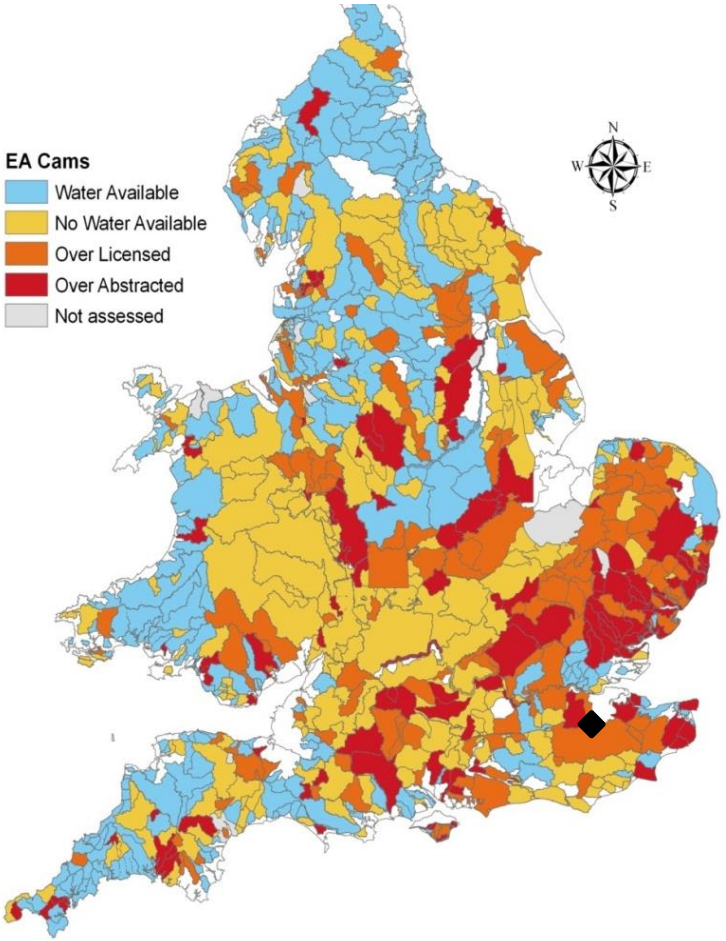
Improving water use efficiency and quality of fresh produce

Dr Mark A. Else

Resource Efficiency for Crop Production

Contents

- Introduction
- Water use efficiency in soft and tree fruit production
- Plant responses to abiotic stresses
- Developing water-saving irrigation strategies for soft and tree fruit
- Improving on-farm water productivity
- Technologies to manage the risks
- Developing deficit irrigation strategies to improve ‘quality’ and crop management
- Outputs from our research



The challenges

- Climate change
- Water & energy efficiency
- Emerging pests and diseases
- Increasing population
- Increasing affluence
- Healthy eating
- Healthy ageing
- Food security
- Supply chain resilience



- Requirement for us to double food production in next 30 years
  - To produce as much food between 2000 and 2050 AD as we did between 1500-2000 AD

UK soft and tree fruit industries



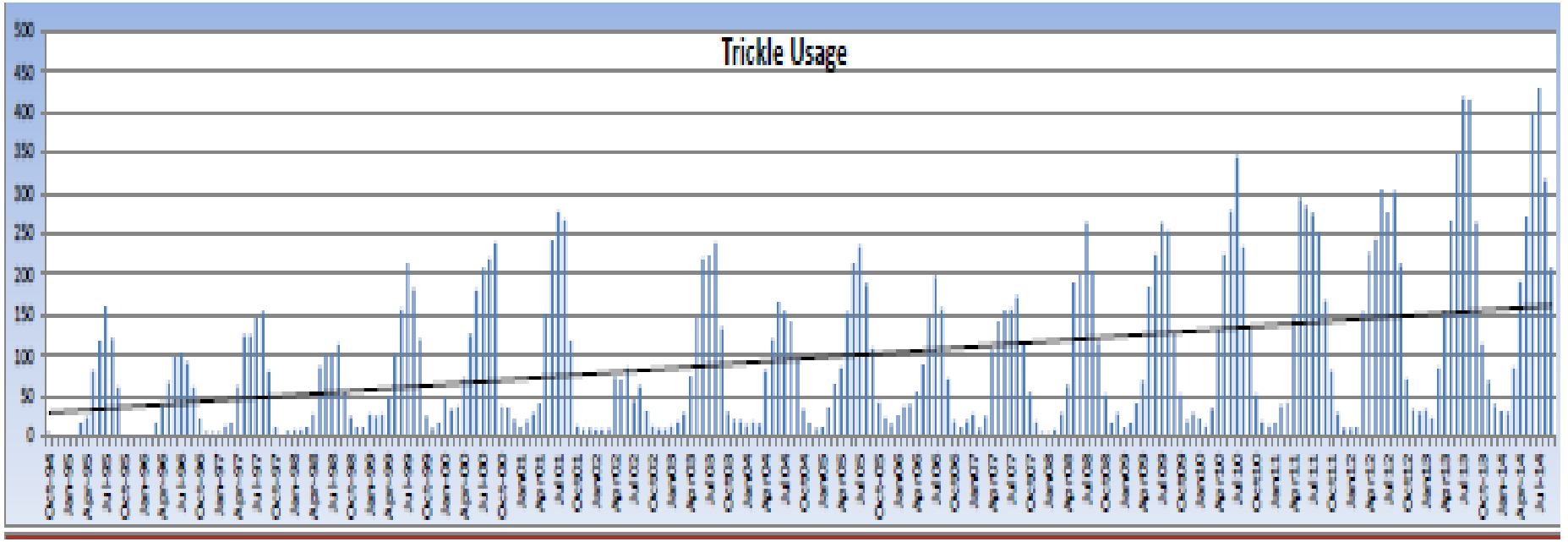






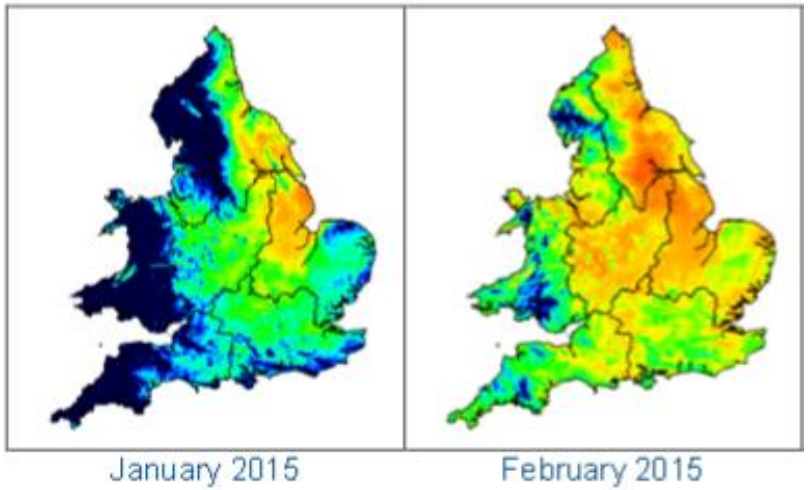
- Soil- and substrate-grown crops
- Covered (soft fruit, stone fruit) and uncovered (top fruit)
- 388,600 tonnes soft and tree fruit p. a.
- Worth £513M p. a. (Defra)
- High value horticulture (£3,000 to £6,500 per tonne)

