Delta-T Devices

Precision Sensing and Control for Improved Water Use Efficiency

Dr John Newstead, Dr Martin Goodchild,
Dick Jenkins and Tony Peloe



2015 International Year of Soils

IAgrE Annual Conference 2015

Delta-T Devices Ltd

Delta-T Devices

Founded in 1971

Approximately 20km from **Cambridge, UK**

Currently 36 employees

100% employee owned and co-operatively managed



Providers of soil, plant and meteorological sensors for over 40 years

BSI

ISO 9001
FS 565621



Commercial/Academia Collaborative Products

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In the beginning….

1974 John Monteith – Tube Solarimeter

1976 John Monteith – Porometer (now AP4)

1990 Cranfield Uni. – Evapotranspiration software

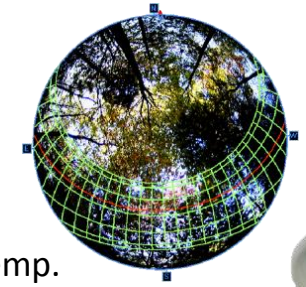
1995 Macauli Land Use Inst. (MLURI) – ThetaProbe (now ML3)

1997 Peak Design – SunScan Crop Canopy Analysis

1998 Kansas Uni. – HemiView Tree Canopy analysis











More recently….

2000 Wageningen Uni. – WET Sensor, water content, EC & soil temp.

2003 CSIRO (Australia) – Root length analysis

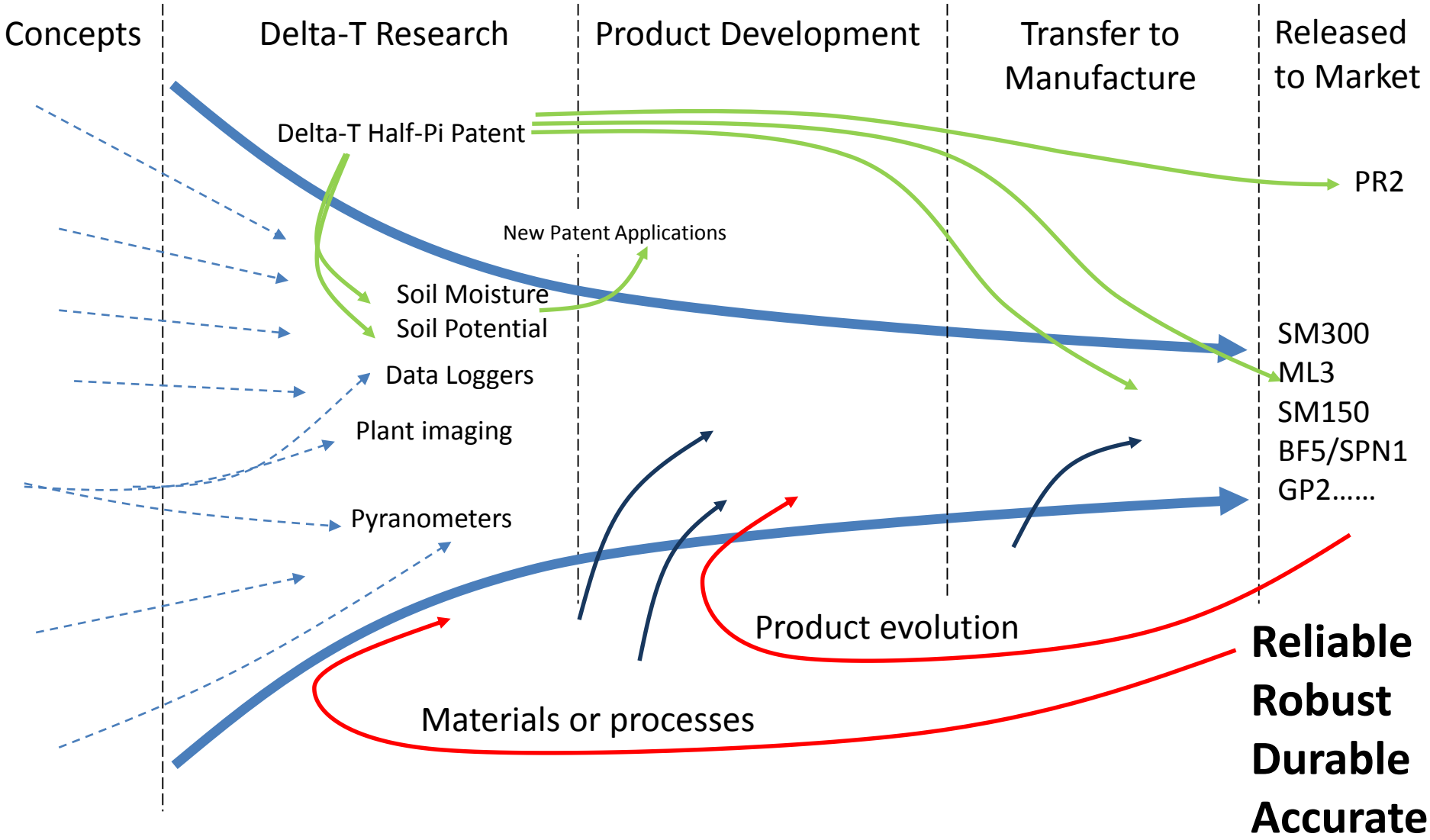
2005 Peak Design – Solar Rad. Beam Fraction Sensor (now BF5)

2008 Peak Design – Sunshine Pyranometer (now SPN1)

2009 – Rothamsted Research – Prototype Soil Matric Potential DT160

2013 – 15 UK Innovation (Formerly the Technology Strategy Board) commercial partnership research grants (currently 7 in progress) in sensor development and commercial application with Sheffield University, East Malling Research, G's Fresh, Rothamsted Research, Berry Garden, James Hutton Institute.....

