Precision fertigation of soft fruit: innovations and technologies to enhance resource use, productivity, and resilience

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- Precision fertigation
- Managing variability within the cropping area
- Monitoring and managing the phytoclimatic
- Plant-priming to improve resource use and stress resilience
WATERR Project – water applied per hectare (2011-2013)

- 101,000 tonnes of UK soft fruit in 2005, 169,000 tonnes in 2017 (Defra)
- Substrate soft fruit production under polytunnels is wholly reliant on irrigation
- Limited rooting volumes necessitate frequent irrigation events
Drivers for change?

- Abstraction Licence Reform
- Only 27% of water-bodies in England classified as being of ‘good status’
- Requirement for us to double food production in next 30 years
- Food security, supply chain resilience, healthy eating
- Risk mitigation – automation / AI to offset skilled labour shortages
Benchmarking Water Productivity (2011-2013)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water applied</th>
<th>Marketable yield</th>
<th>Irrigation productivity</th>
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<td>M³ / hectare</td>
<td>Tonnes / hectare</td>
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<td>87 - 134</td>
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<tr>
<td>Soil</td>
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<td>650 - 2,600</td>
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<td>13</td>
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<td>Substrate</td>
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- What constitutes irrigation “Best Practice” for different crops / growing systems?
- What are the drivers for more efficient use of water?
- What approaches to water management do this group take?
- Strong correlation between optimising irrigation water use and financial returns
Factors affecting irrigation decisions in substrate systems

- Variety
- Plant quality and consistency
- Planting density
- Developmental stage
- Crop load
- Fruit quality
- Aspect / location / topography
- Polytunnel aerial environment
- Zonal phytoclimates
- Polytunnel venting strategy
- Age of polytunnel plastic
- Age of coir
- Use of wetting agents
- Irrigation system design
- Irrigation uniformity
- Fertigation / nutritional inputs versus plant needs
- Pore E.C. build-up and target run-off volumes
Scheduling tools to aid decision making

[Image of scheduling tools and graphs showing irrigation, SMD, drainage, and irrigation]

EasyAG profiling probe

[Image of EasyAG profiling probe]

NIAB CUF Potato Crop Management

[Image of NIAB CUF device]

Threaded rod
Movable toric magnet
Leaf
Sensor chip
Lower toric magnet
Cable to ZIM-transmitter

[Images of medical equipment and sensors]
What do we mean by Precision Irrigation?

- A system that applies the target volumes of water consistently
- A system that delivers target run-off volumes consistently
- A system that matches crop demand for water with supply

Ensuring that irrigation is managed to optimise:

- Plant health
- Plant nutrition
- Class 1 yields
- Fruit quality
- Canopy size and light interception
Benefits of Precision Irrigation

To growers
- Consistent berry yields and quality
- Improved time management for expert staff
- Informed decision-making
- Less time spent on cane/canopy management
- Lower picking costs
- Water and fertiliser savings

To retailers
- Improved consistency of supply of high quality fresh fruit
- Fruit with an assured shelf-life leading to reduced wastage in store
- Innovative production methods to deliver sustainable intensification

To consumers
- High quality, phytonutritious, flavoursome fruit
- Improved availability of locally-sourced fresh produce
Deriving irrigation set points - *e.g.* Maravilla

- Well-watered and Drying Down treatments imposed on cropping plants using the precision irrigation tool
- CVMC, RH, air temperature, solar radiation and vapour pressure deficit recorded every 2.5 min
- CVMC gradually reduced in the DD treatment over a 3-4 week period, by reducing the irrigation trigger level 2-3 times per week
- Physiological measures (stem water potential, photosynthesis, stomatal conductance, fruit expansion rate), yield and quality (SSC, firmness) recorded at each CVMC value
- The CVMC that triggers a statistically significant change in each measured parameter, compared to well-watered values, is identified
- Variety-specific irrigation set points derived, and tested and refined in commercial trials
How does the Precision Irrigation system work?

- Variety-specific irrigation set points
- Sensors measure coir moisture content (CVMC)
- Sensors measure coir pore EC
- CVMC values averaged by Advanced Datalogger
- Signal sent to commercial rig once set point reached
- Duration of each irrigation event adjusted to deliver target run-off volumes
- Automated flushing based on pore EC values
- Variability in weather automatically accounted for
- Different plant sizes, varieties, crop loads, planting densities automatically accounted for
- Alarm state built in to the PI system
- Safety margin built in around set points
What difference does precision irrigation make?

