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

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- Current irrigation practices
- Challenges and opportunities
- Benefits of precision irrigation

- The Precision Irrigation Package
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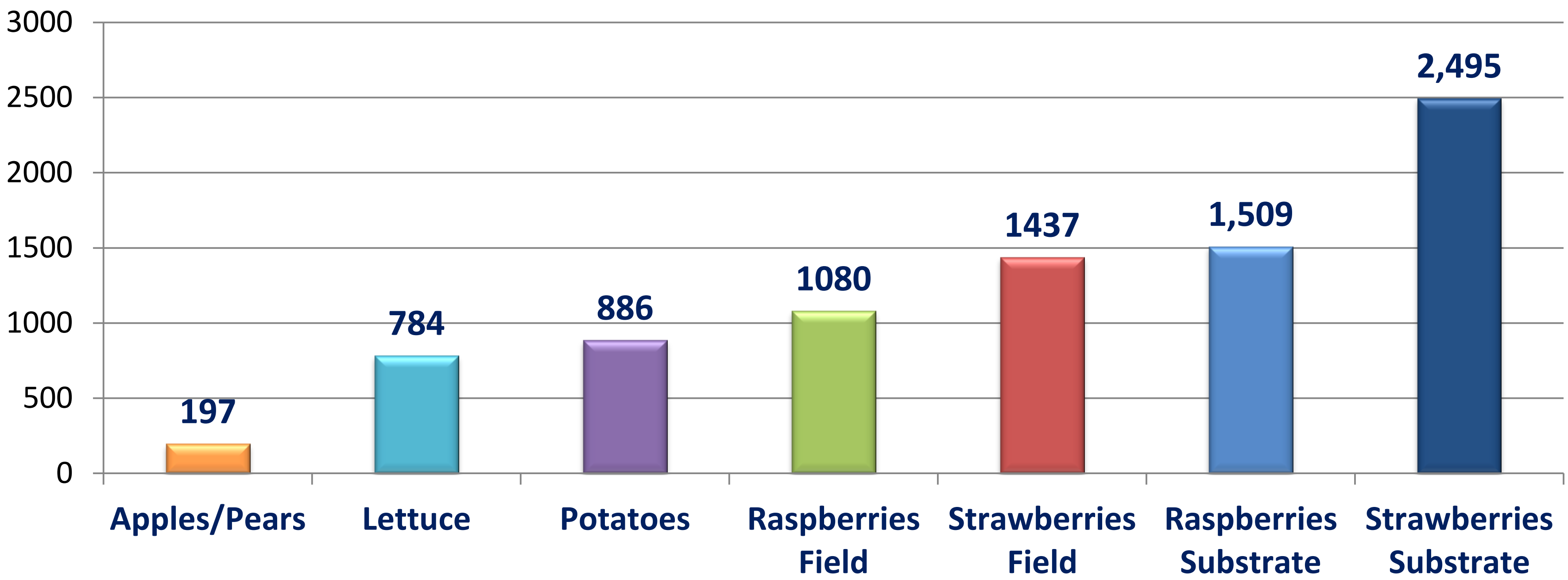
- Rain water harvesting

- Reducing the need for fertigation “run-off”
- Precision fertigation
- Managing variability within the cropping area
- Monitoring and managing the phytoclimate
- Plant-priming to improve resource use and stress resilience

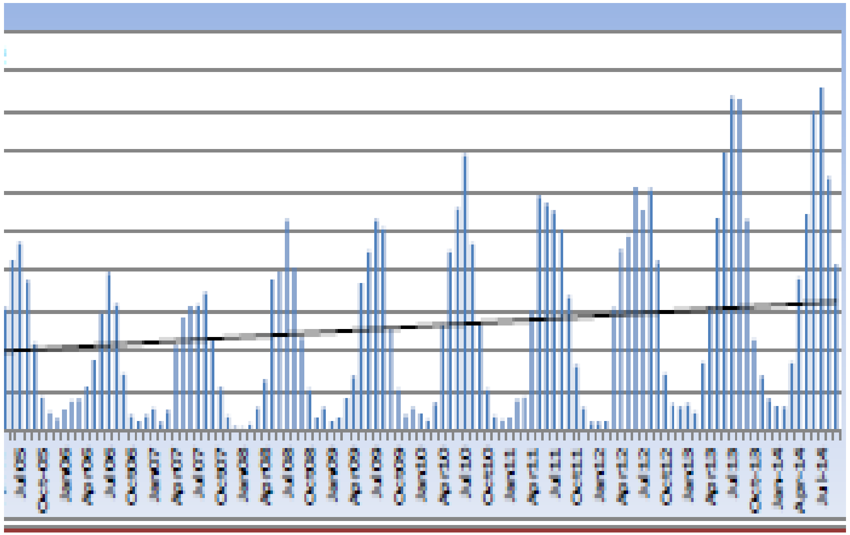
WATERR Project – water applied per hectare (2011-2013)

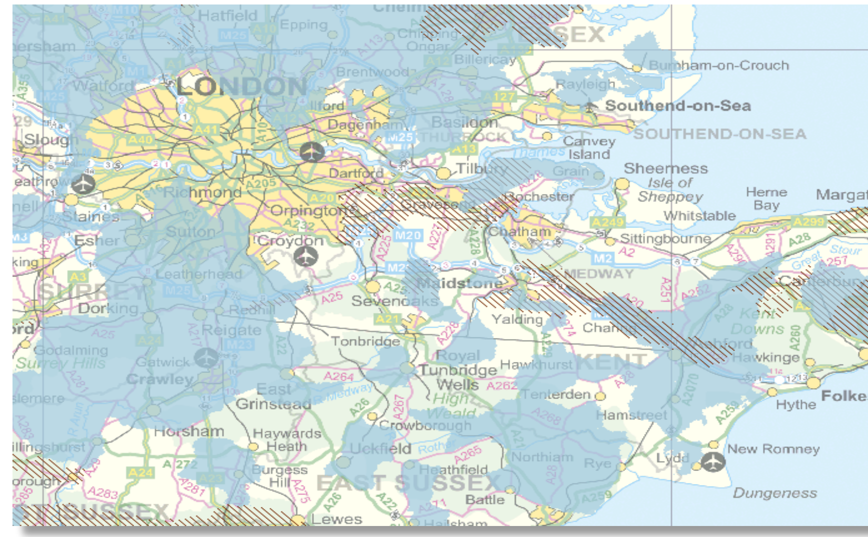


- 101,000 tonnes of UK soft fruit in 2005, 169,000 tonnes in 2017 (Defra)
- Substrate soft fruit production under polytunnels is wholly reliant on irrigation
- Limited rooting volumes necessitate frequent irrigation events

EUROPEAN UNION
Investing in Your Future
European Regional Development Fund 2007-13

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

Environment Agency

Benchmarking Water Productivity (2011-2013)

Crop	Water applied		Marketable yield		Irrigation productivity	
	M^3 / hectare		Tonnes / hectare		M^3 / tonne	
	Average	Range	Average	Range	Average	Range
Raspberry						
Soil	1,080	543 - 1,523	10	7 - 17	114	87 - 134
Substrate	1,509	650 - 2,600	13	10 - 20	111	43 - 166
Strawberry						
Soil	1,437	244 - 2,400	19	5 - 34	79	58 - 99
Substrate	2,495	1,275 - 3,942	32	18 - 45	82	49 - 108