Delta-T's Development Funnel



What do we do?

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Soil Moisture temperature, EC



Solar radiation sensors



Porometer for Water stress studies



Plant Canopy Studies

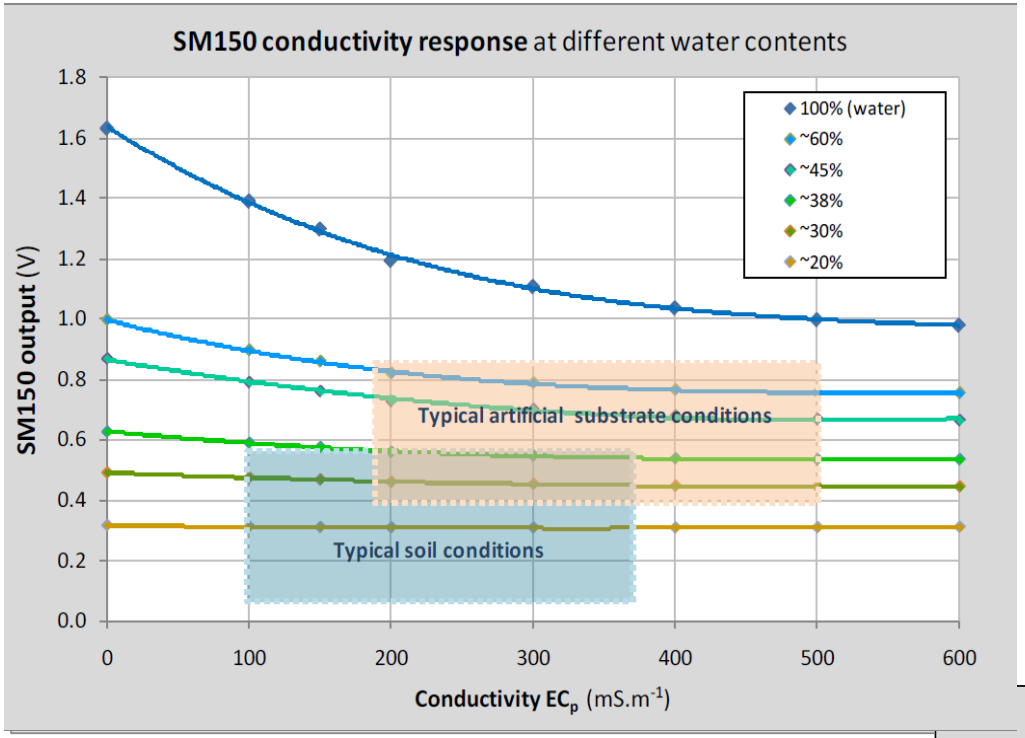


Data Loggers / Controllers





Weather stations



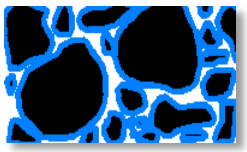
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Sensor Response to environmental conditions

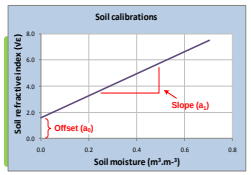
100 MHz wave form applied to soil via pins.



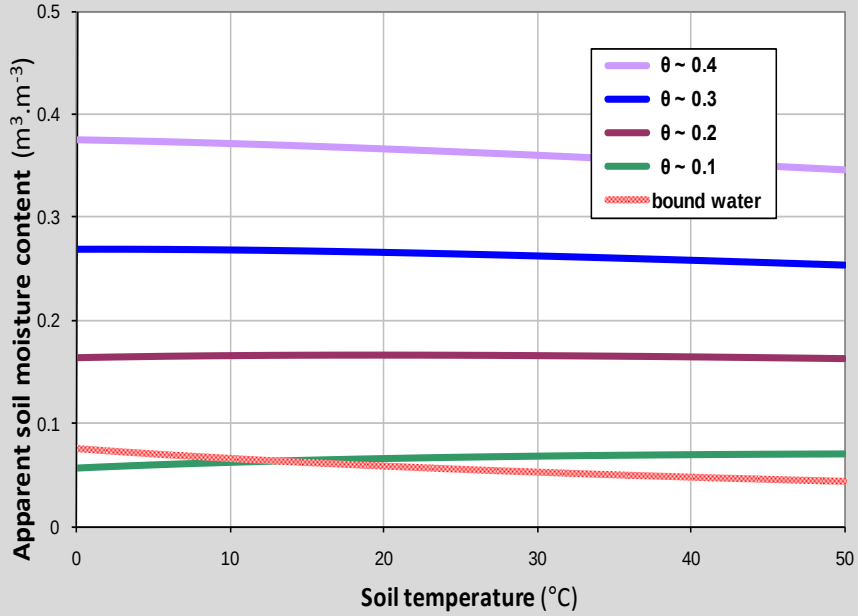
Soil Permittivity dominated by soil water (A measure of a material's response to polarisation in an electromagnetic field. Water has a permittivity ≈ 81, compared to soil ≈ 4 and air ≈ 1)



Output voltage related to permittivity which is converted to water content



Illustrating **temperature dependence** of SM300 readings in a clay soil



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What is ‘Precision Irrigation?’

The application of water and fertiliser to a growing crop, *when its needed*, *where it is needed* and *in the quantities required* by the plants.






Precision Irrigation = improved water use efficiency (dry matter production per unit of water) or ‘more crop per drop’.

