Grower Summary

TF 210

Deriving irrigation set points to improve water use efficiency, fruit quality and sustainability of irrigated high intensity apple and sweet cherry orchards

Annual 2014

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Further information

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GROWER SUMMARY

Headline

- Irrigation set points that have the potential to deliver water savings without affecting fruit yields and quality were identified for ‘Gala/M9’ and ‘’Braeburn/M9’ and will be tested in 2014

Background and expected deliverables

The droughts of 2011-2012 and the planned reform of the abstraction licencing system highlight the need for tree fruit growers to use water for irrigation more efficiently. The challenge is to implement measures that improve irrigation water use efficiency, especially in areas of water vulnerability, but also maintain or improve marketable yields and fruit quality. Irrigation of high-intensity orchards is generally needed to optimise productivity, consistency of cropping and fruit quality but improved guidelines for UK growers need to be developed as the impacts of climate change alter evaporative demand and summer water availability. Changes in legislation mean that from 2015, drip irrigators will no longer be exempt from abstraction licencing and will have to demonstrate an efficient use of irrigation water. A new water-saving irrigation test regime (ITR) has been developed for high-intensity pear production in HDC Project TF 198. Water savings of over 50% have been achieved, compared to current commercial practice, and yields and quality of marketable fruit were maintained. This approach is now being tested on a commercial farm in a project funded by Marks and Spencer plc and led by Worldwide Fruit Ltd.

The HDC Tree Fruit Panel has identified the need to develop targeted irrigation strategies to optimise water use efficiency, yields and fruit quality for other high-intensity tree fruit crops. In this project, scientifically-derived guidelines will be developed that optimise irrigation water use efficiency for ‘Gala/M9’, ‘Braeburn’/M9, ‘Merchant’/Gisela 5 and ‘Kordia’/Gisela 5. Soil matric potentials and midday stem water potentials that slow rates of fruit expansion and photosynthesis will be identified and this information will be used to develop Irrigation Test Regimes for each variety. The effects of the Irrigation Test Regimes on shoot physiology, fruit yields and quality will be determined and compared to unscheduled commercial and non-irrigated controls. The proposed research will provide new guidelines to optimise water (and fertiliser) use efficiency in high-intensity apple and sweet cherry orchards on a range of different soil types.

Expected project deliverables are:

- Irrigation guidelines to optimise water use efficiency in high-intensity apple and sweet cherry orchards on a range of soil type used for tree fruit growing.
- Increased awareness of the effects of scheduled, unscheduled and no irrigation on canopy growth, fruit quality and consistency of cropping.
- Reduced water usage by up to 40% (compliance with legislation, maintenance or expansion of current production, despite increasingly limited and expensive freshwater supplies).
- Improved sustainability (more efficient use of water, lower production costs).
- Reduced environmental impact (lower abstraction rates, reduced nutrient leaching).
- Improved fruit flavour (less dilution of essential flavour compounds).
- Greater resource use efficiency to enable sustainable intensification despite limited freshwater supplies.

Summary of the project and main conclusions

Irrigation Test Regimes are being developed for 'Gala/M9', 'Braeburn'/M9, 'Merchant/Gisela 5' and 'Kordia/Gisela 5' in orchards at EMR to try to optimise water use efficiency (WUE) without reducing Class 1 yields or quality. To optimise WUE, the frequency and duration of irrigation events must be managed carefully to avoid run-through of water and nutrients past the rooting zone. In order to achieve this, information on changes in soil water availability and soil moisture content at different depths within the rooting zone throughout the season is needed. In this project, Decagon MPS2 probes, which measure soil matric potential, and Decagon 10HS probes, which measure soil volumetric moisture content, are being used to provide this information.

Experimental design

The experiments were conducted in a high intensity mixed 'Gala/M9' and 'Braeburn/M9' orchard at EMR. The trees were planted in spring 2009 at an in-row spacing of 1 m, with 3.5 m between rows. All trees within the orchard received the same crop husbandry practices (*e.g.* pest and disease spray programmes, fertiliser application, weed control). Separate irrigation lines were installed along the centre of each row at a height above the ground of 50 cm to deliver water to each treatment via 1.6 L h^{-1} pressure compensated drippers positioned 50 cm apart.

