Grower Summary

SF 118

Irrigation scheduling of raspberry as a tool for improving cane management

Final 2013

Disclaimer

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.

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Project Number:	SF 118
Project Title:	Irrigation scheduling of raspberry as a tool for improving cane management
Project Leader:	Dr Mark Else
Contractor:	East Malling Research
Industry Representative:	Laurie Adams and Stephen McGuffie
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Headline

- Irrigation scheduling using coir volumetric moisture contents as set points delivered good marketable yields, reduced or eliminated run-through and optimised water and fertiliser inputs
- This approach could be readily implemented into commercial production using the ‘closed loop’ system developed in SF 136 and now needs to be evaluated on growers’ sites
- Regulated Deficit Irrigation regimes applied throughout the season did not consistently limit cane extension growth in ‘Autumn Treasure’ and ‘Tulameen’ but yields of marketable fruit were reduced although fruit quality was not affected

Background and expected deliverables

More efficient use of inputs including labour, water and fertilisers is vital to the future success of the UK soft fruit industry. Recent droughts, particularly affecting the south east and east regions (Figure GS1) have highlighted the need for growers to use water (and fertilisers) more efficiently. Trickle irrigation has been exempt from legislation until now but it is envisaged that drip irrigators will require an abstraction licence in future and growers must be able to demonstrate an efficient use of water to comply with legislation. There is also concern about the effects of intensive soft fruit production on groundwater quality in the south east and the Environment Agency commissioned ADAS to promote ‘best practice’ in a series of grower workshops in 2012.

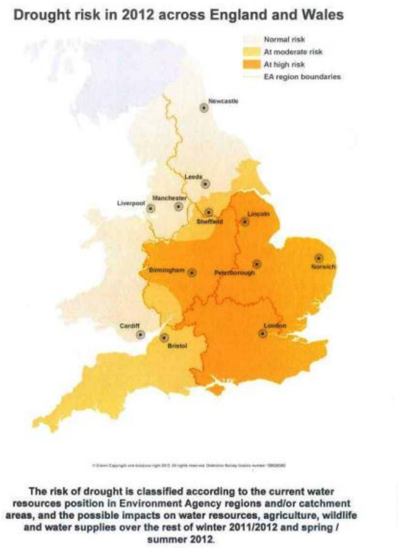

Figure GS1. Assessment of drought risk across England and Wales for 2012. Source: the EA.

However, there are few practical guidelines for growers on how best to schedule irrigation, and matching demand with supply can be difficult in changeable summer weather. Many substrate strawberry growers are advised to irrigate to achieve 10-20% run-off, in part to avoid dry spots within the substrate but mainly to prevent the accumulation of potentially damaging ‘salts’ within the substrate. This approach can lead to excessive vegetative growth, increased disease, and fruit with a reduced shelf-life and associated increases in waste fruit. Berry eating quality can also be reduced because key flavour compounds are diluted by the high water content. If soft fruit growers are to maintain or increase yields against a backdrop of increasing summer temperatures, dwindling water supplies, and governmental demands for greater environmental protection, new production methods that improve water and nutrient use efficiency and utilise ‘best practice’ are needed.

Recent research at EMR and elsewhere has provided major opportunities to use water and fertilsers more efficiently while continuing to meet consumer demand for sweet fruit with good flavour and shelf-life. Irrigation management techniques such as Regulated Deficit irrigation (RDI) offer the potential to deliver large water savings while maintaining or improving crop quality. Deficit irrigation techniques such as RDI replace only a percentage of the water the plant loses *via* transpiration. In addition to saving water, altered root-sourced hydraulic and chemical signalling can limit excessive shoot growth without reducing yields of marketable fruit. The smaller, less dense canopy can reduce disease pressure and helps to improve light capture by the plant because there is less self-shading of the leaves. Better light penetration and interception will also help to increase fruit quality including flavour volatile production and bioactive content. The reduction in vegetative growth also provides opportunities to reduce fertiliser inputs without affecting berry flavour. However, the potential of using RDI to control cane vigour without reducing marketable yields is not yet known.

