Grower Summary

SF 118

Irrigation scheduling of raspberry as a tool for improving cane management

Annual 2012

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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:	John Clark, Laurie Adams and Stephen McGuffie
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Previous report/(s):	Annual Report 2011
Start Date:	01 April 2010
End Date:	31 March 2013
Project Cost:	£88,688

Headline

- Progress is being made towards developing an irrigation scheduling system for soilless substrate grown raspberry.

Background and expected deliverables

This project aims to provide the potential to increase water use efficiency (WUE) and nutrient use efficiency (NUE) in UK substrate-grown raspberry production by 40% thereby saving water, reducing groundwater pollution and improving fruit quality and shelf-life.

Irrigation of substrate-grown raspberries is essential to ensure the yields and quality demanded by retailers and consumers. Many growers apply sufficient irrigation to achieve 10-20% run-off to avoid dry spots within the substrate and to reduce the accumulation of salts. However, Defra, the Environment Agency (EA) and the soft fruit industry are all becoming increasingly concerned about the future availability of abstracted water for trickle irrigation. At the time of writing (March 2012), the south east is already officially under drought and other major soft fruit growing regions are at high risk of drought in 2012 (Figure GS 1).

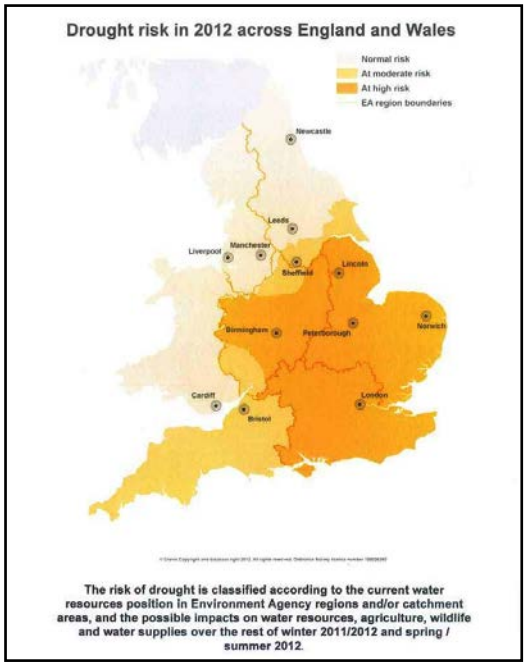

Figure GS 1 Assessment of drought risk across England and Wales for 2012. Source: the Environment Agency.

Current abstraction rates in the major soft fruit-growing regions are unsustainable and growers must now comply with legislation designed to safeguard these resources (The Water Act 2003). Mains water will become progressively more expensive and its use for irrigation of horticultural crops is likely to be restricted in heavily populated areas as pressure on finite

supplies intensifies. Future legislation will require that drip/trickle irrigators demonstrate an efficient use of water, and current EA concerns about the impact of horticulture on groundwater quality in the south east will focus attention on improving NUE in soft fruit production. 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 prevent 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.

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 of 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

Three experiments were conducted simultaneously during 2011. Two of these, one on the summer fruiting variety 'Tulameen' and the second on the primocane variety 'Autumn Treasure', were carried out to determine the effects of RDI on growth and cropping. Tulameen was grown in 7.5 litre pots and Autumn Treasure in 10 litre pots. Both contained washed coir as a substrate. Twenty-four experimental plants were included in each

experiment and three irrigation treatments were applied: 1) well-watered (Ww) control where plants were given 110% of plant daily water use; 2) 80-70% RDI treatments (RDI-70%) where plants were initially given water at 80% of daily water use which was then reduced to 70%; 3) 70-60% RDI treatments (RDI-60%) where plants were initially given water at 70% of daily water use which was then reduced to 60%. The more severe RDI treatments were imposed on 24 June 2011 to try to limit cane height more effectively. Both experiments were set up as a complete randomised block design, with one of each treatment in each experimental block; there were eight blocks for each experiment, however only six blocks were used for routine measurements.