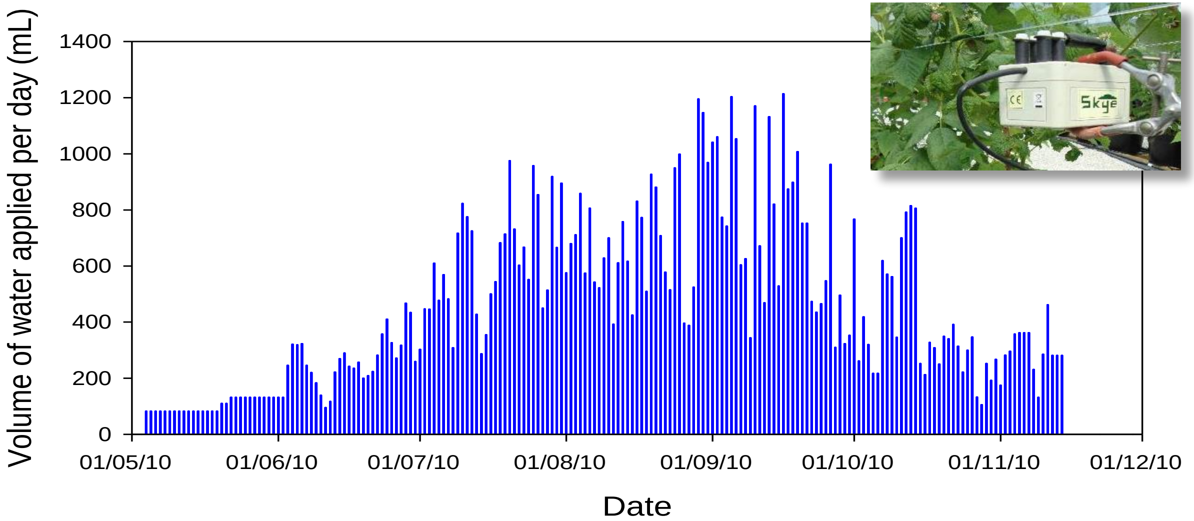
- What constitutes irrigation “Best Practice” for different crops / growing systems?
- What are the drivers for more efficient use of water?
- What approaches to water management do this group take?
- Strong correlation between optimising irrigation water use and financial returns

Factors affecting irrigation decisions in substrate systems

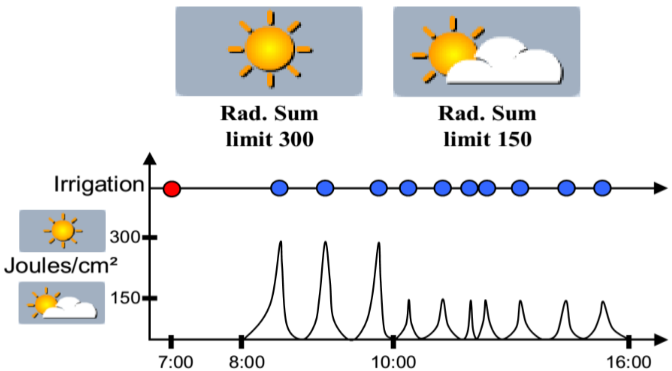
- Variety
- Plant quality and consistency
- Planting density
- Developmental stage
- Crop load
- Fruit quality

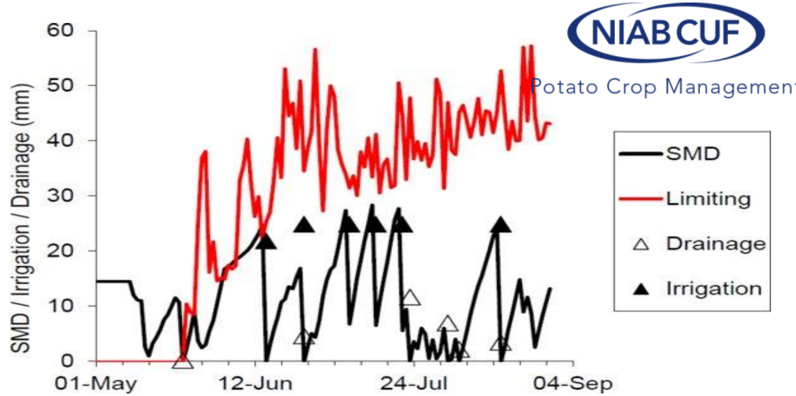
- Aspect / location / topography
- Polytunnel aerial environment
- Zonal phytoclimates
- Polytunnel venting strategy
- Age of polytunnel plastic
- Age of coir
- Use of wetting agents

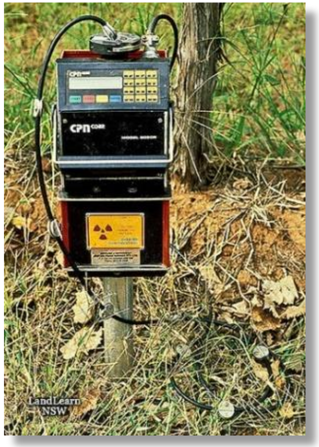
- Irrigation system design
- Irrigation uniformity
- Fertigation / nutritional inputs versus plant needs
- Pore E.C. build-up and target run-off volumes

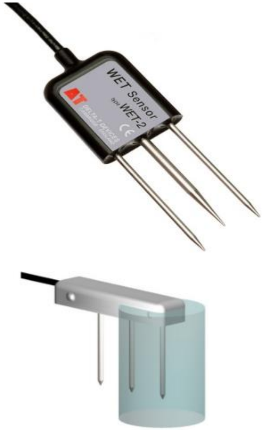


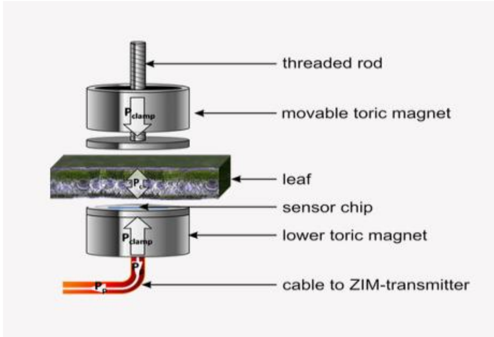
Scheduling tools to aid decision making

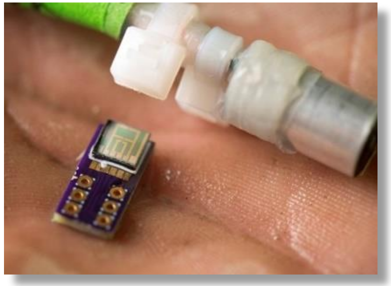






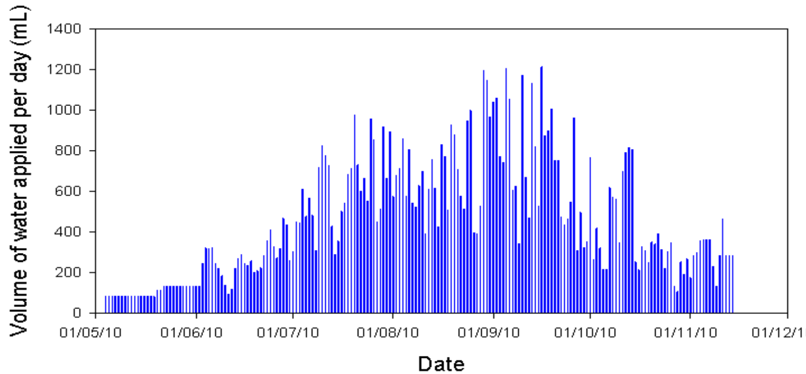






What do we mean by Precision Irrigation?

