

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 2015

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Project Number: TF 210

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

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Report: Annual report 2015

Publication Date: 08 July 2015

Previous report(s): Annual report 2014

Start Date: 01 April 2013

End Date: 31 March 2016

Project Cost: £96,294

GROWER SUMMARY

Headlines

- Results from the non-irrigated treatment suggest that it is not necessary to apply frequent irrigation events to maintain the soil near to field capacity to deliver good commercial yields in 'Gala/M.9' and 'Braeburn/M9'.

Background and expected deliverables

The droughts of 2011-2012, the move to more intensive growing systems and the on-going reform of the abstraction licencing system highlight the need for tree fruit growers to use water for irrigation more efficiently. The challenge is to put in place measures that improve irrigation water use efficiency, especially in areas of water vulnerability, but also maintain or improve marketable yields and consistency of fruit quality at harvest and after removal from store. 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. Under the Government's Abstraction Licence Reform programme, drip irrigators will no longer be exempt from abstraction licencing and when implementation of the new system begins in late 2015, drip irrigators 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 TF 198. Water savings of over 50% were achieved, compared to current commercial practice, and yields and quality of marketable fruit were maintained. The 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 AHDB Horticulture 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 are being developed that optimise irrigation water use efficiency for 'Gala/M.9', 'Braeburn'/M.9, '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 and test ITRs for each cultivar. The effects of the ITRs 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 types 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
- Demonstrable compliance with legislation

Summary of the project and main conclusions

The aim of this project is to optimise water use efficiency (WUE) without reducing Class 1 yields or quality in apple and sweet cherry. 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.

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 (ITR) for each variety. Since the aim of this work is to develop a 'low-risk' strategy for commercial growers, the lower irrigation set point was 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. -1,500 kPa.

Apple

The experiments were conducted in a high intensity mixed 'Gala/M.9' 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.

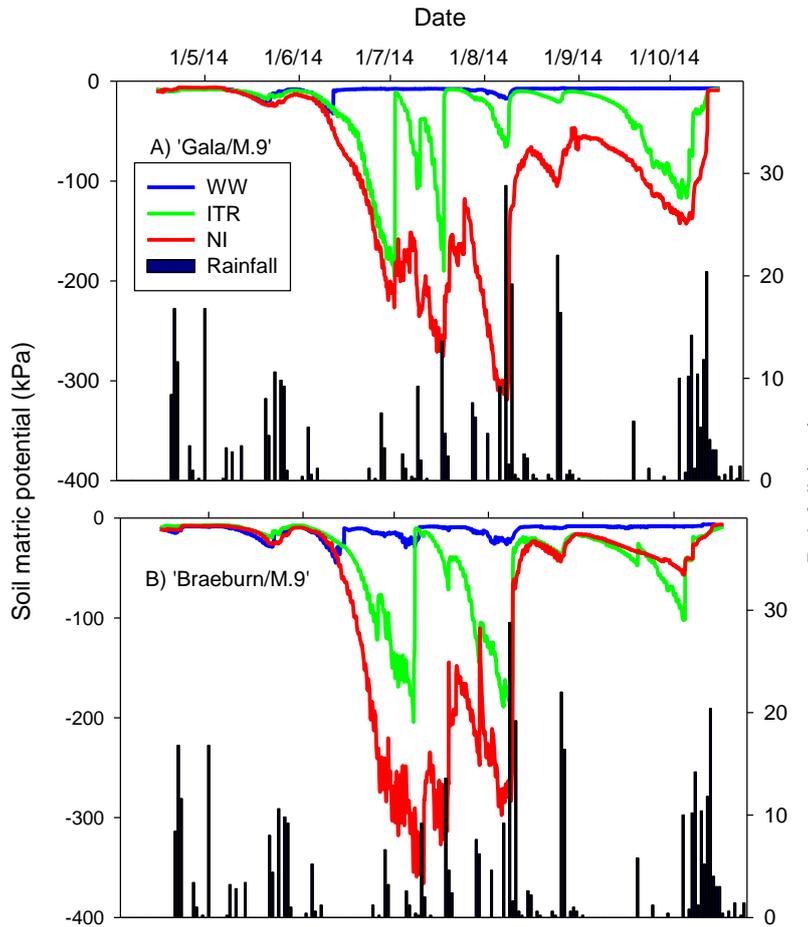


Figure 1. A) Changes in soil matric potential averaged over the top 60 cm of soil in each of the three irrigation treatments applied to 'Gala/M.9' trees in 2014. Rainfall throughout the experiment is also shown. B) Changes in soil matric potential at 20, 40 and 60 cm depth in 'Braeburn/M.9' trees under the three irrigation treatments.

Three irrigation treatments were imposed on both 'Gala/M.9' and 'Braeburn/M9' (Figure 1); 1) Commercial control (CC) where irrigation decisions were taken by EML's Farm Manager Mr Graham Caspell; 2) An Irrigation Test Regime (ITR) in which irrigation was applied when soil matric potential averaged over 20, 40 and 60 cm and reached the irrigation set point of -200 KPa; 3) No Irrigation (NI) to determine the effects of increasing soil moisture deficits on tree physiological responses and fruit size.