There are two aims to this project:

1. To use RDI as a tool to control cane vigour without reducing marketable yields
2. To improve water and nutrient use efficiencies in substrate-grown raspberry production

Expected deliverables from this work will include:

- Reduced production costs per tonne marketable fruit
- Improved cane management
- Reduced water and fertiliser usage by up to 40%
- Reduced environmental impact
- Improved economic sustainability
- Demonstration of compliance with legislation

Summary of the project and main conclusions

In 2012, four experiments were conducted on the floricane cultivar 'Tulameen' and two on the primocane 'Autumn Treasure'. The first pair of experiments (1 A&B) tested the effect of continuing the RDI regimes first imposed in 2011 on marketable yields and cane vigour of 'Tulameen' and 'Autumn Treasure' in the second year of production. The second pair of experiments (2 A&B) investigated the potential of applying RDI at different stages during development and cropping of 'Tulameen' and 'Autumn Treasure' to determine whether cane vigour could be controlled without reducing marketable yields.

Irrigation treatments

All experiments were carried out in a polytunnel at EMR (Figure GS2). Eighteen experimental plants were included in Experiments 1A&B. Three treatments were applied: 1) Well-watered (Ww) control where plants were given 110% of their daily water use; 2) 70% RDI (RDI-70%) where plants were given 70% of their daily water use; 3) 60% RDI (RDI-60%) where plants were given 60% of their daily water use. The same irrigation regimes were applied to the same plants in both 2011 and 2012 so that longer-term effects of the RDI regimes on yields and cane vigour could be determined.

Figure GS2. 'Tulameen' plants used in Experiment 2B. Photo taken on 12 May 2012.

Although cane vigour of 'Tulameen' was effectively reduced by a RDI-60% treatment imposed throughout the growing season in 2011, marketable yields were also lowered. In 2012, Experiments 2A&B were carried out on 'Tulameen' and 'Autumn Treasure' to determine whether applying RDI at specific stages during plant growth and crop development could be used to control cane vigour without reducing marketable yields. All plants were irrigated to match demand with supply and so were kept well watered until the 21 June 2012 when the first fruit started to ripen. Four treatments were imposed in Experiment 2A: Ww, where plants were given 110% of their daily water use; 2) early RDI-70% where plants were given 70% of their daily water use for most of the growing season; 3) early RDI-60% where plants were given 60% of their daily water needs for most of the growing season; 4) late RDI-60% where plants were given 60% of their daily water use towards the end of fruiting for the remainder of the growing season. In Experiment 2B, three treatments were imposed: Ww, where plants were given 110% of their daily water use; 2) early RDI-60% where plants were given 60% of their daily water use for most of the growing season; 3) early RDI-60% followed by a return to Ww conditions at the beginning of fruiting.

Fertigation

Two different nutrient regimes were applied to each cultivar depending on whether the plants were in the vegetative or fruiting stage of growth. These nutrient feeds were formulated by Mr Michael Daly (The Agrology House, Lincs., UK) after mineral analysis of the mains water used for the experiment. Plants were fertigated from three stock tanks, one containing calcium nitrate and potassium nitrate, the second containing potassium nitrate, monopotassium phosphate, magnesium sulphate and a Hortifeed trace element mix and the third containing 60% nitric acid. The target pH range of the solution applied to the plants was 5.4 - 5.6; dosatrons were used to adjust the feed EC

Effects of RDI on plant growth and yields in the second cropping year

Experiment 1A – 'Tulameen': The growth of individual canes did not differ between the plants in the different irrigation regimes (Figure GS3A). Leaf elongation was reduced between 14 June and 21 July 2012 in plants in the RDI-60% treatment when compared to those in the Ww treatment, which suggests that in 'Tulameen', leaf growth is more sensitive to limited substrate water availability than cane growth.