- 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



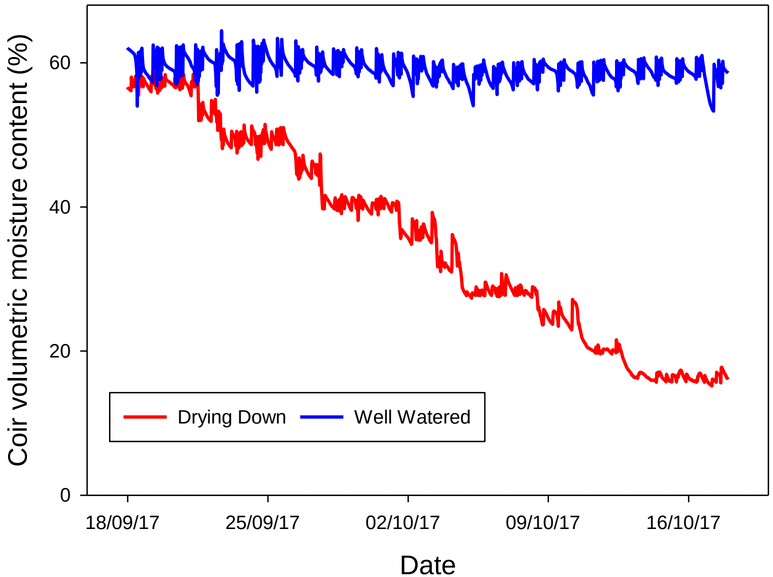
- Ensuring that irrigation is managed to optimise:
  - Plant health
  - Plant nutrition
  - Class 1 yields
  - Fruit quality
  - Canopy size and light interception

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

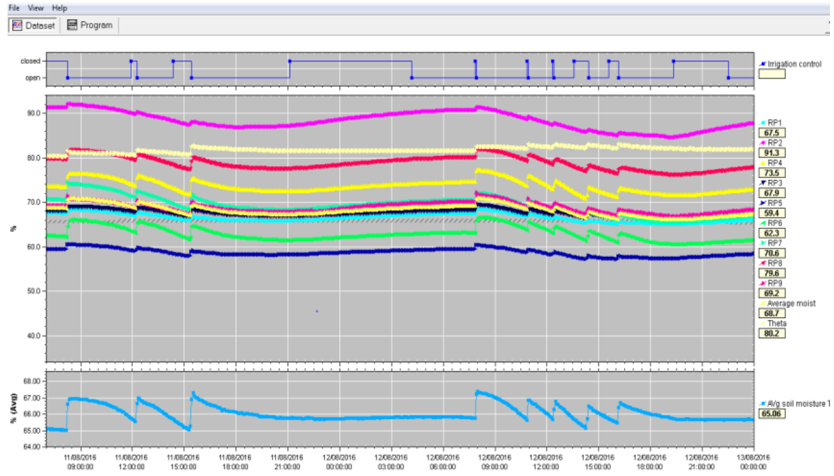
Deriving irrigation set points - *e.g*. Maravilla

- 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

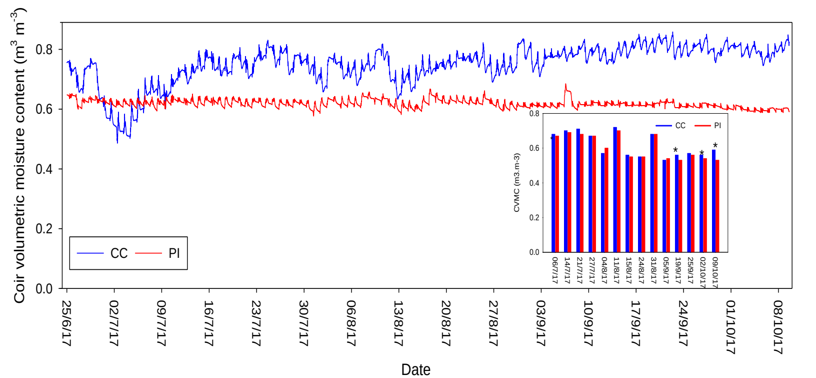


How does the Precision Irrigation system work?

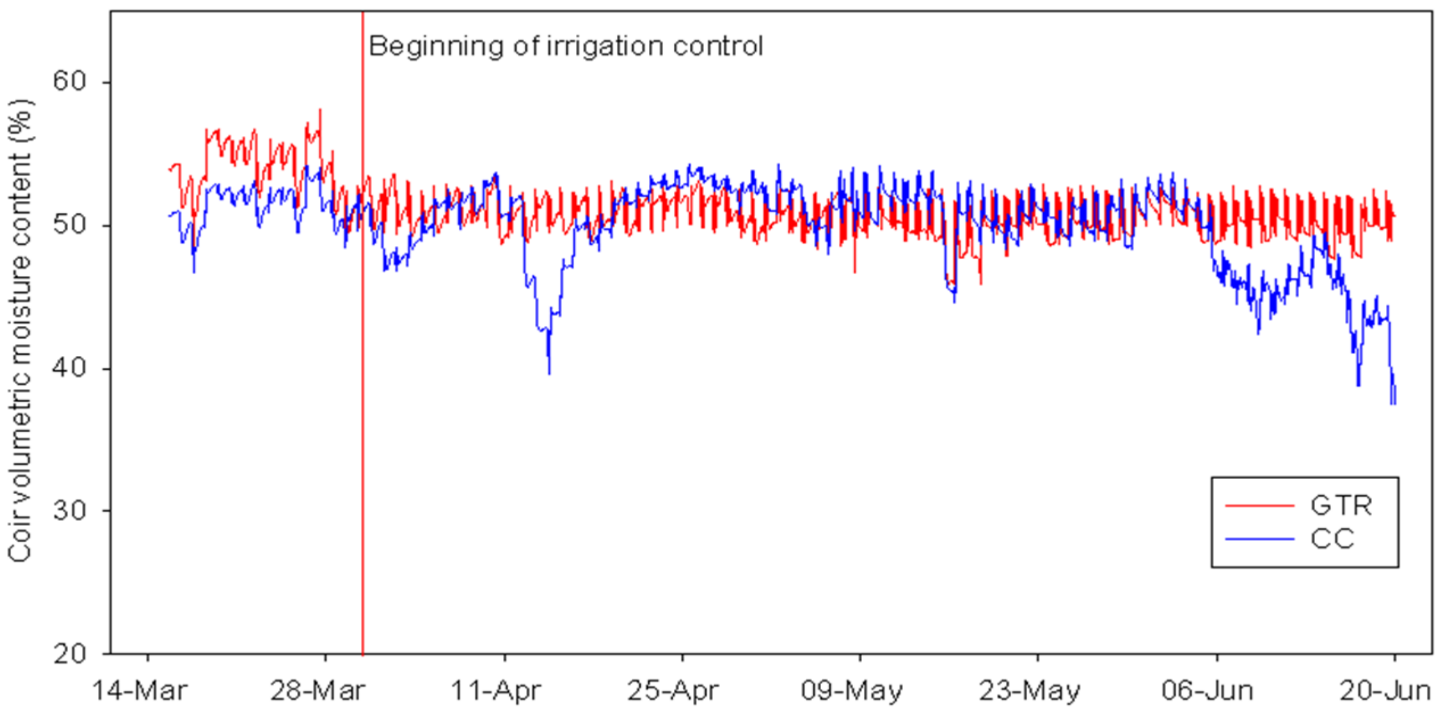
- Variety-specific irrigation set points
- Sensors measure coir moisture content (CVMC)
- Sensors measure coir pore EC
- CVMC values averaged by Advanced Datalogger
- Signal sent to commercial rig once set point reached
- Duration of each irrigation event adjusted to deliver target run-off volumes