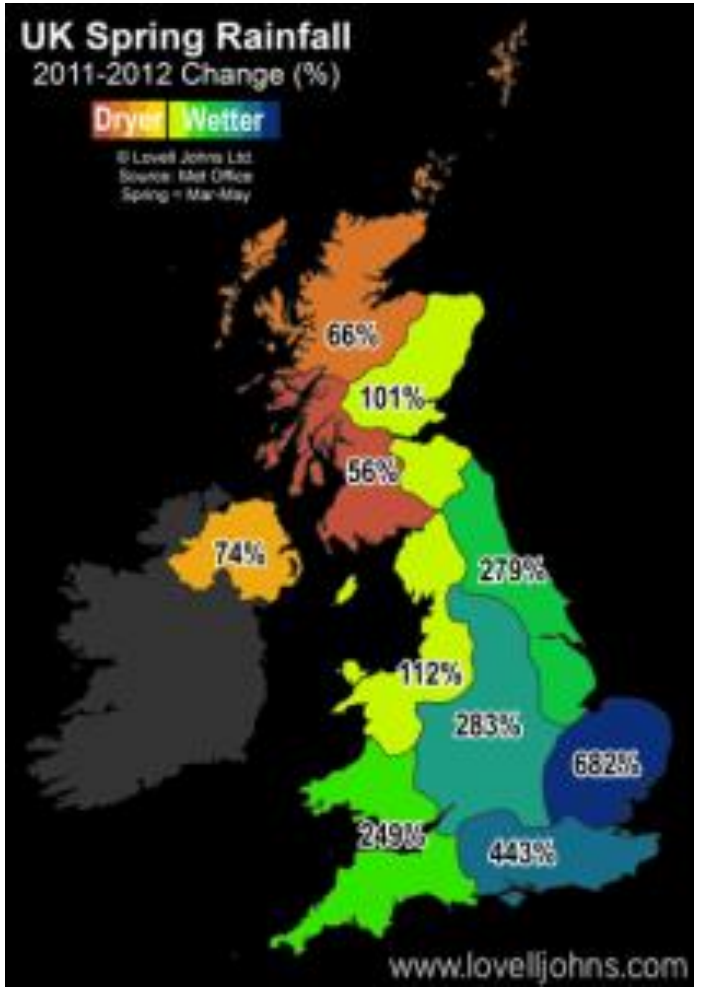
Drip irrigation - Abstraction Licence Reform



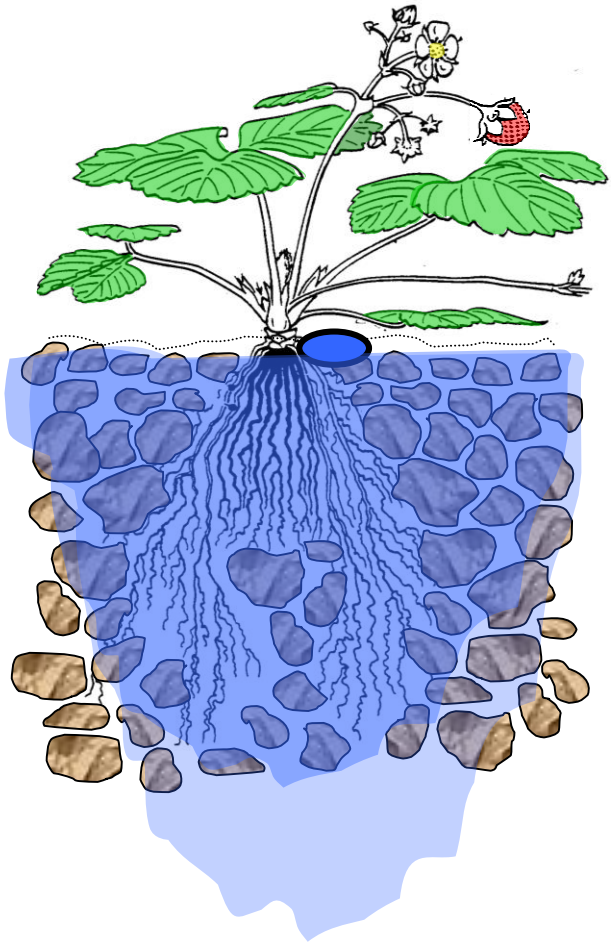
- Consultation closed 28 March 2014
- Aim to legislate for abstraction reform early in new Parliament
- Bring trickle irrigation under abstraction licencing in early 2016
- EA to begin implementing changes in October 2015

It never rains…. but it will pour…

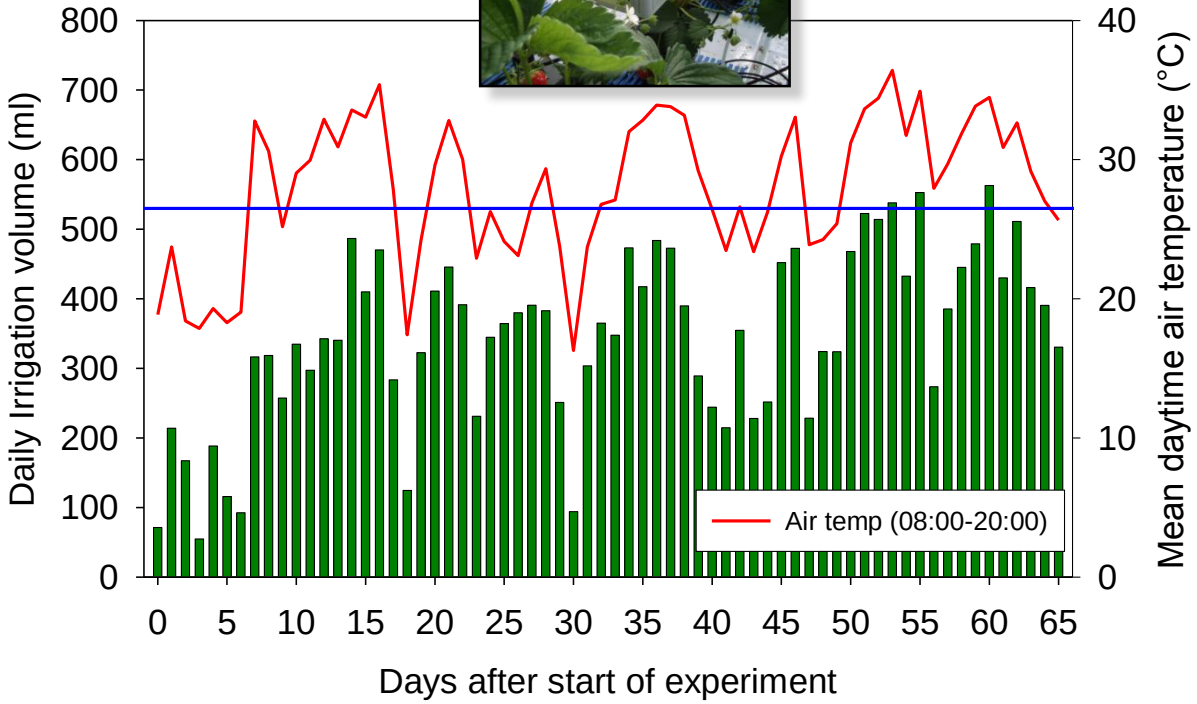




Irrigation scheduling – matching demand with supply







- Plant water use can vary up to 15-fold
- Need effective irrigation scheduling tools
- Water deficits may reduce yields…