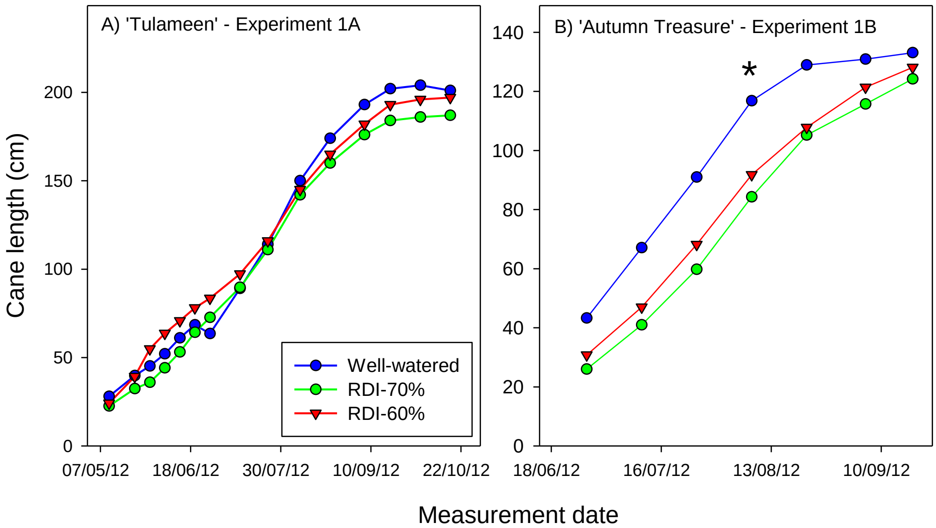

Figure GS3. The effects of different irrigation treatments on the growth of new canes in A) 'Tulameen' and B) 'Autumn Treasure' plants in Experiment 1. Results are means of six plants for each treatment; asterisks indicate statistically significant differences between treatments (*p*<0.05)

Ripe fruit were first picked from 'Tulameen' plants on 14 June 2012, cropping peaked between 25 June to 16 July 2012 and continued until the middle of August 2012. The average yield of marketable fruits per plant in the Ww, RDI-70% and RDI-60% treatments were 1100 g, 808 g and 659 g, respectively (Table GS1). Although these differences were not statistically significant due to high sample variability, a potential loss of yield of between 27 and 40% would be unacceptable to commercial growers. These lowered yields resulted largely from an effect of the RDI regimes on berry size and although fruit number was not significantly affected due to high sample variability, fruit number was reduced by 20% by the RDI-60% regime. Berry brightness, cohesion, flavour, outline, skin strength, texture, SSC and uniformity were unaffected by the different irrigation regimes. There were no treatment differences in rates of berry water loss during the shelf-life tests and aspects of fruit quality were unaffected at the end of the shelf-life period.

Table GS1. Effects of RDI treatments on fruit number, marketable yields per plant and average fruit fresh weight for 'Tulameen' in Experiment 1A. Results are means of six plants for each treatment; asterisks indicate a statistically significant difference from the Ww (control) value (p<0.05).

Irrigation regime	Fruit number	Yield (g)	Mean fruit weight (g)
RDI-60%	202	659	3.3*
RDI-70%	225	808	3.5*
Ww	256	1100	4.1

Experiment 1B – 'Autumn Treasure': The RDI-70% and RDI-60% treatments significantly reduced cane extension growth in 'Autumn Treasure' plants during August 2012 compared to Ww plants (Figure GS3B). However, canes under both RDI regimes continued to grow throughout August and September whereas cane extension in Ww plants had slowed by the end of August, so values were similar in all treatments by the end of September 2012. Leaf elongation of 'Autumn Treasure' was not affected by the RDI regimes.

Fruit were first harvested from 'Autumn Treasure' on 13 August 2012 and cropping peaked between 10 September and 8 October 2012, with approximately 60% of the total yield being picked during this time. Fruit production declined during October and the final harvest was on 13 November 2012. The yield of fruit harvested on individual days was significantly greater for plants in the Ww treatment than for those receiving RDI and consequently, total marketable yields per plant were significantly lowered by the two RDI regimes (Table GS2). This was largely due to reductions in fruit numbers rather than to significantly smaller berries. There were no statistically significant effects of the RDI treatments on components of berry quality, rates of berry water loss or deterioration in berry quality at the end of the shelf-life period.

Figure GS4. The effects of different irrigation treatments on the growth of new canes in A) 'Tulameen' and B) 'Autumn Treasure' plants in Experiment 2. Results are means of six plants for each treatment; asterisks indicate statistically significant differences from the Ww (control) value (*p*<0.05)

Table GS2. Effects of RDI treatments on fruit number, marketable yields per plant and average fruit fresh weight for 'Autumn Treasure' in Experiment 1B. Results are means of six plants for each treatment; asterisks indicate a statistically significant difference from the Ww (control) value (*p*<0.05).

Irrigation regime	Fruit number	Yield (g)	Mean fruit weight (g)
RDI-60%	129*	462*	3.8
RDI-70%	101*	358*	3.8
Ww	318	1280	4.2

<u>Effects of RDI applied at different developmental stages on plant growth and yields</u>

Experiment 2A – 'Tulameen': Leaf elongation was significantly reduced in plants receiving RDI-60% when compared to plants in the other three treatments during the period 14 June and 21 July 2012 (data not shown). Individual cane extension was also reduced by approximately 20% in those plants (Figure GS4A) but this effect was not statistically significant due to high sample variability.