The third experiment was an additional one set up to test the effectiveness with which the crop coefficients developed in year 1 could be used to schedule irrigation. Although in the original proposal it was planned to test this approach in commercial trials at Belks Farm in 2011, it was thought prudent to first test the regime in a scientific experiment at EMR. Two different approaches to irrigation scheduling were tested on 'Tulameen', 'Autumn Treasure' and 'Polka'; the first was based on the actual amount of water used by the plant ('Actual' treatment) where the frequency and duration of irrigation events was scheduled to match the volume of water transpired during the previous 24 h. The second approach was to apply irrigation to replace the volume of water that was predicted to have been transpired each day using the derived crop coefficients for each variety ('Predicted' treatment). This experiment was set up as a split plot design, with five blocks, each block containing pairs of each variety, each pair consisted of plants receiving the 'Actual' or the 'Predicted' treatment. Like the first two experiments, washed coir was used as a substrate. Tulameen was planted in 7.5 litre pots, with Autumn Treasure and Polka in 10 litre pots.

Effects of RDI regimes on cane extension growth and yields

Regulated Deficit Irrigation regimes were developed and imposed on two-year-old cropping 'Tulameen' and Autumn Treasure' plants. Some shoot physiological responses to drying substrate were detected in both varieties which confirmed that the mild shoot water deficits developed under the RDI regimes due to limited substrate water availability. These shoot responses were not consistently altered over the whole season due to the need to periodically flush through to reduce substrate EC or pH. However, cane extension growth of 'Autumn Treasure' was effectively limited by both RDI-70% and RDI-60% regimes whilst that of 'Tulameen' was limited only by the RDI-60% regime.

Yields of marketable fruit were generally reduced under the RDI regimes; these differences were statistically significant for 'Autumn Treasure' (Figure GS 2) but not for 'Tulameen'. The

yield penalties were due to a combination of fewer fruit and a lower average berry fresh weight. Components of berry quality were not affected by the RDI regimes, with the exception of inconsistent effects on berry redness.

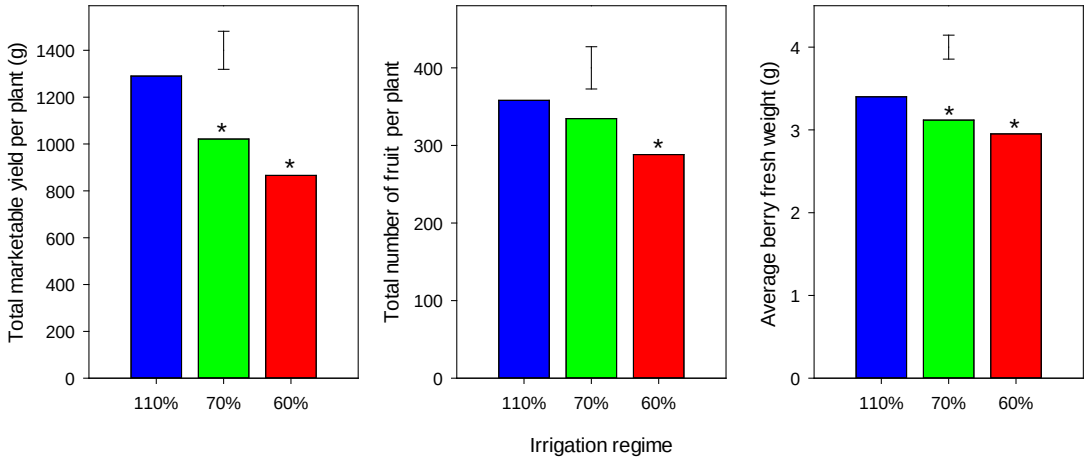

Figure GS 2. RDI-70% and RDI-60% regimes reduced marketable yields of 'Autumn Treasure due to reductions in fruit number and average fruit size. Results are means of six replicate plants per treatment.

Given the losses of marketable yields that occurred when RDI was imposed throughout the season, further developmental work will be carried out in scientific experiments at EMR (see plans for 2012). Although the RDI regimes imposed in our 2011 experiments were based on estimates of daily evapotranspiration, the VSMC at which shoot responses to soil drying were triggered in each of the three cvs was identified. These VSMC values will be used to derive lower irrigation set points for use in RDI experiments in 2012.