Scientific approach

The approach used in this project was to impose temporary and gradual soil drying so that the soil matric potential (water availability) within the rooting zone at which tree physiology is first affected could be identified at different stages of crop development. Midday stem water potential is very sensitive to changes in soil water availability and is often the first indication that plants are experiencing a degree of water stress. Identifying the values of midday stem water potential at which agronomically important traits such as rates of fruit expansion and photosynthesis are first slowed will help to inform the development of the Irrigation Test Regimes for each variety. Since the aim of this work is to develop a 'low-risk' strategy for commercial growers, the lower irrigation set point will be set 100 kPa above the value at which shoot physiological responses are first detected. Soil matric potentials are negative values and they become more negative as the soil dries and water availability decreases. For example, soil at field capacity would have a matric potential of *ca*. -10 kPa whereas the matric potential of soil at permanent wilting point would be *ca.* -1500 kPa.

Irrigation treatments

Two experiments were set up in the orchard, one for each variety, with three irrigation treatments per experiment. The three irrigation treatments were:

1. A commercial control (CC), in which the frequency and duration of irrigation events was decided by Mr Graham Caspell, EMR's commercial farm manager.
2. Irrigation Test Regime (ITR), in which irrigation was withheld, so that gradual soil drying and the associated decline in soil ψ_m triggered physiological responses to limited soil water availability.
3. No irrigation (NI) throughout the season *i.e*. these trees were rain-fed. This treatment was imposed to test whether irrigation was necessary to ensure good marketable yields, high fruit quality and consistency of cropping in high intensity apple production.

Changes in soil water availability in the three irrigation treatments

In the CC treatments, the average soil matric potential in the rooting zone of 'Braeburn/M9' and 'Gala/M9' was maintained above -30 kPa, except during the first week of the experiments where values reached -120 kPa. Irrigation was withheld from trees in the ITR and NI treatments from 20 July 2013, eight weeks after petal fall. Soil matric potential, averaged over a depth of 60 cm, declined steadily in the ITR and NI treatments from the end of July until 23 August 2013 and reached -300 and -470 kPa in 'Braeburn/M.9' and

'Gala/M.9', respectively. The day after, 37 mm of rain fell at EMR resulting in re-wetting of the soil profile to near field capacity. Sporadic heavy rain throughout September meant that soil matric potential was maintained above -125 kPa in each of the three irrigation treatments in both experiments until harvest.

Effects of irrigation treatments on tree physiology

Consistent treatment effects on tree physiology were only detected in 'Gala/M9' in the NI treatment when a lower soil moisture availability resulted in statistically significant differences in midday stem water potential between the CC and NI treatments from 27 July to 23 August 2013. As mentioned above, midday stem water potential is very sensitive to changes in soil water availability but other agronomically important traits such as rates of fruit expansion and photosynthesis are often limited only at much lower soil moisture availabilities. Accordingly, there were very few differences in values of photosynthesis and stomatal conductance for both 'Braeburn/M9' and 'Gala/M9' between the well-watered CC and the ITR and NI treatments, even at average soil ψ_m of between -300 and -400 kPa. Following the heavy rainfall on 24 August 2013, no further treatment differences were detected.

Effects of irrigation treatments on marketable yields and quality

Fruit size, fruit number, total yield and Class 1 yields were not affected by the irrigation treatments in either variety. Likewise, fruit firmness, SSC and skin colour measured at harvest were not significantly affected by irrigation treatments.