Current irrigation scheduling methods



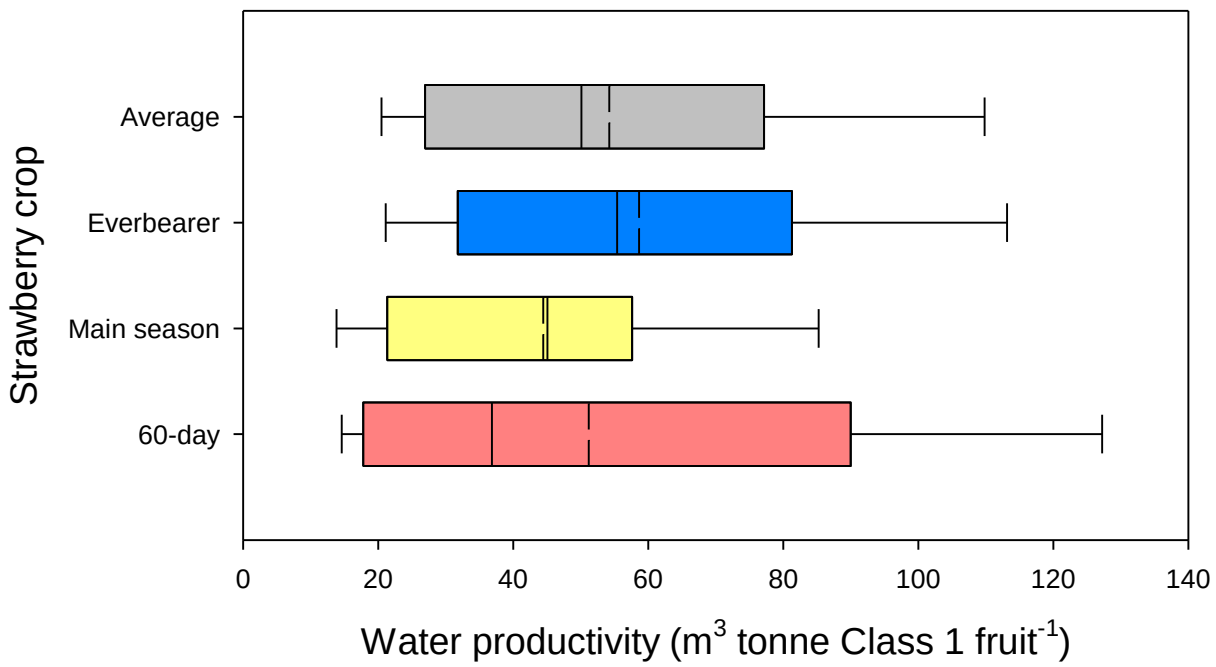




- Intuition, experience
- Rad sum
- Evaporative demand/VPD + crop co-efficients/calibration
- Soil / substrate volumetric water content (range of sensors)
- Substrate matric potential sensor
- Plant-based, continuous measuring tools are being developed



Benchmarking Water Productivity (L water used to produce 1 kg Class 1)



WP	Range
54	20 to 113
59	21 to 113
44	13 to 88
51	15 to 132

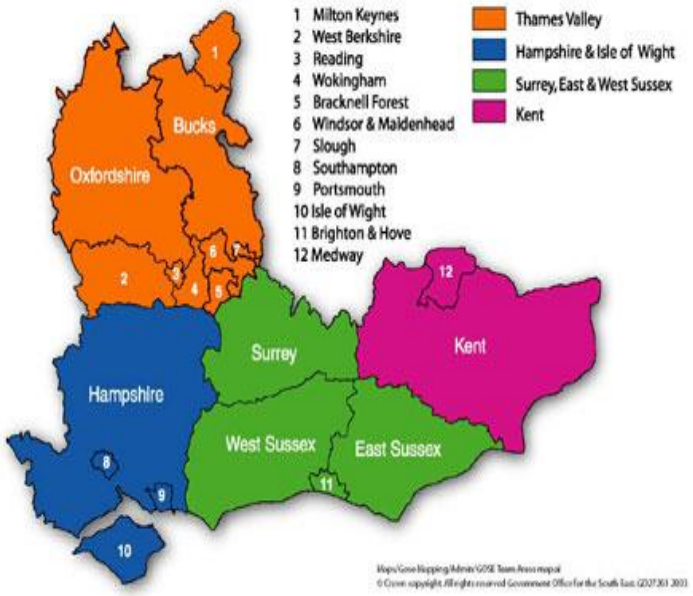
- Soil-grown strawberry crops 2011
- Need to improve water productivity, yields and fruit quality

‘WATERR’ Project

(‘Water Advisory Team for Efficient Resource Recovery’)

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- Assess current irrigation water availability and use efficiency
- Impact on production / yields, pricing and financial returns
- Identify ‘Best Practice’ technologies and techniques
- Improvement opportunities / barriers
- Grower support needs, priorities and Action Plan
- ‘WATERR’ Project Support Programme



EUROPEAN UNION
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European Regional Development Fund 2007-13

Environment Agency

Kent County Council
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Plant physiological responses to abiotic stresses