A comparison of irrigation scheduling methods

Table GS 1 Volumes of water applied to, and per cent run-through from, 'Autumn Treasure' and 'Tulameen' plants when irrigation was scheduled using 'Predicted' or 'Actual' crop co-efficients

Cultivar	Total volume of water applied (L)		Per cent run through (% of applied)	
	'Predicted'	'Actual'	'Predicted'	'Actual'
'Autumn Treasure'	218	98	27.6[1]	0.4
'Tulameen'	203	94	34.5	1.2

Crop coefficients derived from gravimetric estimates of plant water loss were used in conjunction with daily estimates of potential evapotranspiration (ET_P) to schedule irrigation very effectively in our experiments. However, this was achieved by ensuring that values of crop coefficients were calculated frequently. Accurate estimates of total transpirational leaf area can also be used to derive crop coefficients that can be used to schedule irrigation efficiently. Much less certain is the accuracy of this approach when proxy measures of plant water loss are used. Our data show that crop coefficients calculated using the best proxy

measures of transpirational leaf area derived in year 1 for each variety (cane length for 'Tulameen', plant height for 'Autumn Treasure') were 2- to 3-fold greater than those derived using gravimetric estimates of plant water loss. Consequently, scheduling irrigation using proxy measures of plant transpirational leaf area (the 'Predicted' regime) resulted in significant over-irrigation, increased cane vigour in 'Tulameen' and 'Autumn Treasure' and significant wastage of water and fertilisers. The lack of a significant effect of the 'Predicted' regime on cane extension in 'Polka' was probably due to the poor vigour of this variety in our experiments; the 'Polka' plants were obtained in 2010 and didn't establish very well (see SF 118 Annual Report 2010). Coir Volumetric Moisture Content (VMC) was maintained at or near to full water-holding capacity under the 'Predicted' regime which led to average run-offs of between 27 and 59% of the volumes of water applied throughout the season. In contrast, scheduling irrigation using estimates of daily degree hours and crop coefficients derived from gravimetric measurements of plant water loss ('Actual' regime) effectively maintained VSMC within the optimum range and run-through averaged only 1% of the total volume of water applied.

Yields of marketable fruit were increased by 37%, 28% and 23% under the 'Predicted' regime in 'Tulameen', 'Polka' and 'Autumn Treasure', respectively. This was due to a greater number of larger fruit; the excessive fertigation using this strategy resulted in very vigourous plants. Despite the high marketable yields, the excessive application of water and fertilisers and the very vigourous cane growth suggest that this approach would be unsustainable and it is questionable whether this strategy merits further experimental or development work.

Conclusions

- Irrigation was scheduled effectively to well watered plants of each variety using gravimetric estimates of plant water use to calculate daily plant water demand.

- Two RDI regimes were imposed successfully and the VSMC set points that triggered shoot physiological responses were determined for 'Tulameen' and Autumn Treasure'.

- The RDI-60% regime effectively limited cane length in 'Tulameen' without significantly reducing marketable yields or fruit quality. The RDI-70% regime did not reduce cane height or yields.

- Although both RDI regimes inhibited cane growth of 'Autumn Treasure', significant reductions in marketable yield occurred under both regimes although fruit quality was generally unaffected.

- Scheduling irrigation using proxy measures of plant transpirational leaf area (the 'Predicted' regime) resulted in over-irrigation, increased cane vigour in 'Tulameen' and 'Autumn Treasure' and significant wastage of water and fertilisers.

- Yields of marketable fruit were increased by 37%, 28% and 23% under the 'Predicted' regime in 'Tulameen', 'Polka' and 'Autumn Treasure', respectively. This was due to both an increase in fruit number and in fruit size, presumably a consequence of excessive fertiliser applications under the 'Predicted' regime.

- Marketable yields of 'Polka' were low (379 – 526 g per plant) compared to the other two cvs (1108 – 1750 g per plant).

- The project will continue for a further season in 2012.

Financial benefits

The project aims to improve the economic sustainability of substrate raspberry production by improving both water and nutrient use efficiencies and reducing labour costs associated with cane management. Savings associated with a 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. A partial cost-benefit analysis of implementing the new irrigation regimes will be completed in the final year of the project to enable growers to make informed decisions about the best options available to them.

Action points for growers

- 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.

- It would be helpful if substrate raspberry growers would fill in and return a questionnaire on water use efficiency.

- Please contact Scott Raffle or Andrew Tinsley at HDC for a copy of the questionnaire.