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- Helps maximise yield and financial return
- Can help improve product quality and appearance
- Saves water usage – saves money
- Applies what the plant needs
- Reduces water and fertiliser losses
- Saves pumping costs
- Reduces labour costs
- Saves time
- Can reduce weed and pest problems
- Helps control salinisation
- Less reliance on a few individuals with years of experience
- Future legislative requirements may require this knowledge and its implementation – Water Framework Directive






Portable Spot Measurement

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- Easy to use
- High quality sensor
- Substrate calibrations

Portable Spot Measurement

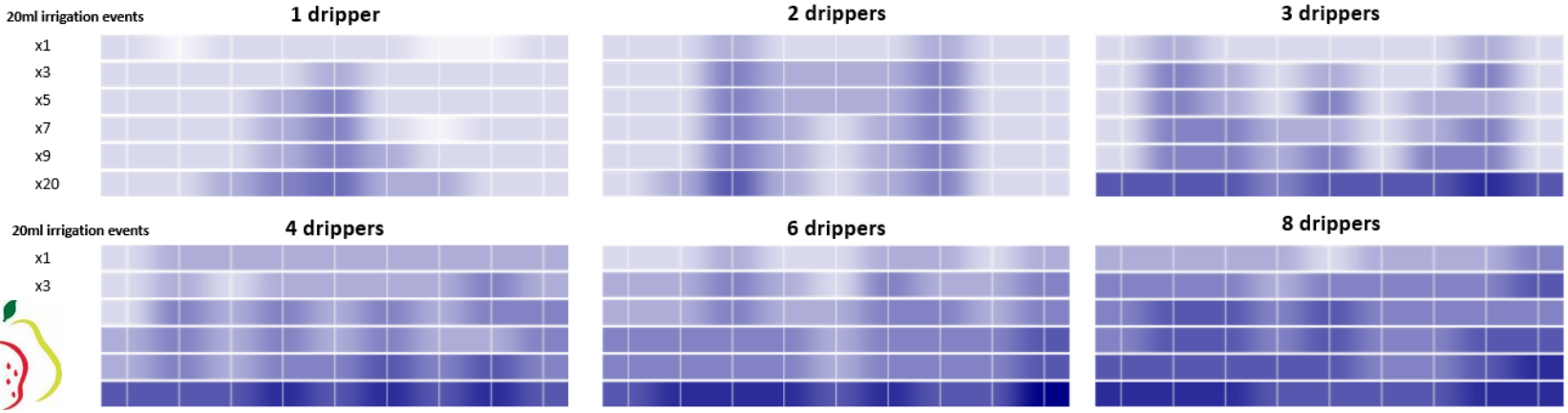
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Experiment : The effect of dripper number on %VWC of coir strawberry grow bags following 20-400ml applied irrigation.