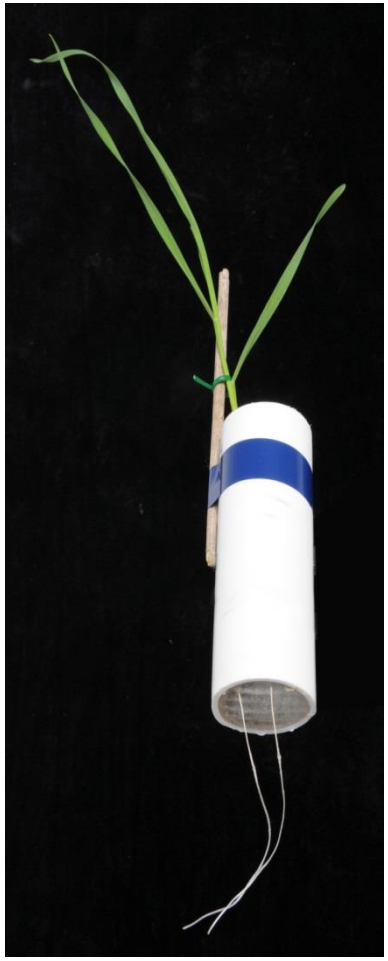


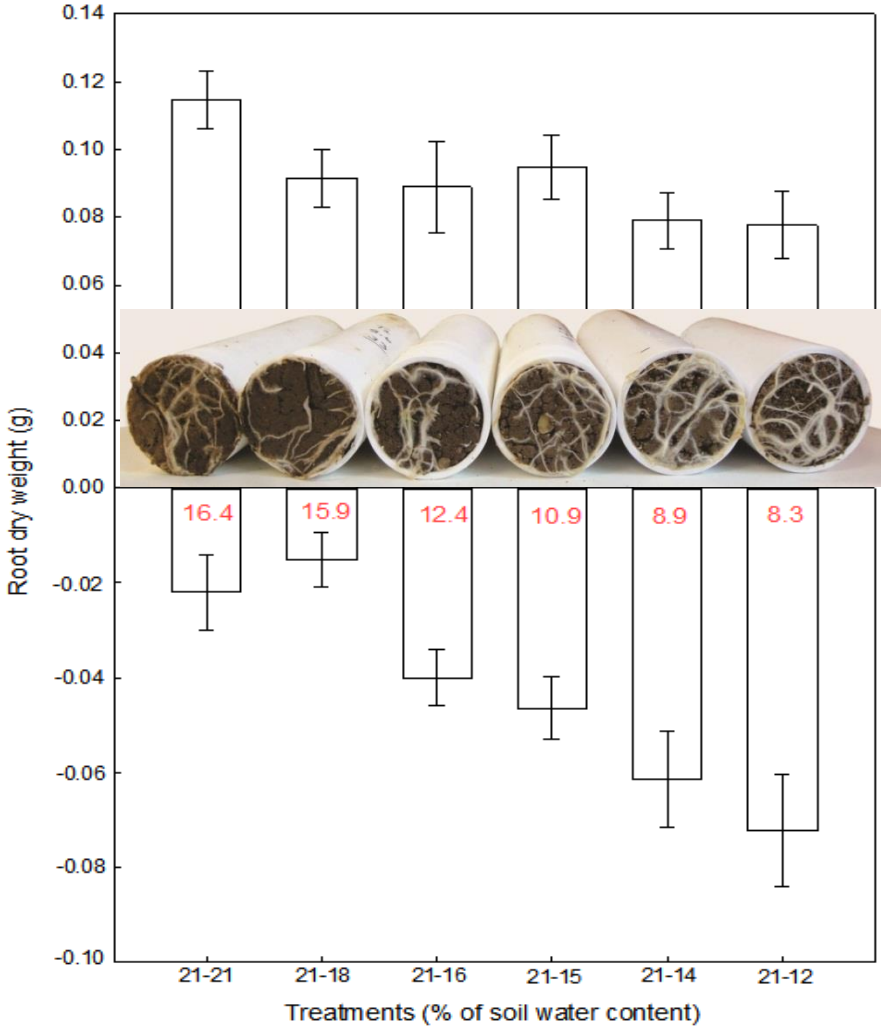
Within 3 hours:
stomata begin to close
leaf extension slows
petiole epinasty begins

⇧ ⇧ ⇧ ⇧ Root to shoot signalling Hydraulic Chemical ⇩ ⇩ ⇩ ⇩

Within 1 hour:
O_2 partial pressures fall from 20.8 to 7.9 kPa
CO_2 partial pressures rise from 0.035 to 8.9 kPa

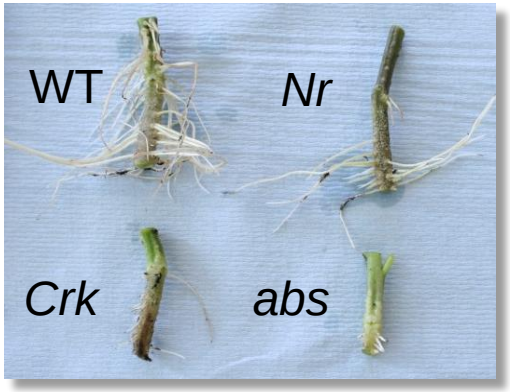
Regulation of root growth in heterogeneous soils