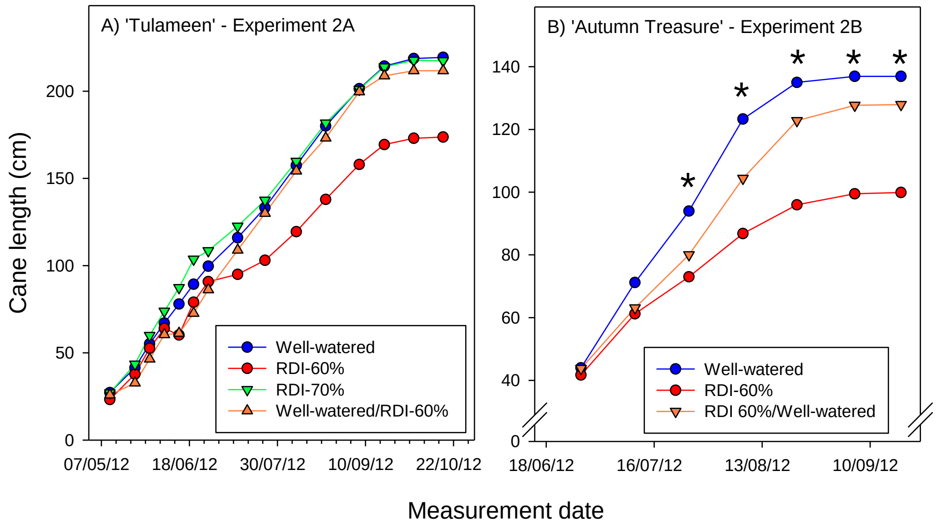

Figure GS4. The effects of different irrigation treatments on the growth of new canes in A) 'Tulameen' and B) 'Autumn Treasure' plants in Experiment 2. Results are means of six plants for each treatment; asterisks indicate statistically significant differences from the Ww (control) value (*p*<0.05)

Ripe fruit were first harvested from 'Tulameen' plants on 14 June 2012, cropping peaked between 25 June and 16 July and continued until the middle of August 2012. Yields of marketable fruit from Ww plants averaged 1,632 g per plant and although not statistically significant, average yields were reduced by between 20 and 29% in RDI-treated plants (Table GS3). Although fruit size was reduced by the RDI-60% and RDI-70% treatments compared to those in the Ww or Ww / RDI-60% treatments, this effect was just outside statistical significance. Berry brightness, cohesion, flavour, outline, skin strength and texture were unaffected by the different irrigation treatments but berry uniformity was significantly reduced in RDI-60% and RDI-70% treatments. Berry SSC was significantly improved by the RDI-60% when compared to the other three treatments. There were no treatment differences in rates of berry water loss during the shelf-life tests and aspects of fruit quality were similarly unaffected at the end of the shelf-life period.

Table GS3. Effects of RDI treatments on fruit number, marketable yields per plant and average fruit fresh weight for 'Tulameen' in Experiment 2A. Results are means of six plants for each treatment; there were no statistically significant treatment effects on fruit number, yield or size.

	Fruit number	Yield (g)	Mean fruit weight (g)
RDI-60%	299	1252	4.3
RDI-70%	268	1160	4.4
Ww/RDI-60% 60%	266	1309	4.8
Ww	326	1632	4.9

Experiment 2B – 'Autumn Treasure': Within one month of the application of RDI-60%, cane length was significantly reduced compared to Ww values (Figure GS4B). However, when the early RDI treatment was returned to a Ww regime (RDI-60% / Ww) at the beginning of August 2012, the rate of cane extension growth increased so that final cane length was similar to that of Ww plants. Leaf elongation was slowed by the continuous RDI-60% treatment but only temporarily.

Fruit were first harvested from 'Autumn Treasure' on 6 August 2012 and cropping patterns and duration were similar to those described for experiment 1B. The yield of fruit harvested on individual days was significantly greater for plants in the Ww treatment than for those receiving RDI and consequently, total marketable yields per plant were significantly lowered by the RDI regimes, due to an effect on fruit number (Table GS 4). Yields from the RDI-60% / Ww plants were significantly lower than those from Ww plants, even though over the fruiting period both sets of plants were effectively being well watered. There were no statistically significant effects of irrigation treatment on fruit quality or shelf-life potential.

Table GS4. Effects of RDI treatments on fruit number, marketable yields per plant and average fruit fresh weight for 'Autumn Treasure' in Experiment 2B. Results are means of six plants for each treatment; asterisks indicate a statistically significant difference from the Ww (control) value (p<0.05).