% VWC Key	
	>68
	60 to 68
	52 to 60
	44 to 52
	36 to 44
	28 to 36
	<28



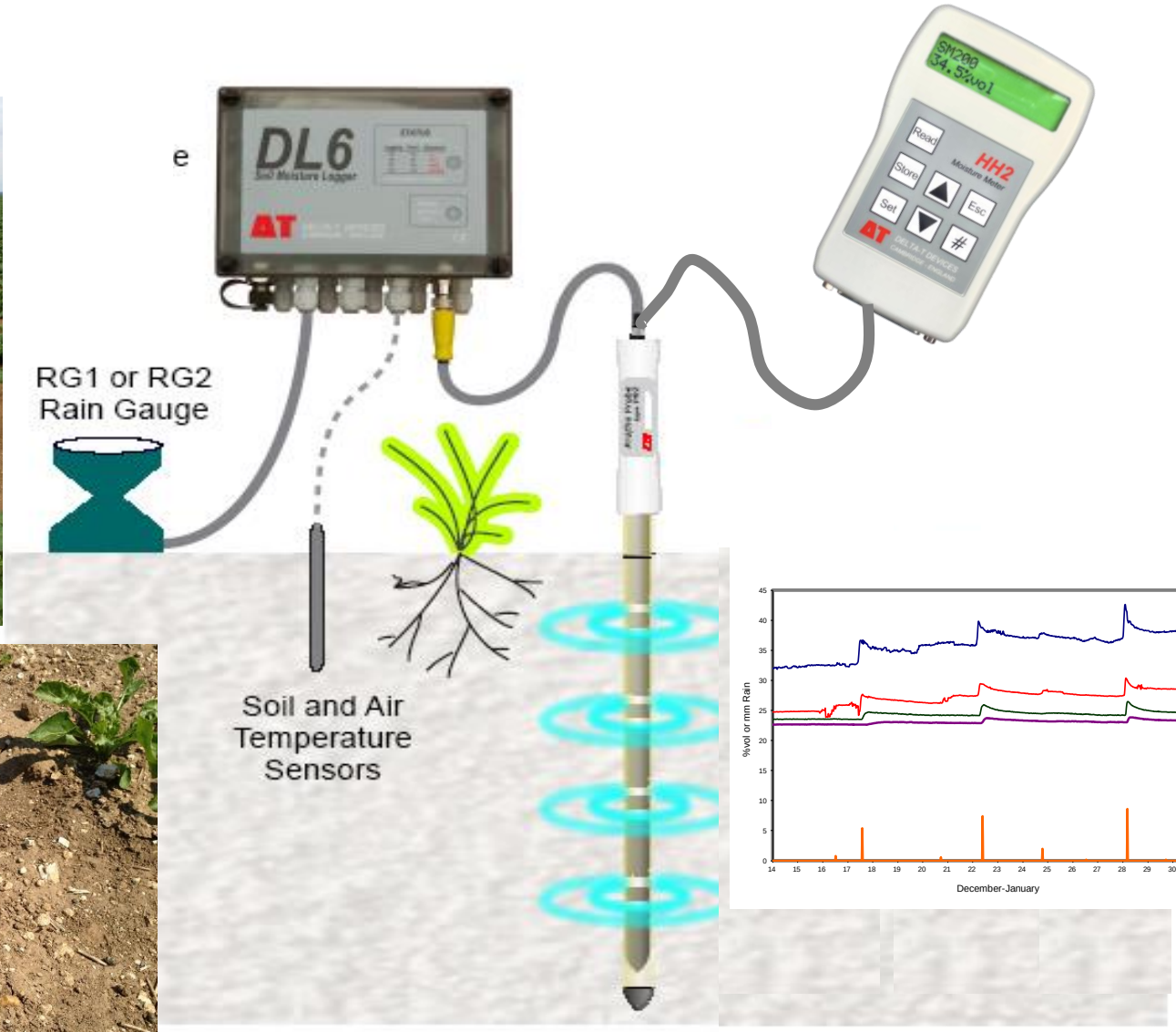
Fast

A Profile Probe System from Delta-T Devices

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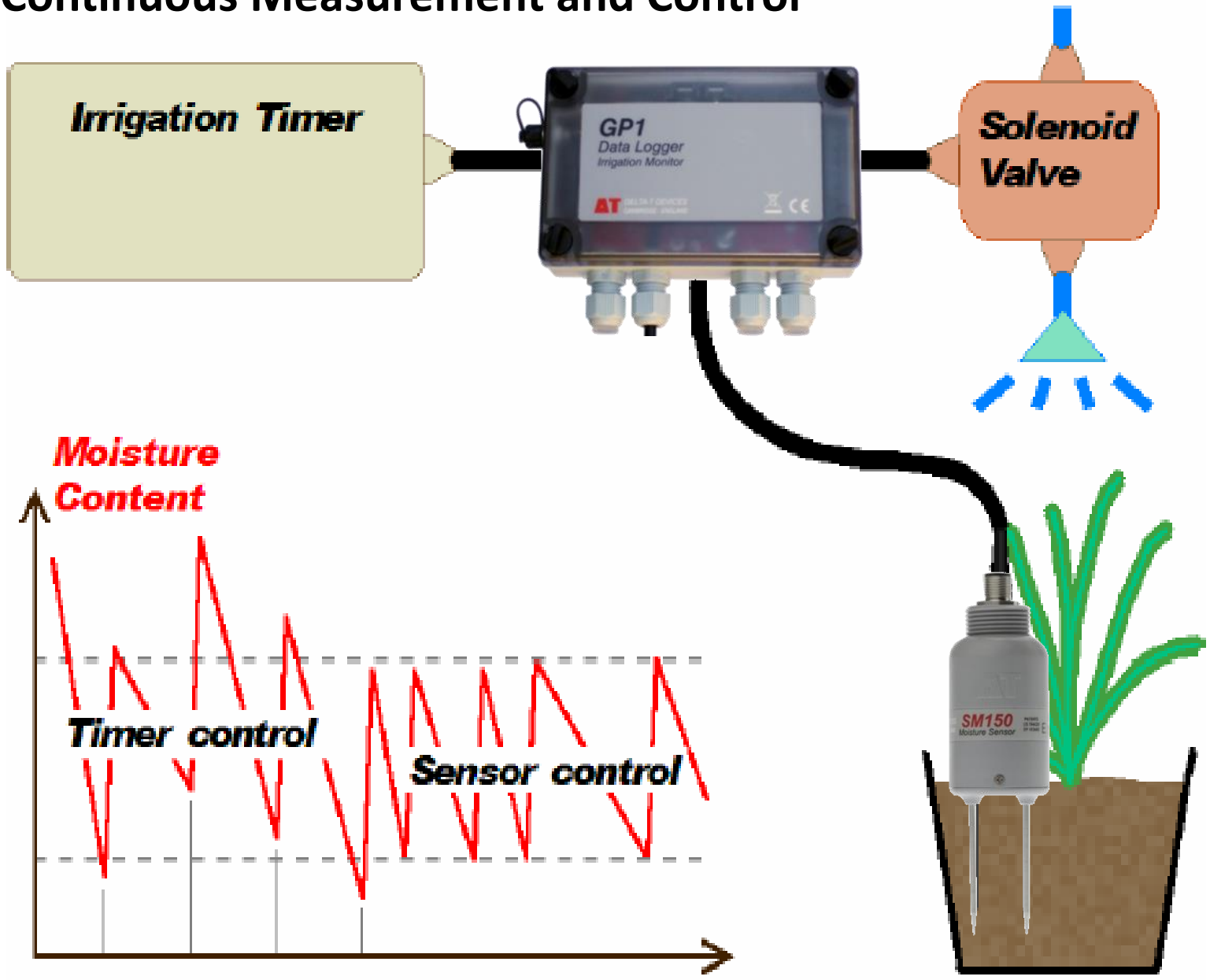