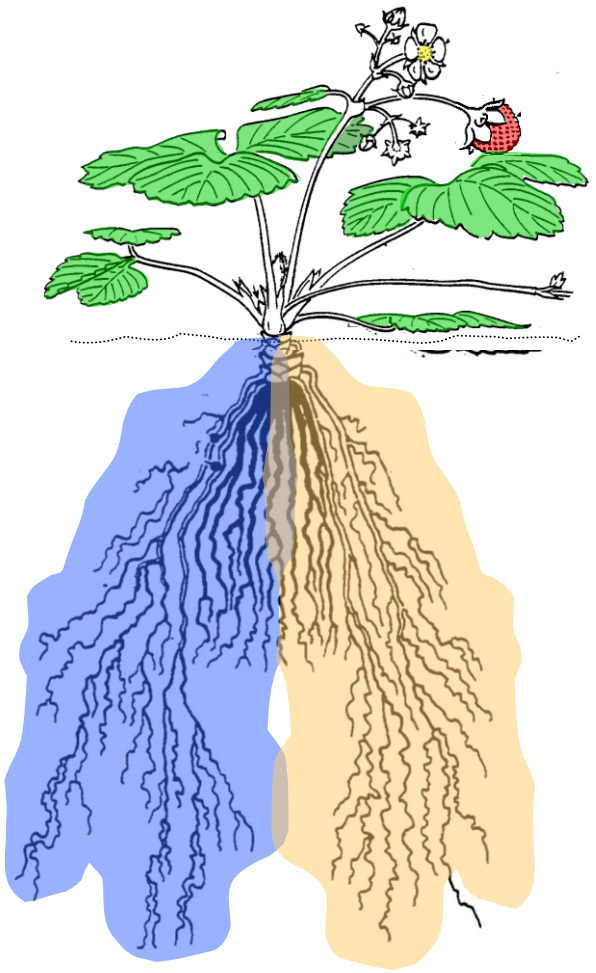


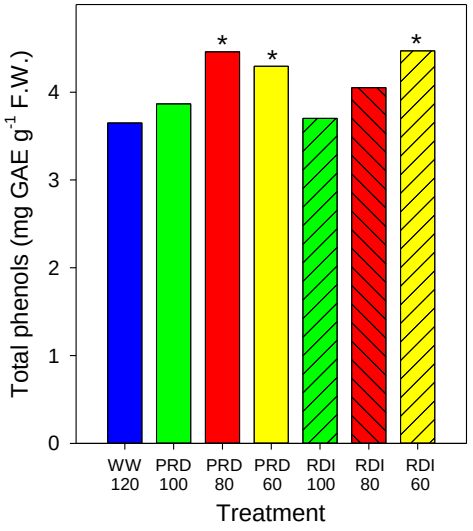


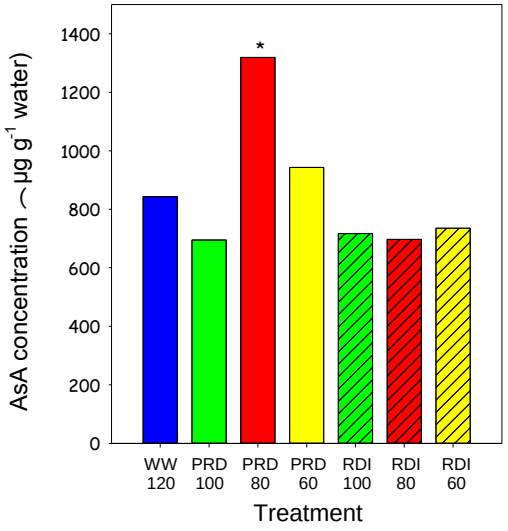
M432 - 51

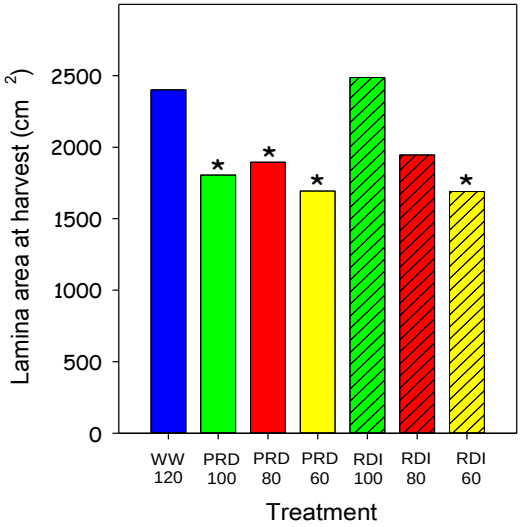


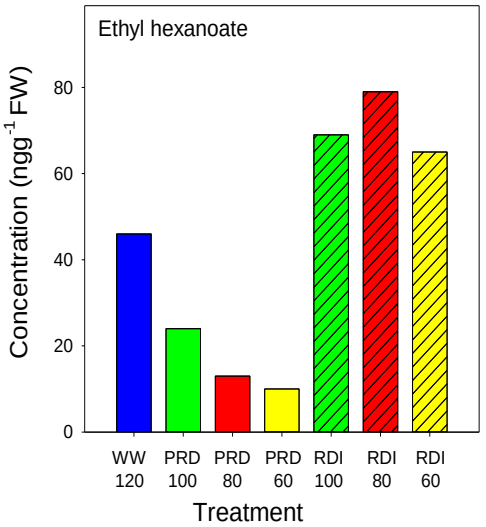
Developing deficit irrigation strategies to improve ‘quality’ and crop management





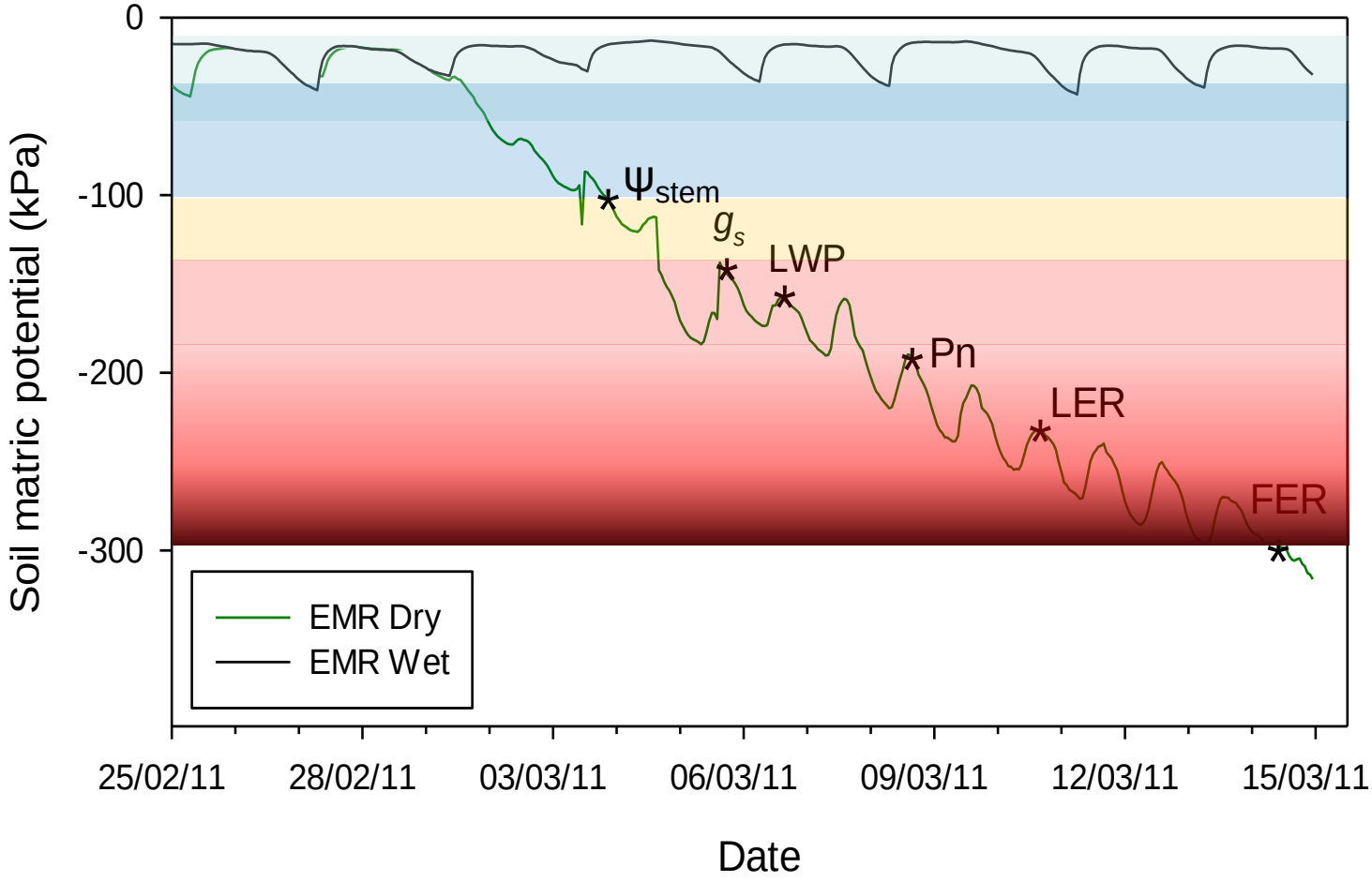






- Managing signal intensity

Physiological responses of ‘Elsanta’ to drying soil



Commercial Grower test regime

Buffer zone

Mild RDI

Quality & yields reduced…

- Irrigation set points will be similar in different soil types

Scientific field experiments at EMR





- Industry average WP in 2012 = 44 (m^3 per tonne Class 1)
- RDI delivered a WP of 9
- Good commercial yields, aspects of berry quality improved
- Demonstrate the potential for water savings…