- 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

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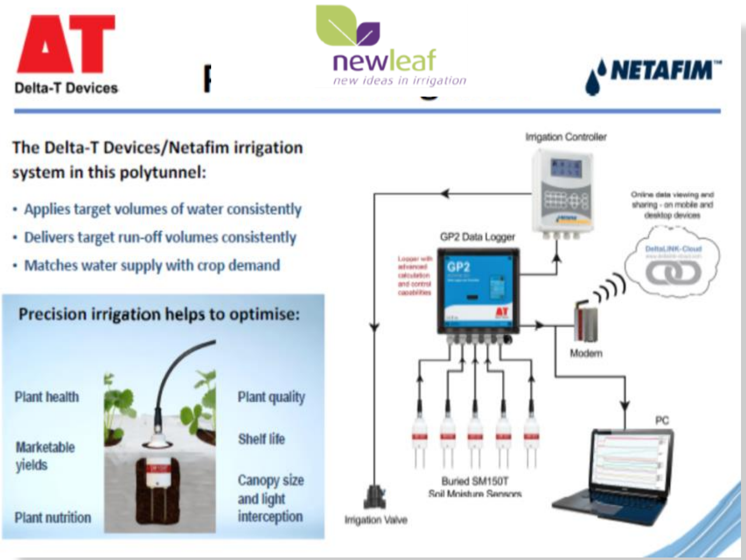
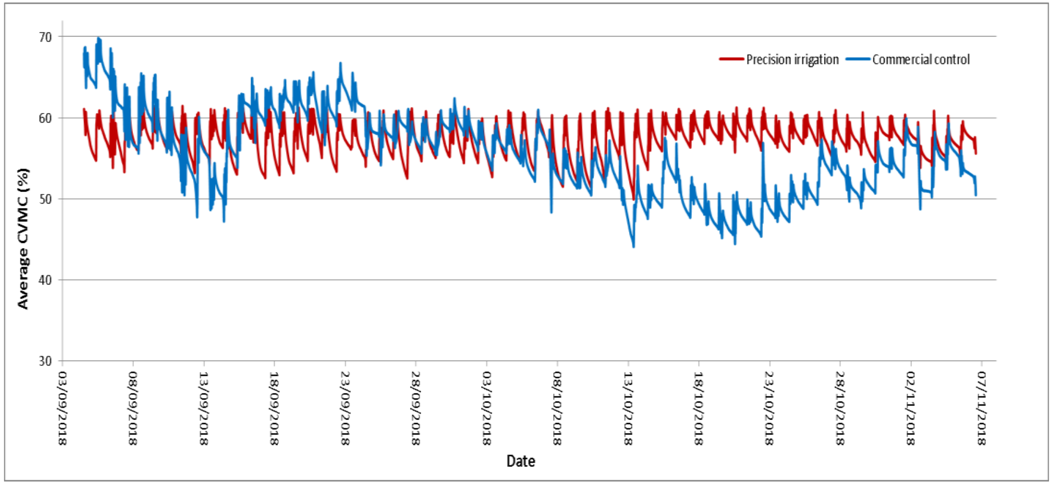
Precision irrigation technologies developed for soft fruit





- 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

PRECISION IRRIGATION PACKAGE

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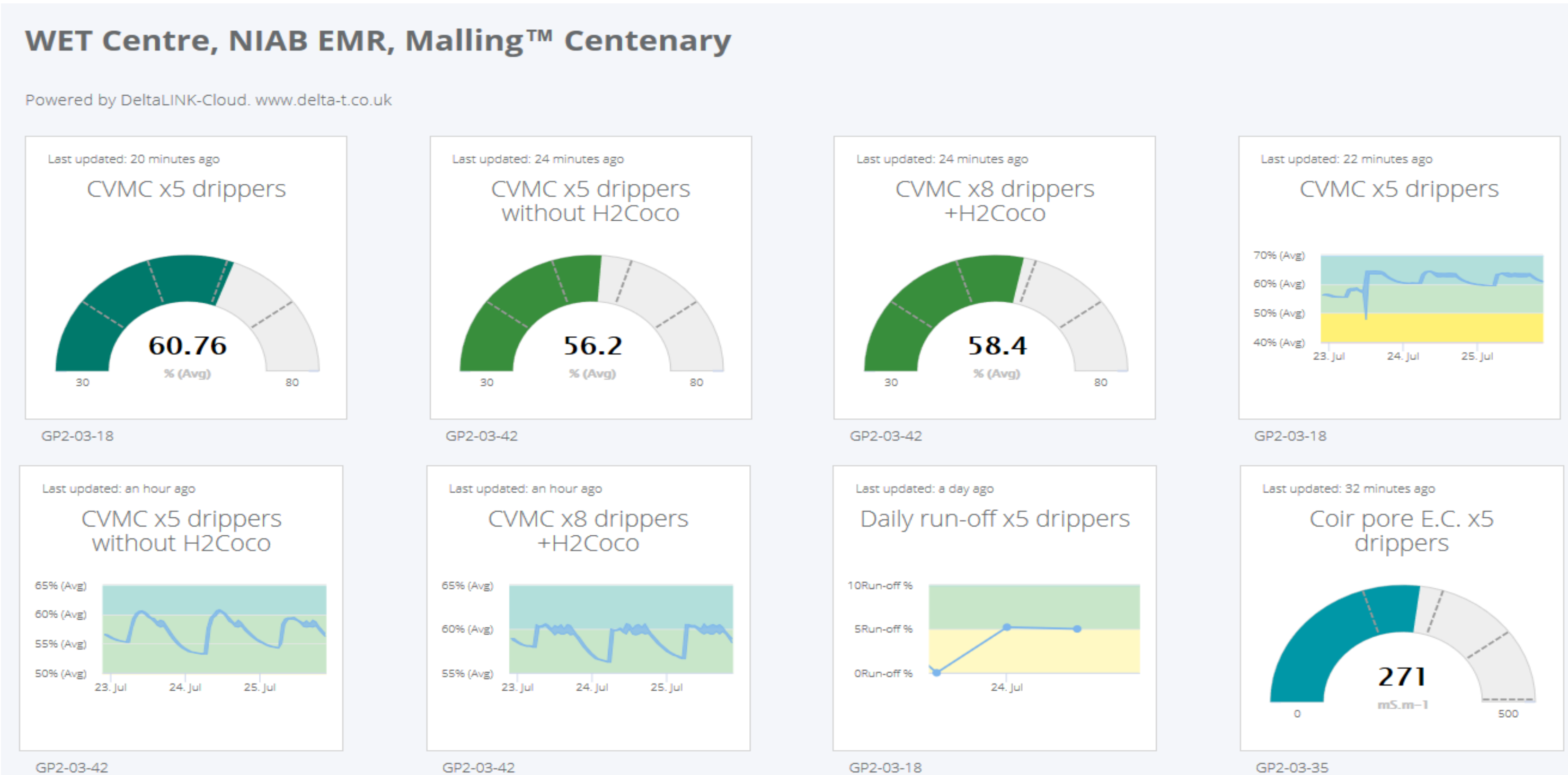
Grower Dashboard



