrigation according to changes in soil moisture content will make more efficient use of limited water resources and maintain good commercial yields.

- Aspects of fruit quality including flavour and shelf-life potential can also be improved.

- Savings up to 40% of current fertiliser costs are also possible without reducing yields or quality.