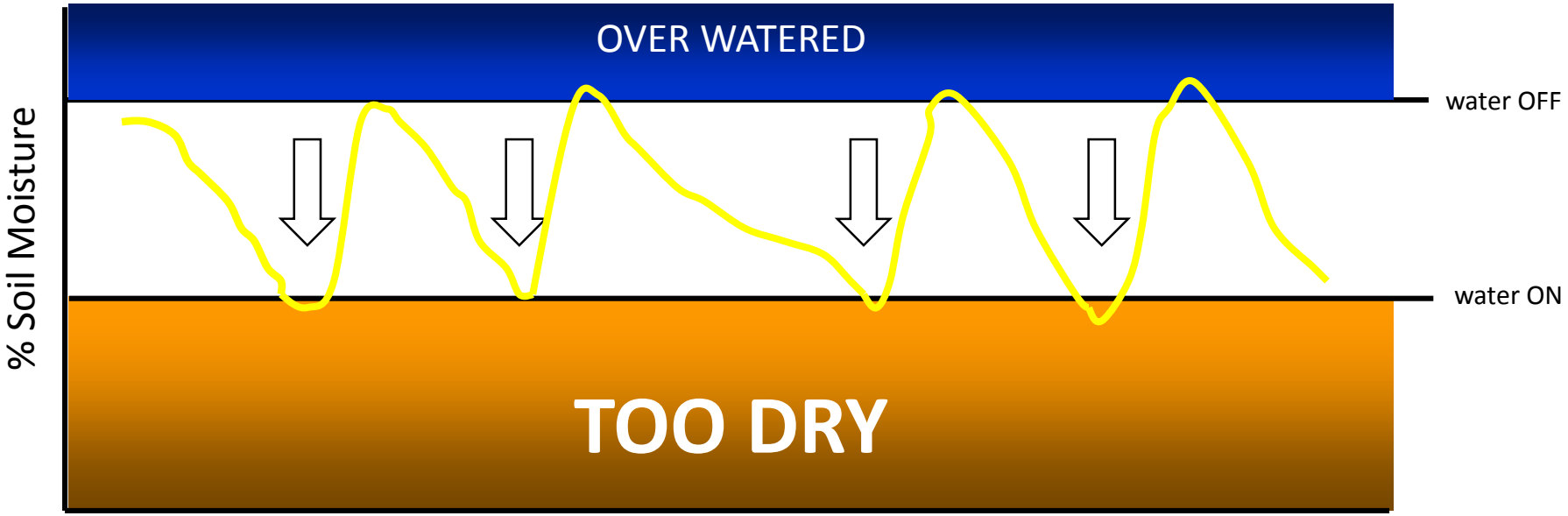
Continuous Measurement and Control

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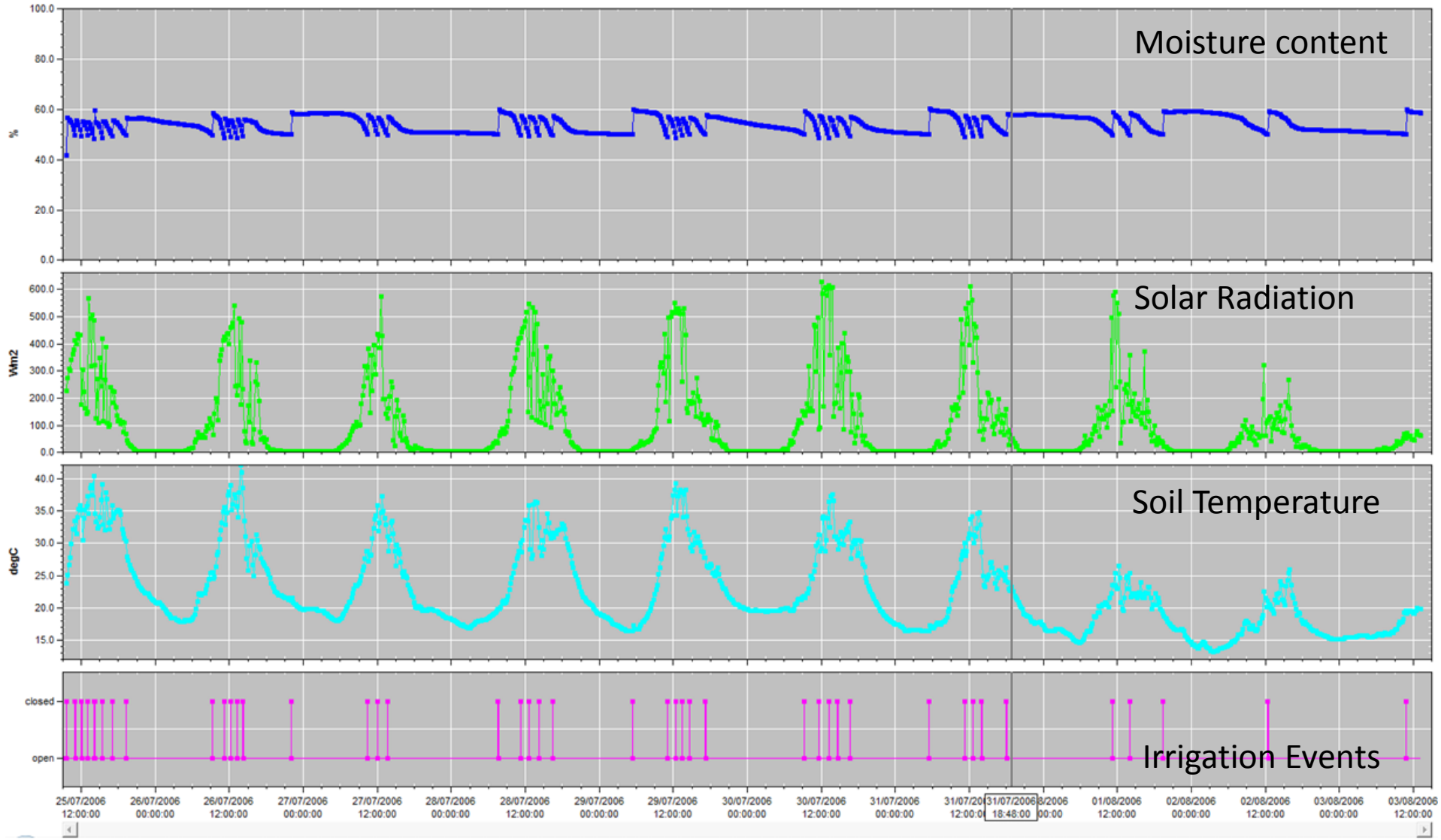
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The Saw Tooth Pattern of Precision Irrigation Control Using a Controller and Continuous Monitoring