Improving on-farm water productivity







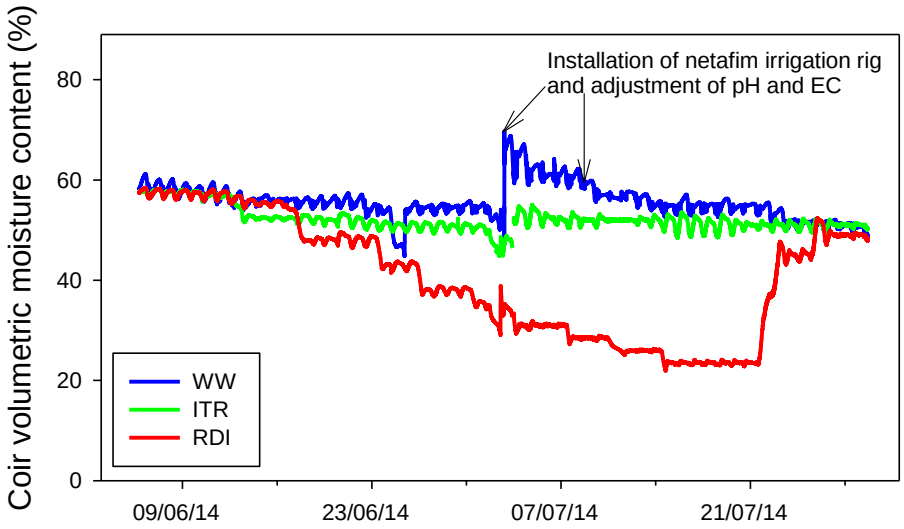






- Class 1 yields improved by 18% under Grower Test Regime
- BRIX similar, soluble sugars and berry firmness improved (berry size similar)
- Flavour and aroma improved (Marks and Spencer taste panel)
- Water (and fertiliser) savings of 5 to 36%

Deriving irrigation set points for substrate strawberry varieties



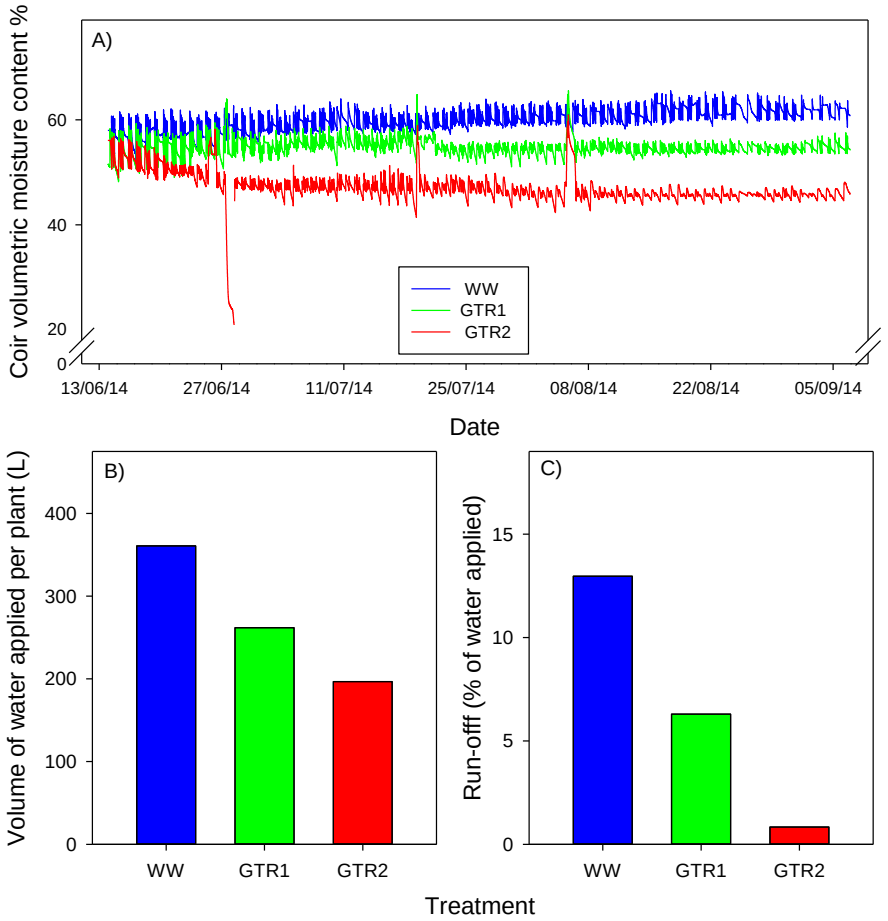


- Precision control of coir water content within 1% of set point
- Maintain, reduce or eliminate ‘run-off’
- Impose controlled drying down treatment
- Coir VMC which trigger plant physiological responses

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Optimising yield potential using precision automated fertigation control





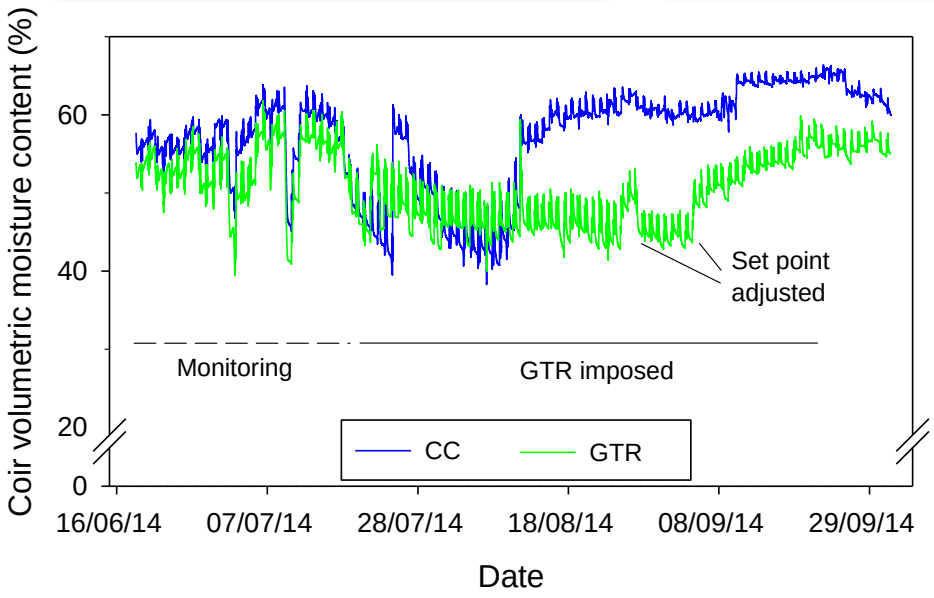
- Fertiliser and water savings of between 14 and 45%
- Floricane - marketable yields of 1.7 Kg per cane (5 Kg per plant)