'Gala/M.9' trees under the ITR were irrigated only twice during the growing season, but no physiological responses to drying soil were detected and yields and number of Class 1 fruit were similar to CC values. In the NI treatment, the average soil matric potential fell to -310 kPa during August, and although this resulted in significant reductions in midday stem water potentials and rates of photosynthesis, Class 1 yield and number were not affected.

'Braeburn/M9' trees under the ITR treatment received only one irrigation event because heavy rainfall in August returned the soil to field capacity just before the irrigation set point

was reached. The number and yield of Class 1 fruit were similar to those in the CC treatment. Significant reductions in midday stem water potential were detected in the NI treatment in which the average soil matric potential fell to -350 kPa before sporadic rainfall raised values to -110 kPa, then to field capacity. Even though the NI trees experienced mild drought stress, the number and yield of Class 1 fruit were not affected.

These data suggest that frequent irrigation to maintain the soil near to field capacity is not necessary to deliver good commercial yields in 'Gala/M.9' and 'Braeburn/M9' and adopting this approach will increase leaching of N and other nutrients past the rooting zone (see Annual Report for TF 214). Adopting an irrigation set point of -200 kPa (matric potential averaged throughout the rooting zone) could be used to optimise both on-farm water use efficiency and crop productivity. The effects of the applied soil water deficits on return bloom will be assessed in 2015.

Sweet cherry

The experiments were conducted on 'Merchant/Gisela 5' and 'Kordia/Gisela 5' in a mixed cultivar sweet cherry orchard at EMR (Figure 2). The trees were planted on 22 April 2011 at an in-row spacing of 3 m between trees, with 3 m between each variety in staggered double rows and 4 m between each double row. Each double row contained a single variety and each tree was supported by a N°6 tree stake.



Figure 2. Two rows of the 'Merchant/Gisela 5' trees in the mixed sweet cherry orchard at EMR. Photo taken on 15 May 2014.

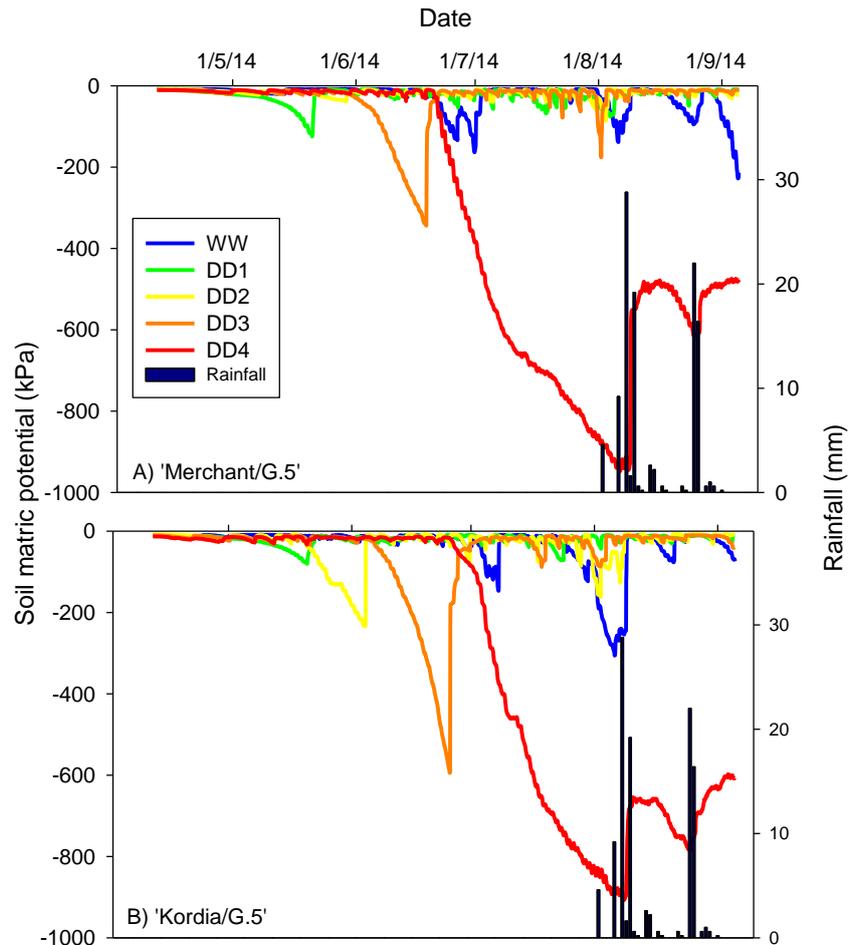


Figure 3. A) Changes in soil matric potential averaged over the top 60 cm of soil in each of the five irrigation treatments applied to 'Merchant/Gisela 5' trees in 2014. Covers were removed on 4 August 2014 and rainfall thereafter is also shown. B) Changes in soil matric potential at 20, 40 and 60 cm depth in 'Kordia/Gisela 5' trees under the three irrigation treatments.