Developing water-saving irrigation scheduling strategies

The information obtained in Year 1 will be used to devise and test an ITR for each variety which will be imposed from 6 weeks after full bloom until harvest. Irrigation will be applied only when the soil matric potential reaches the irrigation set point for each variety, and so the frequency of irrigation events will be determined by the rate of soil drying/crop water use. The duration of irrigation events will be adjusted to ensure that losses of irrigation water past the rooting zone are minimised. Effects of the ITR treatment on fruit expansion, marketable yields and quality will be compared to those of the NI treatment where, in the absence of significant rainfall, we anticipate that average soil matric potentials will fall below the values recorded in 2013. The NI treatment will also enable us to identify the midday stem water potential values at which photosynthesis and fruit expansion rate (FER) are first affected in

each variety. Similar work will also commence with two sweet cherry varieties ‘Kordia/Gisela 5’’ and Merchant/Gisela 5’ in a covered orchard at EMR in 2014.

Main conclusions

- Three irrigation treatments were imposed on 4-year-old ‘Braeburn/M9’ and ‘Gala/M.9’ trees in an experimental orchard at EMR: 1) Commercial Control (CC); 2) Irrigation Test Regime (ITR); 3) No irrigation (NI).
- Soil matric potential was maintained above -100 kPa in the well-watered CC treatments throughout the experiment.
- Irrigation was withheld from trees in the ITR treatments from 20 July 2013 so that gradual soil drying was imposed. The average soil matric potential soil in the top 60 cm of soil reached -300 and -470 kPa in ‘Braeburn/M9’ and ‘Gala/M9’ trees, respectively, before heavy rain on 24 August 2014 returned soil to field capacity at each depth.
- Leaf and fruit physiological responses to drying soil were measured three times each week in order to identify the soil matric potentials at which agronomically important traits were first affected.
- A heavy rainfall event (37 mm) on 24 August 2013 effectively ended the soil drying treatments being imposed in the ITR and NI treatments; subsequent rainfall maintained soil above -100 kPa in all three irrigation treatments until harvest.
- In both varieties, Class 1 yields, fruit size and components of fruit quality at harvest were not affected by the irrigation treatments in 2013.
- Sufficient rainfall meant that no irrigation was needed between 20 July 2013 and harvest in October 2013 to ensure good yields of quality fruit in both varieties.
- The impacts of the three irrigation treatments on return bloom will be determined in 2014.
- The potential of the ITRs to deliver significant water savings **and** to maintain Class 1 yields and quality will be tested for each variety in 2014.
- The scientifically-derived irrigation scheduling guidelines being developed in this project will help growers to optimise WUE and environmental sustainability of high intensity apple and sweet cherry production.

Knowledge exchange and technology transfer activities

- Orchard demonstration of TF 210 during a visit of a Chinese delegation to EMR, 31 July 2013.
- Orchard demonstration of TF 210 during a visit of Univeg Technical Managers to EMR, 4 October 2013.
- An introductory article summarising project aims and objectives was prepared for the 2013 HDC Tree Fruit Review.
- The project aims, objectives and results were presented at the HDC Tree Fruit Agronomists' Day, EMR, 25 February 2014.

Financial benefits

The true economic value of water used for the irrigation of high-intensity tree fruit orchards is difficult to quantify, as are the financial benefits associated with water savings (unless mains water is used as a source of irrigation water). A partial cost/benefit analysis will be carried in Year 3 in which the three irrigation treatments imposed at EMR will be compared. Differences in Class 1 yields obtained under the three regimes will be used to estimate the gain or loss of revenue which could be balanced against the expenditure needed to implement the different irrigation strategies. The potential to target fertilisers more efficiently to the rooting zone under the ITRs may be of more immediate interest to some growers since there is the potential to reduce both inputs and direct costs; this work will be carried out by Dr Eleftheria Stavridou in a new HDC-funded project at EMR.

Action points for growers

- Consider installing probes to measure soil water availability or soil moisture content within the rooting zone to help develop effective irrigation scheduling strategies.
- Consider installing water meters to accurately record the volumes of water used to produce 1 tonne of Class 1 fruit.
- Monitoring water inputs and changes in soil water availability/content in just one block will help to improve awareness of the effectiveness of current irrigation strategies and will highlight opportunities for improvement.