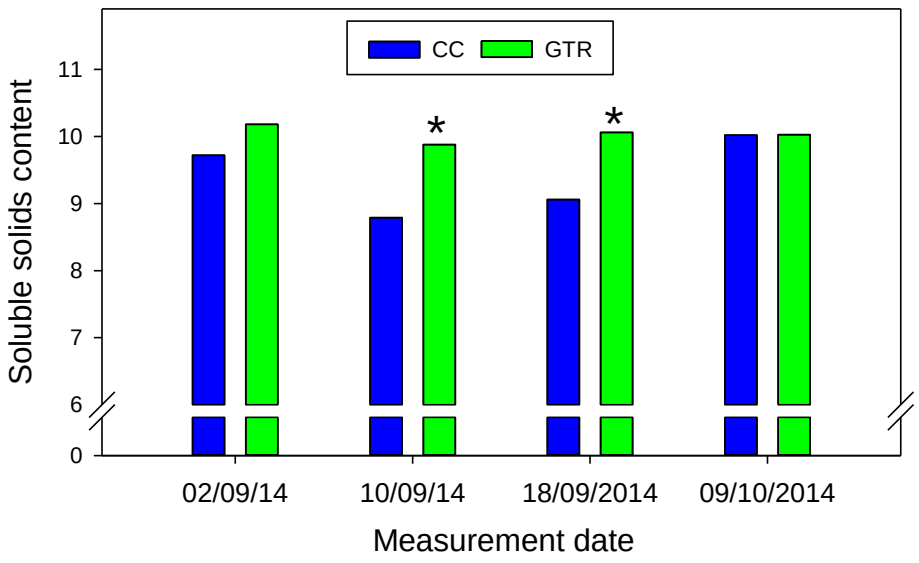
Improving on-farm resource use efficiency and fruit quality





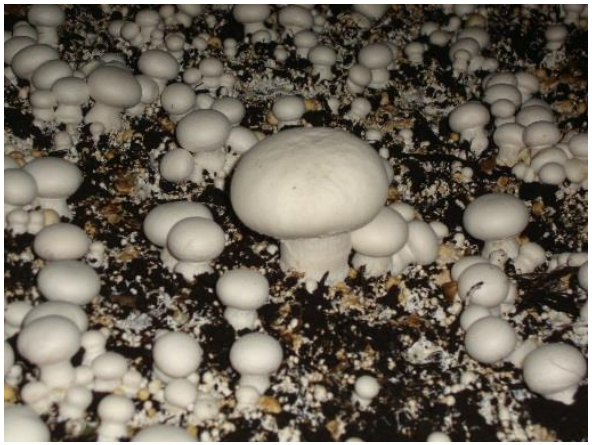




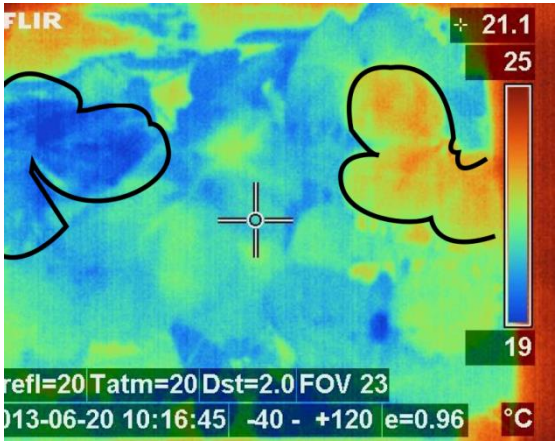


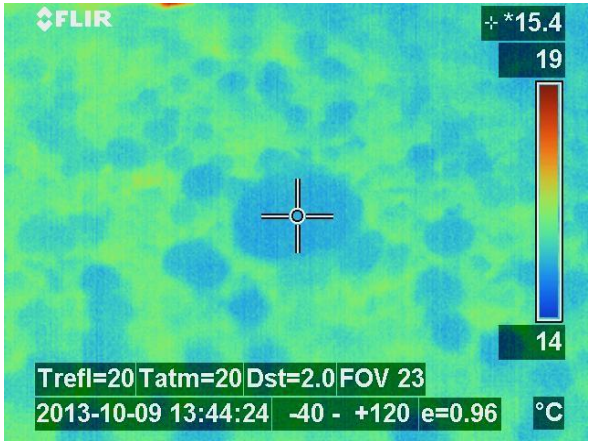
Thermal imaging to detect abiotic and biotic stresses









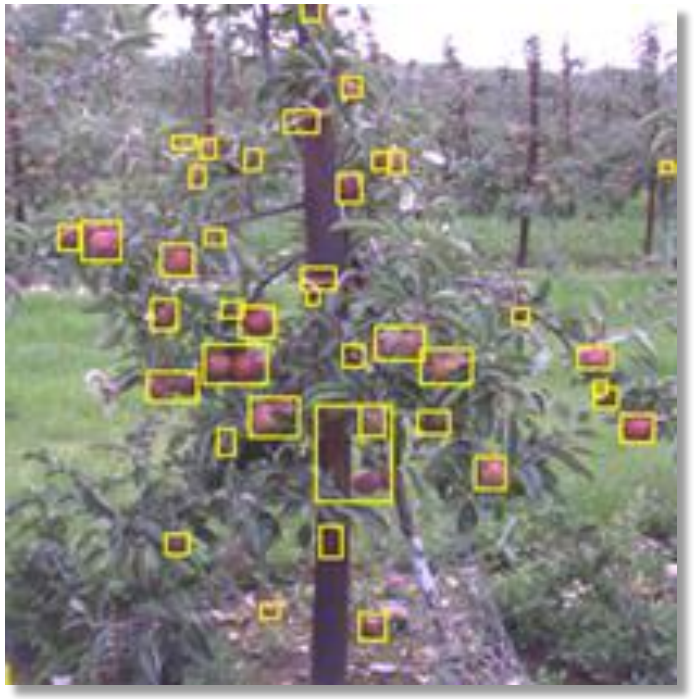


- Monitoring crops for symptoms of water stress
- Early detection of infection by powdery mildew

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Digital imaging to count fruit and improve accuracy of yield forecasts