The Water Efficient Technologies Centre

AHDB HORTICULTURE

Berry Gardens

Cocogreen

Delta-T Devices

NETAFIM

newleaf new ideas in irrigation

south east water

Kent County Council kent.gov.uk

HUTCHINSONS Crop Production Specialists

LEAF

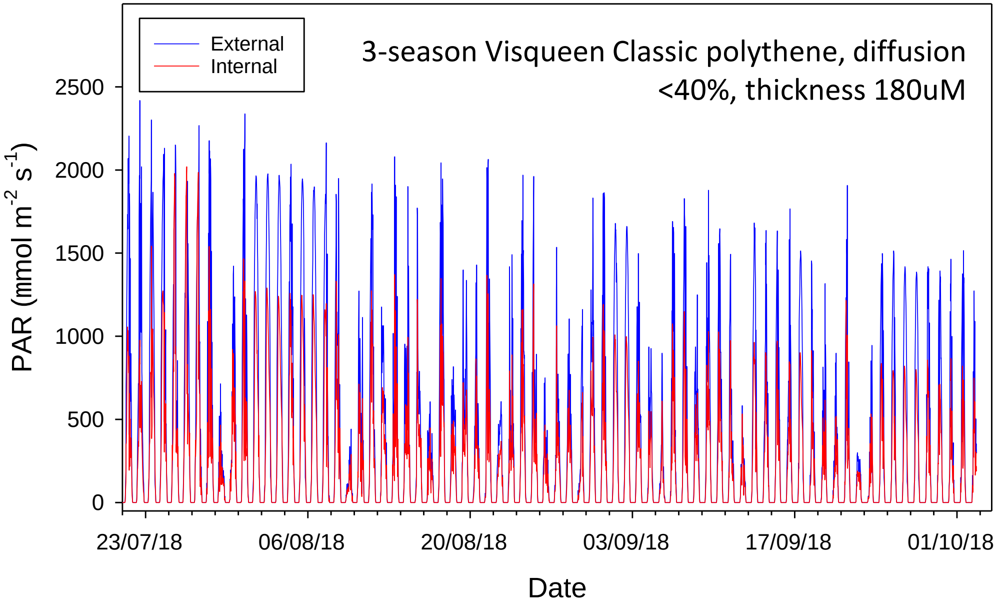
ARTIS Harvesting Knowledge

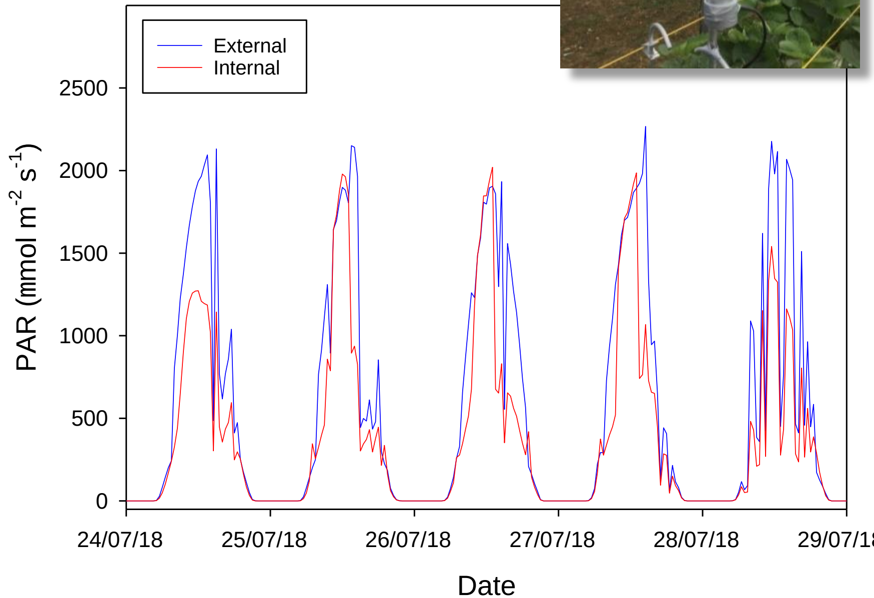
THE WET CENTRE

The WET Centre

- Located at the Fruit Focus site at NIAB EMR
- Eight commercial-scale poly tunnels (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

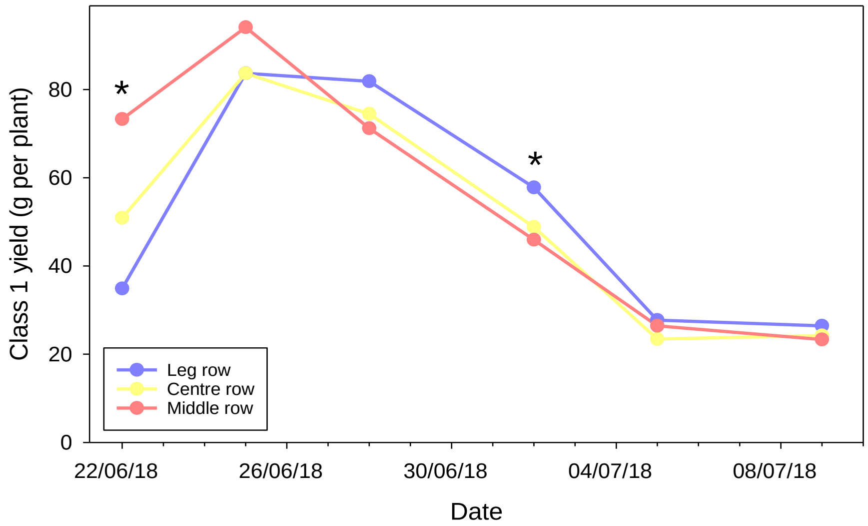
Internal and external PAR

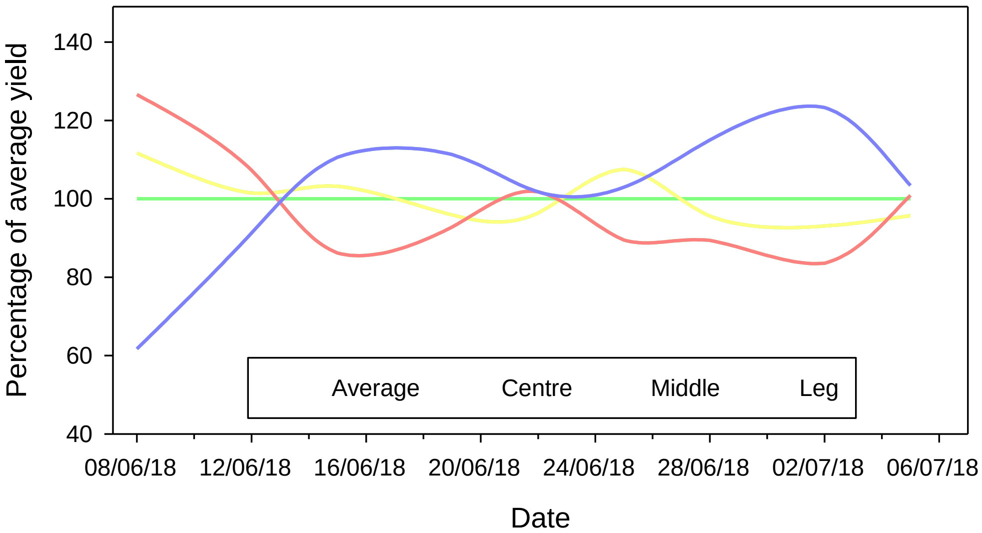




- Internal PAR ~66% of external PAR (>1,700 day time readings)
- Values similar for 3 days around Fruit Focus (tunnel was vented)
- Internal PAR sensor sited above crop in a leg row