- Unplanned transient water deficit reduced Class 1 yields by 7%
- Lost revenue of £213k per year on a 20 ha farm
Advances in ΔT sensors, dataloggers and telemetry
- Data from 12 sensors can be averaged
- Temperature-corrected coir volumetric moisture content and pore E.C.
- Remote access to real time moisture data and environmental metrics
- Precision irrigation control on a commercial scale
The Water Efficient Technologies Centre
The WET Centre

- Located at the Fruit Focus site at NIAB EMR
- Eight commercial-scale polytunnels (0.34 ha)
  - Commercial area – current best practice
  - Advanced area – new technologies
- Precision Irrigation - high performance sensors, data loggers and automated irrigation to ensure optimal coir moisture availability
- Improved coir water availability - tailored coir grades, wetting agents
- Comparison of x5 1.2 L vs x8 0.5 L drippers
- Polytunnel rainwater harvesting and re-use
- Automated polytunnels / environmental control
- Precision fertiliser applications
- Malling™ Centenary 60-day crop
Internal and external PAR

- Internal PAR ~66% of external PAR (>1,700 day time readings)
- Values similar for 3 days around Fruit Focus (tunnel was vented)
- Internal PAR sensor sited above crop in a leg row
Accounting for effects of zonal phytoclimates

- Up to 50% variance in timing of ripening in different rows
- Is separate fertigation to each row needed to optimise plant productivity?
- How does the phytoclimatic differ within the polytunnel?
- How do zonal phytoclimates affect plant growth, cropping and water use?
Automated venting coupled to changes in VPD

- Venting state: 1 closed, 4 fully open
- Higher VPDs after midday so venting more widely in the afternoon
- Potential to use venting to optimise the phytoclimat
PAR distribution
Summary of results

- Class 1 yields of 433 g per plant (23.5 t/ha)
- Coir volumetric moisture contents maintained within 1% of the set point
- Average daily run-off between 1 and 6%
- Total irrigation volume of 18.4 L of water per plant; equates to 995 m³/ha (industry average of 2,495)
- Wetting up improved by use of wetting agent and x8 drippers per bag
- WP value of 42
- Good berry size and consistently high %BRIX
- Significant effect of row position on rate of flower/crop development, and on Class 1 yield
Rain Water Harvesting (RWH)

www.newleafirrigation.co.uk
RWH in a “typical” year – towards self sufficiency?

357 mm rainfall at EM Apr - Oct
Polytunnel roof area ~ 1,720 m²
Run-off co-efficient = 0.85
357 x 1,720 x 0.85 = 522 m³
150 m³ stored over Nov – March
Total volume collected = 672 m³

Equivalent to 3,907 m³ / ha

- How much of the 648 mm of rainfall can be collected and used for irrigation?
- Does sufficient rainfall occur at the right time of year for strawberry production?
- During intense rainfall events, how much water is lost (e.g. surplus water siphoned from underground sump and runs to waste)?
- How much rain water is “lost” in a typical year? (~155 mm, Jan - Mar)
- Does the collected rain water need to be treated to remove biological contaminants?

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105 mm rainfall from 1 Apr to 27 Jul, LTA = 178 mm
56 consecutive days without rain
Innovations and technologies for precision growing of soft fruit
Improved management of run-off

- A programme with 4 CVMC set points was devised and uploaded to the GP2
  - Start time and set-points were set:
    - 08:30 = 61%
    - 09:15 = 64%
    - 12:15 = 61%
    - 15:30 = 58%

- These set points delivered run-off during the target period without any manual intervention from the grower

- Start times and set points were adjusted to tailor PI control to the grower’s needs
Real-time coir NPK monitoring

- A step-change in on-farm data acquisition and decision-making is needed to enable the efficient use of all resources.
- Available techniques cannot inform real-time fertigation decisions for optimum outcomes.
- Measurement of coir pore electrical conductivity (E.C.) cannot differentiate between ions.
- Instrument a live system with ISEs to measure [NO$_3$], [K], and [PO$_4$] in solution.
- To develop a functional fuzzy logic inference system (FLIS) to predict [NO$_3$], [K] and [PO$_4$] in coir.
Variety-specific crop forecasting models

- Identification of base temperature for each variety
- Calculation of variety-specific GDH thresholds
Developing predictions of the polytunnel aerial environment using weather probability forecasting
Plant priming and stress resilience

- Plants adjust to declining coir water availability (osmotic adjustment)
- ‘Stress pre-conditioning’ may help to improve crop resilience
- Inoculation with mycorrhiza to improve resource acquisition
Thank you

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