Soil moisture maintained where it is needed (ie the root zone) at optimum levels

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Source: Delta-T Devices Ltd 2014

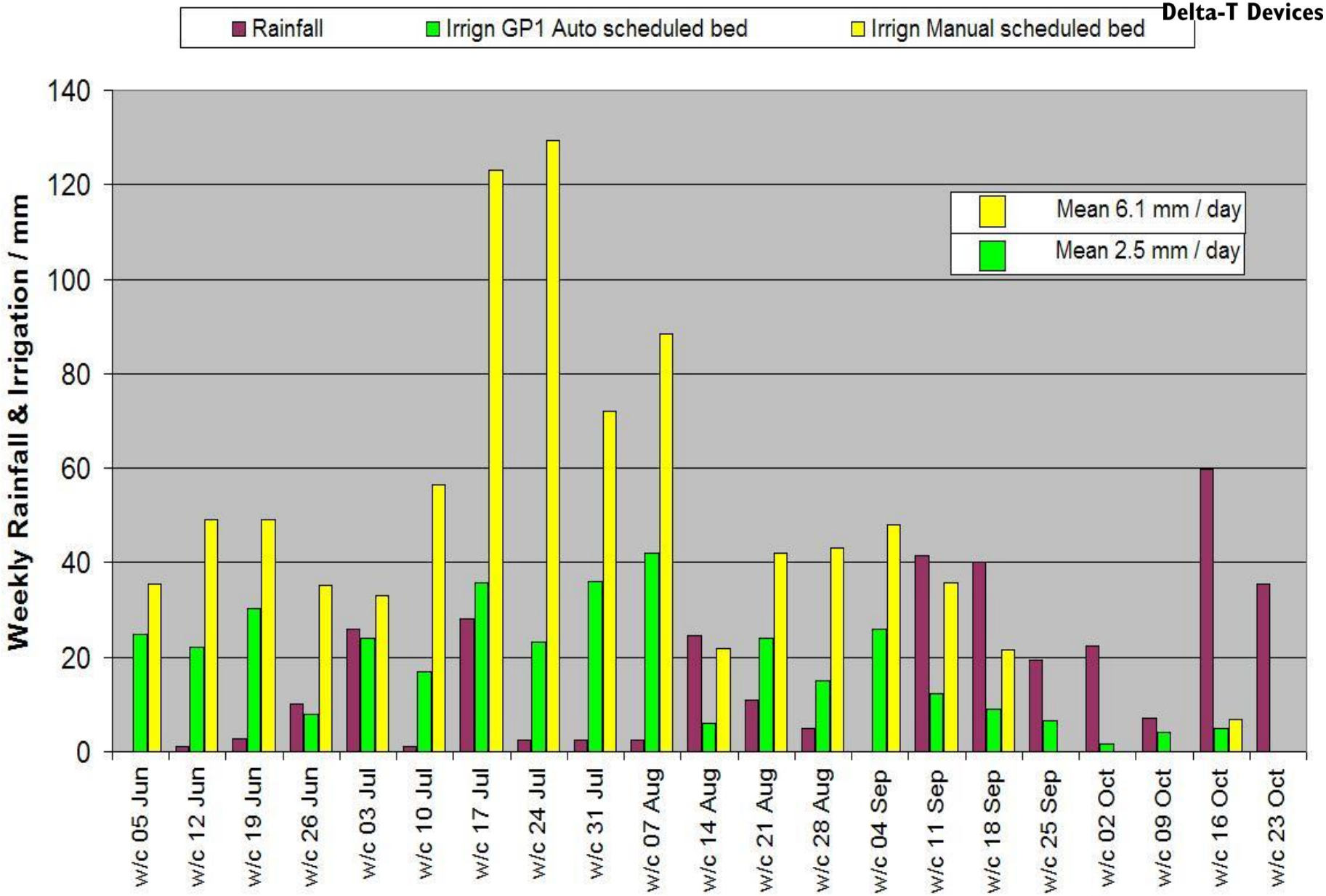
Hillier Nursery Study 2006: A water use efficiency study by Delta-T Devices Ltd and Hillier Nurseries.

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Hillier Nursery Study: A water use efficiency study

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Hillier Nursery Study: A water use efficiency study

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Improving water use in container grown hardy ornamental nursing stock

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Using a ThetaProbe (ML2x) and GP1 data Logger to schedule irrigation.





Precise scheduling of irrigation maximised and modified plant growth and development



WaterLINK 1 ***(Dept Trade & Industry Funded)***

Plants grown under three watering regimes

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Choisya



(a) (b) (c)

Cotinus



(a) (b) (c)

Cornus



(a) (b) (c)

(a) Well Watered **(b)** RDI -50% **(c)** RDI -25%

Benefits :

Less water = less pumping = lower fuel costs

Better shape = more attractive product

Less pruning = reduced labour costs

FLOW AID

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FlowAID EU Funded farm scale project-

"To contribute to sustainability of irrigated agriculture where water supply is limited or water quality variable."

Test sites in: Jordan, Turkey, Italy, Lebanon and the Netherlands

Save Water ♦ Save Money

Flow-Aid EC Project

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+ the Netherlands and Lebannon



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A *farm Scale* Deficit Irrigation Management System using Soil Sensor Activated Control

Deficit Irrigation strategies were compared with current farming practice

(Abridged Project Summary from Balendonck et al. (2010) 3rd International Symposium on Soil Water Measurement using Capacitance, Impedance and TDT. Paper 1.8 – Obtainable from the Delta-T website, Horticulture and irrigation page)

Italy – *Drip/sprinkler irrigation of ornamentals* – Water savings increased by 17 – 19%

Turkey – Drip irrigation of Cucumbers – Yield increase of up to 14% achieved over farmer. Up to 89% reduction in leaching achieved compared to farmer. 19% water savings achieved.