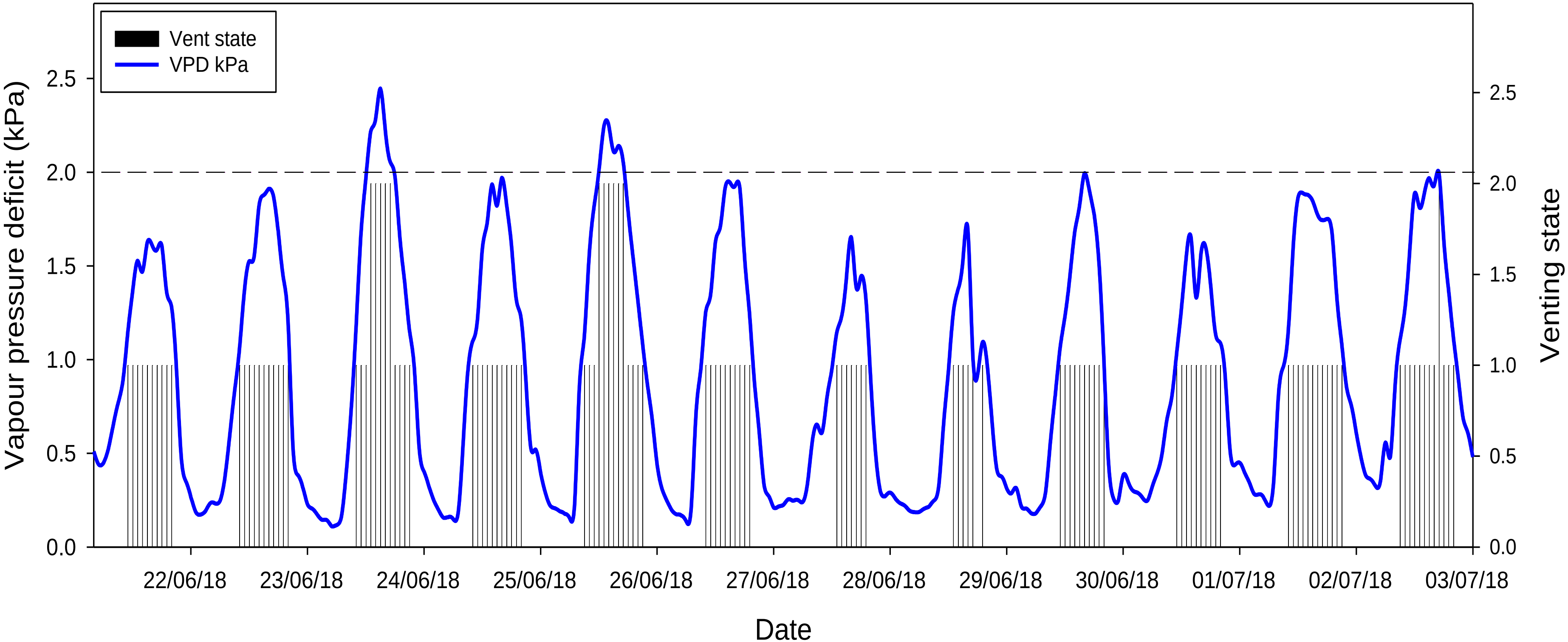
Accounting for effects of zonal phytoclimates





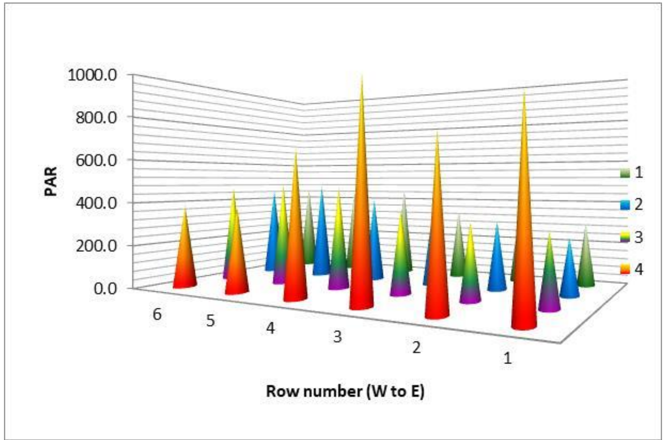
- Up to 50% variance in timing of ripening in different rows
- Is separate fertigation to each row needed to optimise plant productivity?
- How does the phytoclimate differ within the polytunnel?
- How do zonal phytoclimates affect plant growth, cropping and water use?

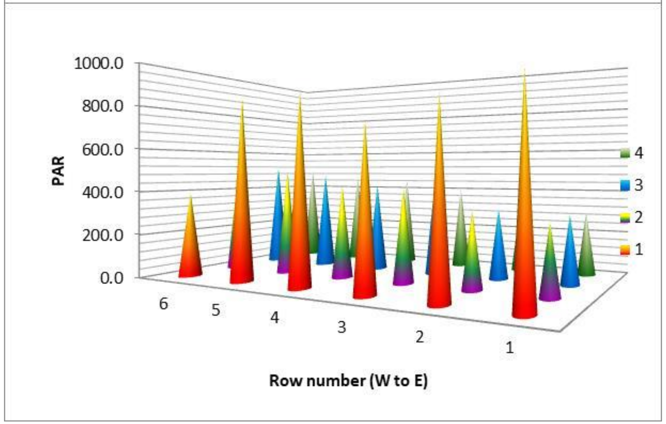
Automated venting coupled to changes in VPD



- 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 phytoclimate

PAR distribution





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THE WET CENTRE

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 m^3 / 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

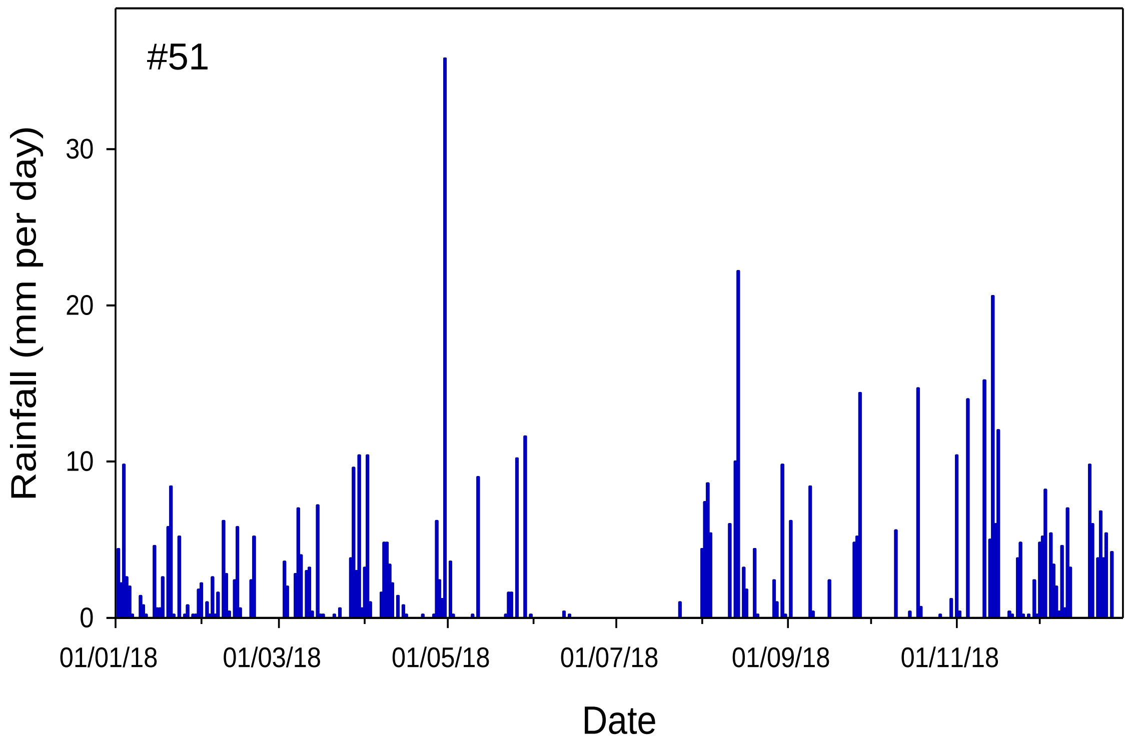
RWH in a "typical" year – towards self sufficiency?