Irrigation regime	Fruit number	Yield (g)	Mean fruit weight (g)
RDI-60%	194*	749*	4.0
RDI-60%/Ww	168*	664*	4.0
Ww	330	1326	4.1

Main Conclusions

- A new irrigation scheduling regime has been developed using irrigation set point based on coir volumetric moisture contents. This approach has the potential to deliver significant water and fertiliser savings in commercial 'Tulameen' and 'Autumn Treasure' raspberry production without reducing marketable yields or quality
- Water productivities obtained using this approach were 89 and 96 L of water used to produce 1 kg of marketable fruit for Ww 'Tulameen and 'Autumn Treasure', respectively
- The scheduling approach now needs to be tested in experiments on commercial growers' sites with a high background EC in the irrigation water. This work would help to determine whether the reduced water inputs and associated loss of 'flushing' causes EC to rise in the substrates to the extent that plant growth and marketable yields are affected
- Although irrigation can be scheduled effectively using estimates of ET, gravimetric water losses and crop co-efficients in scientific experiments, this approach is not practical for use in commercial raspberry production
- RDI-60% and RDI-70% regimes did not limit cane growth in 'Tulameen' and marketable yield was reduced by up to 40%
- RDI-60% applied to 'Tulameen' at the beginning of the fruiting phase did not limit extension growth of new canes but marketable yields were reduced by 20%
- The severity of RDI needed to limit cane extension growth in 'Autumn Treasure' also reduced marketable yields
- Applying an early RDI-60% regime to 'Autumn Treasure' and then switching to a Ww regime during fruiting did not limit cane extension growth but did reduce marketable yields
- The use of RDI is not recommended for the control of cane vigour in substrate-grown 'Tulameen' or 'Autumn Treasure'
- The effects of very short-term 'wilting' treatments on cane extension, fruit yields and quality need to be determined and incorporated into the water-and fertiliser-saving irrigation strategy developed in SF 118

Knowledge exchange and technology transfer activities

- The project aims, objectives and results were presented to BIFGA during a visit to EMR, 25 April 2012
- Project aims, objectives and results were presented in a feature article for the HDC News in June 2012

- The project aims, objectives and results were presented at the Kent Water Summit: Water security for Farmers and Growers, 12 November 2012, EMR
- The project aims, objectives and results were discussed during a visit to Angus Soft Fruit Ltd, 7 February 2013, Dundee

Financial benefits

The project aims to provide the potential to improve the economic and environmental sustainability of soil-less raspberry production by improving both water and nutrient use efficiencies. However, current industry 'standard', 'best' and 'better' practice must be first be established before the water and nutrient use efficiencies and productivities delivered in this project can be assessed in a commercial context.

Given the lack of information regarding current water and fertiliser use in soil-less raspberry production, it is difficult to estimate the potential financial benefits that might be achieved by adopting the irrigation scheduling approach developed in this project. The Rural Business Research (RBR) 2008/2009 Farm Business Survey for Horticulture Production in England reported average annual fertiliser costs (across all specialist glass businesses including soft fruit) of £3250-£4500/ha. On this basis, a 20% reduction in fertiliser used could on average therefore save £650-£900/ha. The RBR 2008/2009 survey reported average annual water costs (across all specialist glass businesses including soft fruit) of £530-£630. This confirms that on average the savings in expenditure on water do not justify expenditure on irrigation scheduling tools. Growers using mains water would be expected to pay significantly more for water and there may then be a significant financial benefit to using less water.

Unlike strawberry, there seems to be a paucity of information on the average marketable yields obtained from commercial plantings of substrate-grown raspberry cultivars. Collection and collation of this data would help to set the yields obtained in the current work (Ww 'Tulameen' = 1,632 g and Ww 'Autumn Treasure' = 1,326 g per plant) into a commercial context.

Action points for growers

- Employ an irrigation consultant to ensure that irrigation systems are designed correctly to achieve accurate and precise delivery of water and fertilisers
- 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 scheduling decisions

- Consider using the coir volumetric moisture content set points developed in this project to optimise water and fertiliser inputs and reduce or eliminate run-through without affecting marketable yields or fruit quality
- Assess the impact of the transient wilting treatment (used to control cane vigour) on marketable yields
- Current industry ‘standard’, ‘best’ and ‘better’ practice must be first be established before the water and nutrient use efficiencies delivered in this project can be assessed in a commercial context