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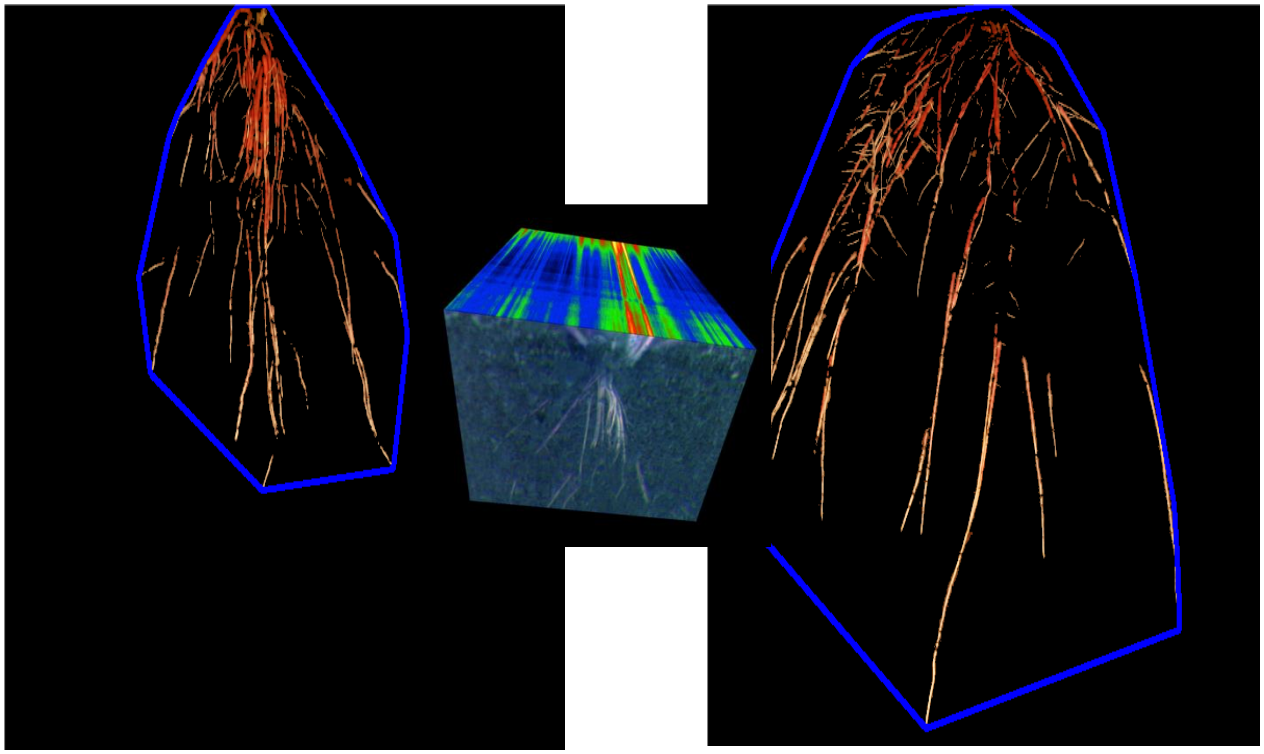


- Counting apples (and strawberries)
- Improved forecasts of marketable yields
- Predicting grade out (fruit size classes)
- The Technology Research Centre, Worldwide Fruit Ltd

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Hyperspectral imaging to quantify root traits, wilt disease and fruit quality

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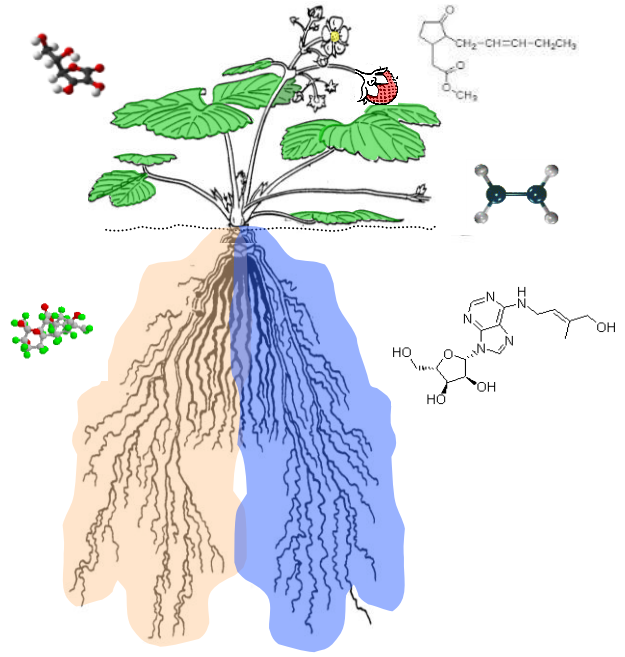


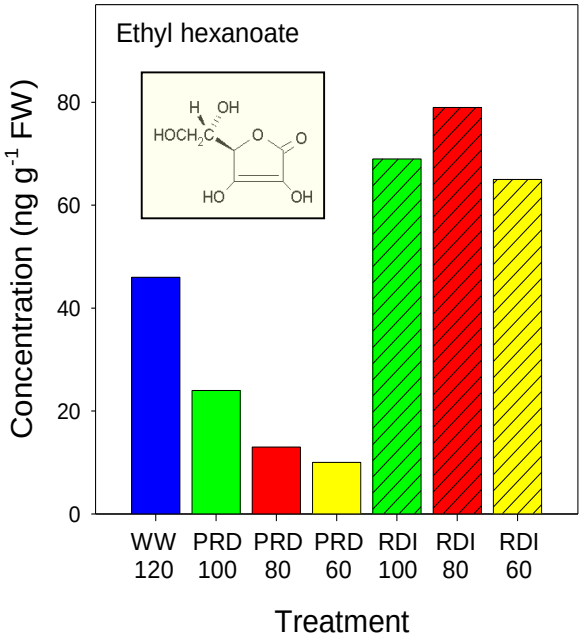


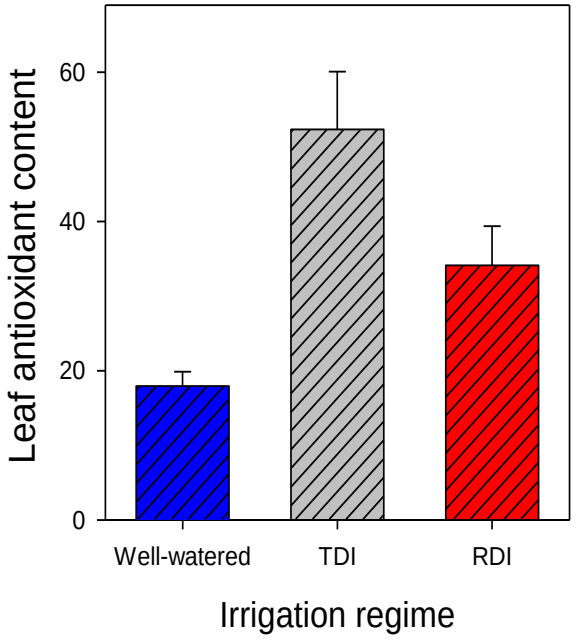
- *Verticillium dahliae* causes serious wilt-related problems in strawberry
- Non-destructive assessment of fruit quality attributes

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Exploiting stress signals to improve flavour, firmness and shelf-life







- 'Beneficial stresses'
- Improved flavour, firmness, antioxidant capacity, shelf-life
- Resource partitioning – higher dry matter content
- Stress pre-conditioning to improve crop resilience

Outputs from our research

- Increased resource use efficiency
- Higher yields
- Consistent quality
- Assured shelf life
- Reduced waste
- ‘Best practice’ guidelines
- Improved resilience
- Commercial roll-out
- Sustainable intensification



With thanks to…

- Mike Davies, June Taylor, Clare Hopson, Helen Longbottom, Roger Payne, Dr Eleftheria Stavridou, Graham Caspell, Antonio Llorente
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- Julian Gruzelier (NUK)
- Laurence Dingle, Trevor Bean et al. (TRC)
- Richard Harnden, Orlin Atanasov (BGG)
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- IUK, HDC, EMT, BBSRC, Defra, EA