357 mm rainfall at EM Apr - Oct
Polytunnel roof area ~ 1,720 m^2
Run-off co-efficient = 0.85
357 x 1,720 x 0.85 = 522 m^3
150 m^3 stored over Nov – March
Total volume collected = 672 m^3
Equivalent to 3,907 m^3 / ha

Crop	Water applied	
	m^3 / hectare	
	Average	Range
Raspberry		
Substrate	1,509	650 - 2,600
Strawberry		
Substrate	2,495	1,275 - 3,942

- 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?

How representative is the Long Term Average?

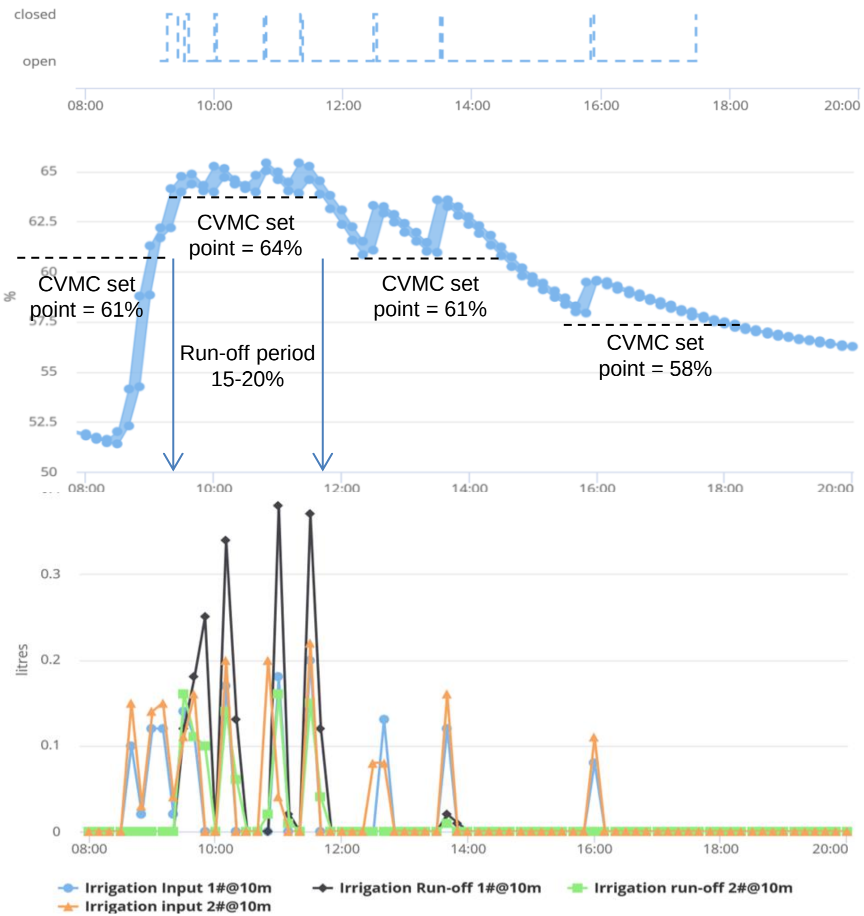


Month	Rainfall (mm)		
	Actual	LTA	Difference
January	57.0	66.1	-9.1
February	31.4	43.7	-12.3
March	61.8	45.4	16.4
April	79.8	46.2	33.6
May	38.4	48.9	-10.5
June	0.6	42.8	-42.2
July	26.8	40.2	-13.4
August	67.4	51.6	15.8
September	35.6	54	-18.4
October	47.6	73.9	-26.3
November	94.6	68.7	25.9
December	61.0	66.4	-5.4
	602.0	647.9	-45.9

- 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

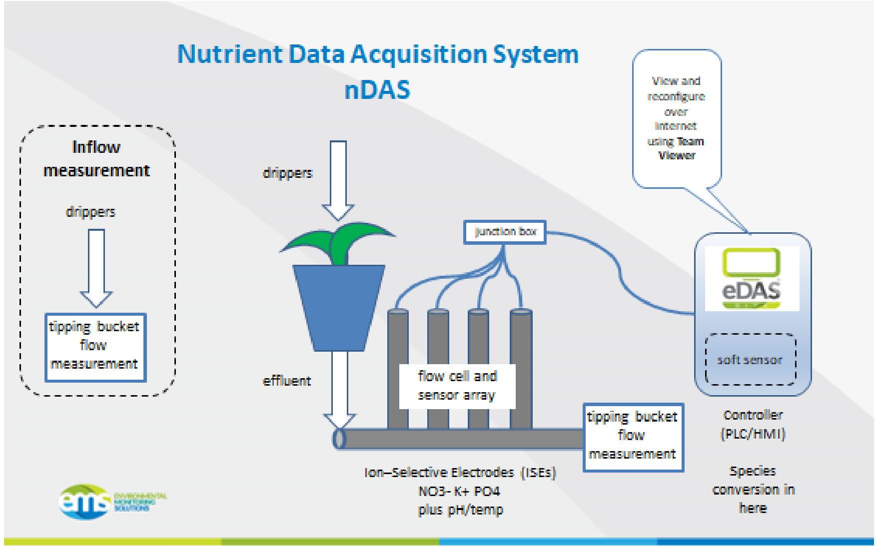
Improved management of run-off



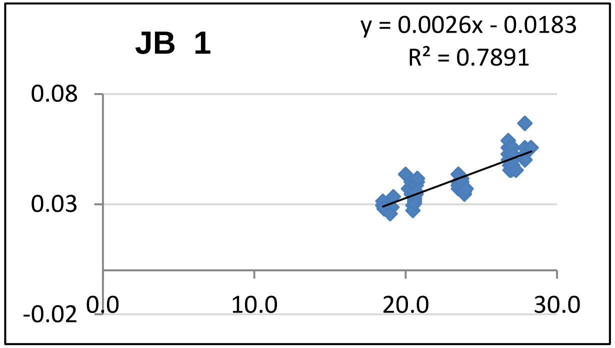
- A programme with 4 CVMC set points was devised and uploaded to the GP2
  - Start time and set-points were set:
  - 08:30 = 61%
  - 09:15 = 64%
  - 12:15 = 61%
  - 15:30 = 58%
- These set points delivered run-off during the target period without any manual intervention from the grower
- Start times and set points were adjusted to tailor PI control to the grower's needs

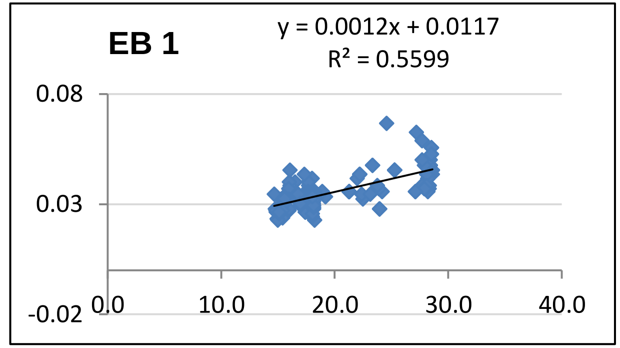
Real-time coir NPK monitoring

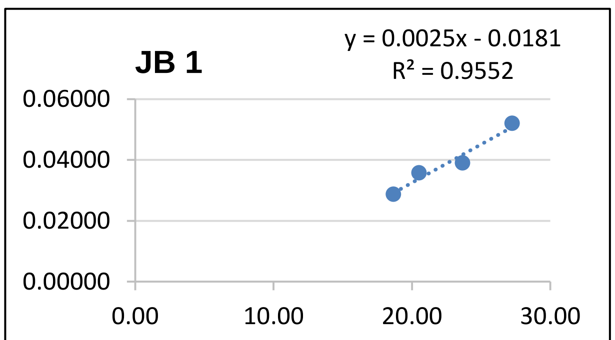
- A step-change in on-farm data acquisition and decision-making is needed to enable the efficient use of all resources
- Available techniques cannot inform real-time fertigation decisions for optimum outcomes
- Measurement of coir pore electrical conductivity (E.C.) cannot differentiate between ions
- 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