Two experiments were set up in the orchard using the West row of each double row, with five irrigation treatments per experiment. Irrigation in the CC treatment was applied to maintain the average soil matric potential above -40 kPa throughout the season and Deficit Irrigation (DI) treatments of different duration and intensity were imposed during fruit growth Stages I, II and III, and postharvest (Figure 3). DI treatments were imposed to determine whether fruit growth stages were differentially sensitive to soil moisture deficits, otherwise average soil matric potential was maintained above -40 kPa. Irrigation was also withheld post-harvest to some trees to test the effects of soil moisture deficits during the flower initiation phase on cropping potential in the following year.

In 'Kordia/Gisela 5', average soil matric potentials fell to -65, -218, -581 and -900 kPa during Stages I, II, III and post-harvest, respectively. Rates of photosynthesis were similar irrespective of treatment and there were no significant treatment effects on 'Kordia' Class 1

yields, which ranged from 1.6 to 3.2 Kg per tree. This variability meant that it was not possible to identify if specific fruit growth stages were sensitive to mild soil drying since there were no statistically significant treatment effects on fruit number or yield, and the work will be repeated in 2015. In the post-harvest treatment, midday stem water potentials were significantly lowered once the average soil matric potentials fell beyond -350 kPa and the effects of this treatment on return bloom, Class 1 yields and fruit quality will be determined in 2015.

In 'Merchant/Gisela 5', average soil matric potentials fell to -115, -22, -332 and -925 kPa during the four deficit irrigation treatments. Similar physiological responses to those described for 'Kordia' were seen in 'Merchant', but the mild soil drying imposed during Stage 1 significantly reduced both yield (2 Kg vs 3 Kg) and number (172 vs 285), of Class 1 fruit per tree, compared to the CC treatment. In 2015, soil matric potential will be maintained above -60 kPa during Stages I and II, and above -200 kPa during Stage III, and the effects on Class 1 yields will be compared with those from CC trees. The effects of soil moisture deficits during the flower initiation phase (the post-harvest treatment) in 2014 on yields and quality of Class 1 fruit in 2015 will also be determined.

Conclusions

Apple

- 'Gala/M.9' trees under the ITR were irrigated only twice during the growing season, but no physiological responses to drying soil were detected and yields and number of Class 1 fruit were similar to CC values.
- In the NI treatment, the average soil matric potential fell to -310 kPa during August, and although this resulted in significant reductions in midday stem water potentials and rates of photosynthesis, 'Gala/M.9' Class 1 yield and number were not affected.
- 'Braeburn/M.9' trees under the ITR treatment received only one irrigation event because heavy rainfall in August returned the soil to field capacity just before the irrigation set point was reached. The number and yield of 'Braeburn' Class 1 fruit were similar to those in the CC treatment.
- Significant reductions in midday stem water potential were detected in the NI treatment but the number and yield of Class 1 fruit were not affected.

- Results suggest that it is not necessary to apply frequent irrigation events to maintain the soil near to field capacity to deliver good commercial yields in 'Gala' and 'Braeburn'. This approach will increase leaching of N and other nutrients past the rooting zone.
- Trees of both varieties under the NI treatment received 397 mm rainfall between 12 April and 26 October 2015. Potential evapotranspiration during this time was 446 mm.

Sweet Cherry

- In 'Kordia/Gisela 5', average soil matric potentials fell to -65, -218, -581 and -900 kPa during Stages I, II, III and post-harvest, respectively. Rates of photosynthesis were similar irrespective of treatment and there were no significant treatment effects on 'Kordia' Class 1 yields, which ranged from 1.6 to 3.2 Kg per tree.
- In the post-harvest treatment, midday stem water potentials were significantly lowered once the average soil matric potentials fell beyond -350 kPa and the effects of this treatment on return bloom, Class 1 yields and fruit quality will be determined in 'Kordia' in 2015.
- In 'Merchant/Gisela 5', average soil matric potentials fell to -115, -22, -332 and -925 kPa during the four deficit irrigation treatments. The mild soil drying imposed during Stage 1 significantly reduced both yield (2 Kg vs 3 Kg) and number (172 vs 285) of Class 1 fruit per tree, compared to the CC treatment.
- In 2015, soil matric potential will be maintained above -60 kPa during Stages I and II, and above -200 kPa during Stage III in each of the two cultivars, and the effects on Class 1 yields will be compared with those from CC trees.
- The effects of soil moisture deficits during the flower initiation phase (the post-harvest treatment) in 2014 on yields and quality of 'Kordia' and 'Merchant' Class 1 fruit in 2015 will be determined.

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 out 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 AHDB Horticulture project TF 214 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.
- For 'Gala/M.9' and 'Braeburn', adopting an irrigation set point of -200 kPa (matric potential averaged throughout the rooting zone) will optimise both on-farm water (and fertiliser) use efficiency and crop productivity.
- Maintain soil near to field capacity during fruit growth Stage 1 to avoid the negative effects of limited soil water availability on marketable yields of 'Merchant'.