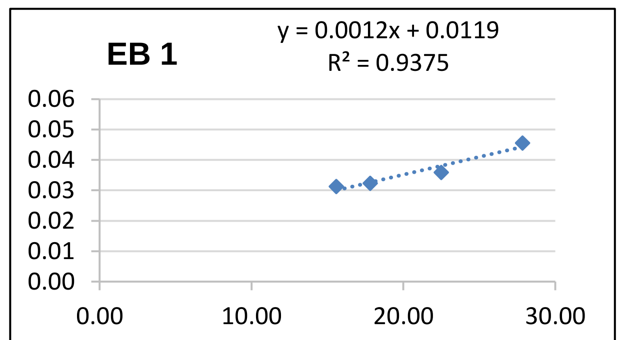


Variety-specific crop forecasting models



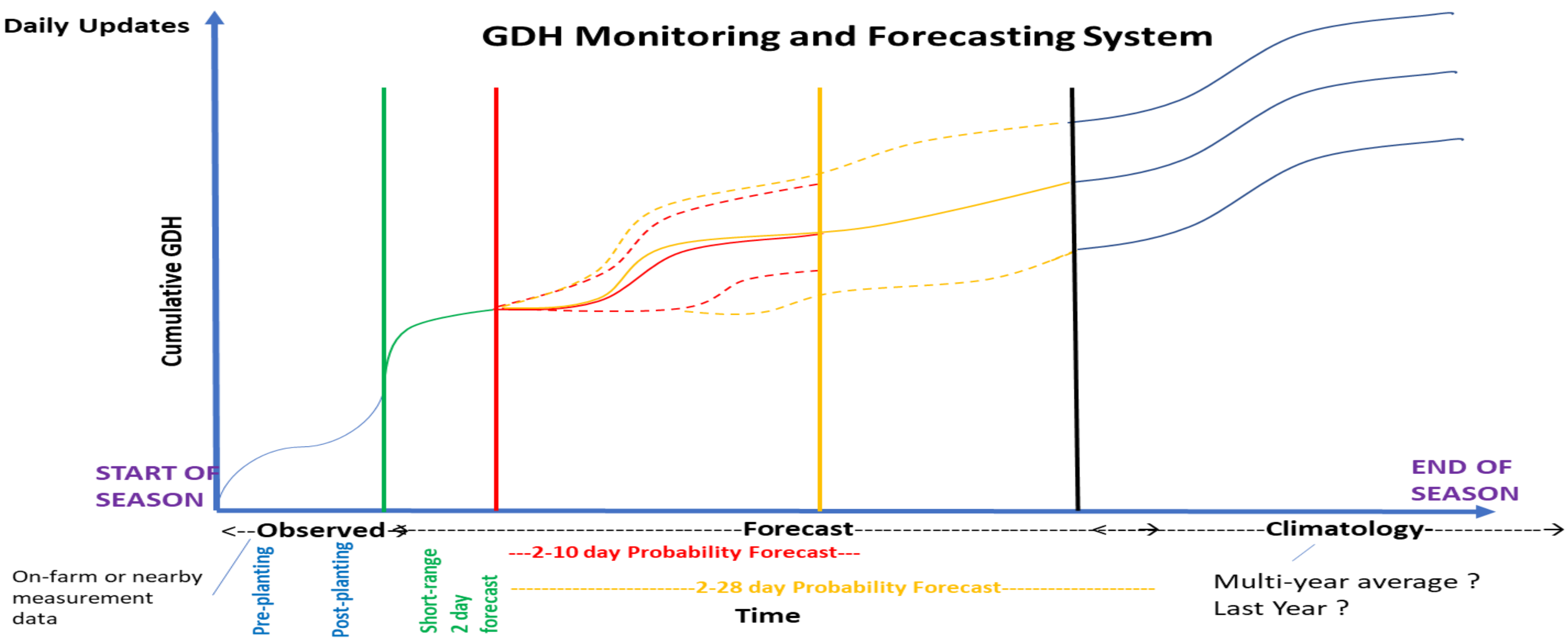






- Identification of base temperature for each variety
- Calculation of variety-specific GDH thresholds

Developing predictions of the polytunnel aerial environment using weather probability forecasting



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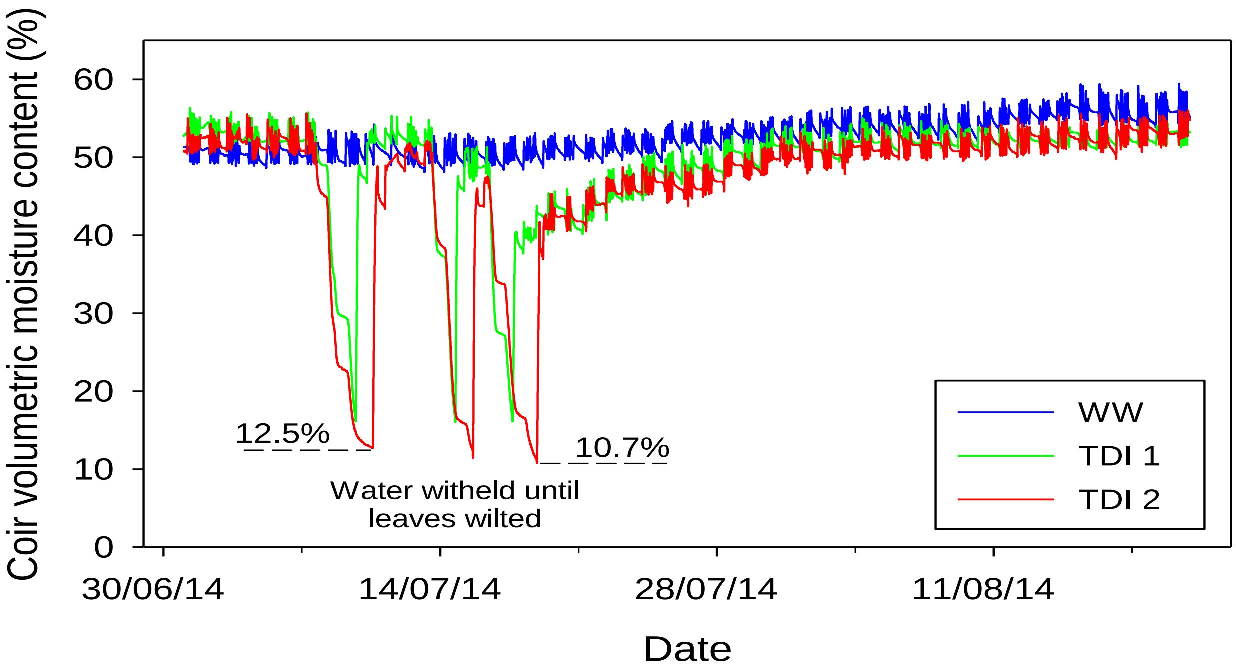
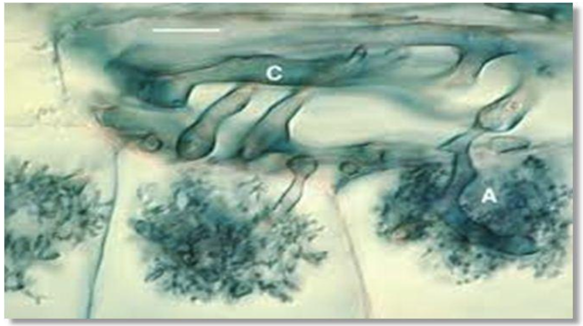
Plant priming and stress resilience





- 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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