Labanon – Drip/Sprinkler irrigation – Eggplants. 70% increase in yield over farmers conventional furrow irrigation system. 35% water saving and deficit irrigation (75%) had greatest yield

Jordan – Drip irrigated Tomato. Water saving of 13%. Reclaimed rainwater resulted in build up of salts

Netherlands – Drip irrigation of Iceburg Lettuce in high leaching soil. 98.8% of produce was graded high quality. Up to 68% water saving compared to farmer.

Frequent small irrigations worked best, being better able to match the crop demand over time.
Such systems are highly adaptable.
Dual irrigation water sources and the ability to initiate an irrigation event useful



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Italy – *Drip/sp*

Turkey – Drip 9%
reduction in l

Labanon – Dr furrow
irrigation syst

Jordan – Drip salts

Netherlands - d high
quality. Up to

Frequent sma
Such systems are highly adaptable.
Dual irrigation water sources and the ability to initiate an irrigation event useful

Water savings across all farms and scales (17 to 68%)

Often increased yields

Reduced leaching

Often the crops were judged to be of better quality than before.

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Precision Irrigation using Industrial PID Control and the GP2 Data Logger

PID – Proportional, Integral, Derivative = increased control



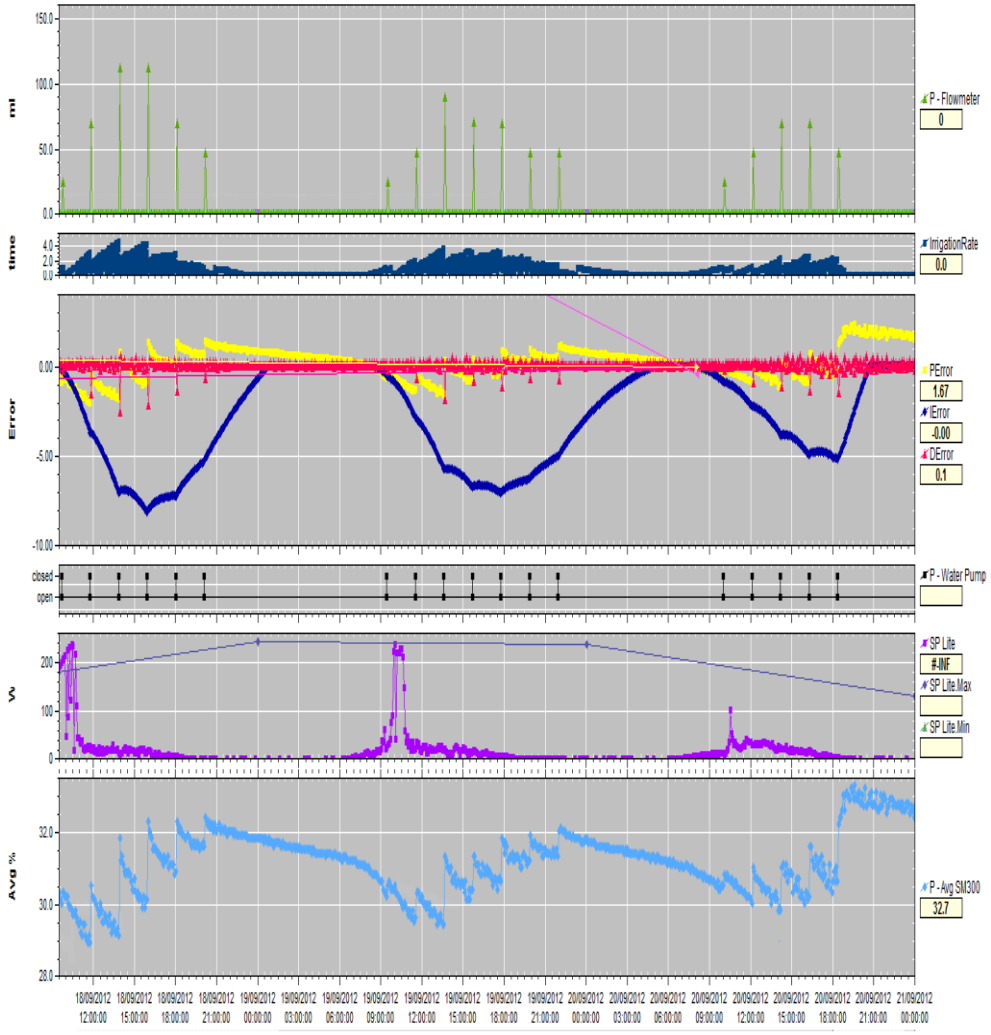


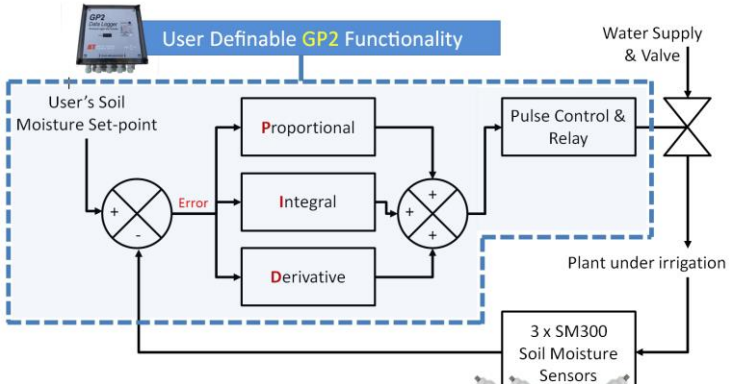


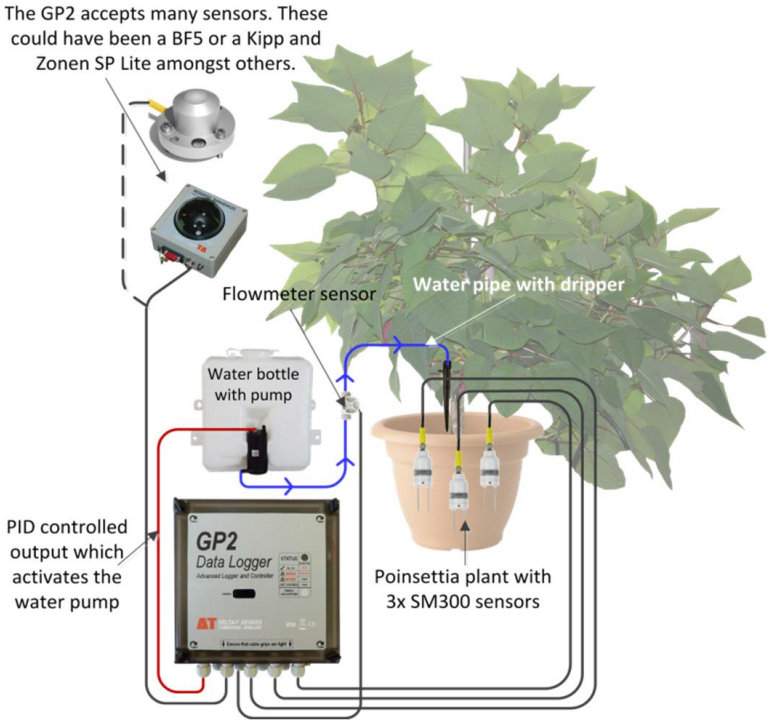


Proportional Integral Derivative (PID) controller with control out relays

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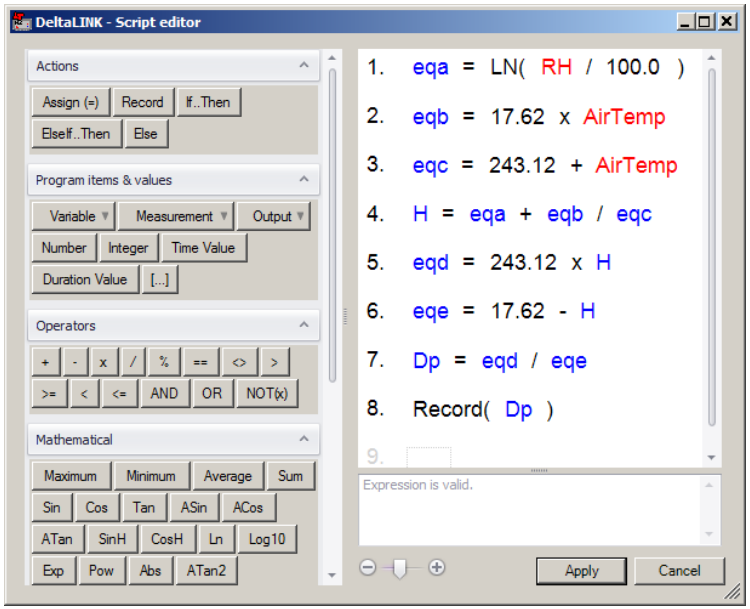




Kuhn K. D. et al (2013) A method for precision closed loop irrigation using a modified PID control algorithm. GP2 Resource Page www.delta-t.co.uk

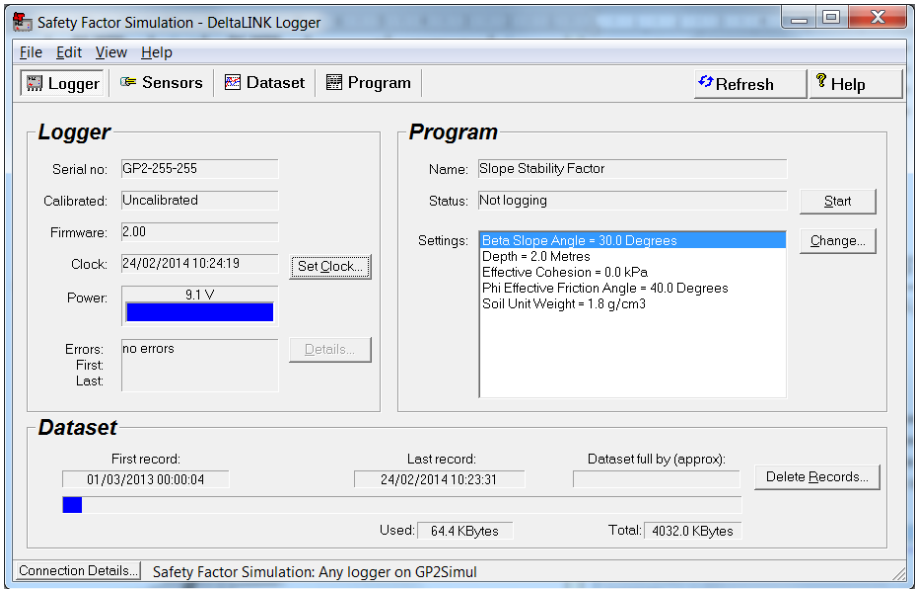
Application Possibilities:

- Irrigation control
- Blight predictions
- Degree days
- ET Calculations
- Wind Chill
- Slope stability
- Full suite of Statistical functions

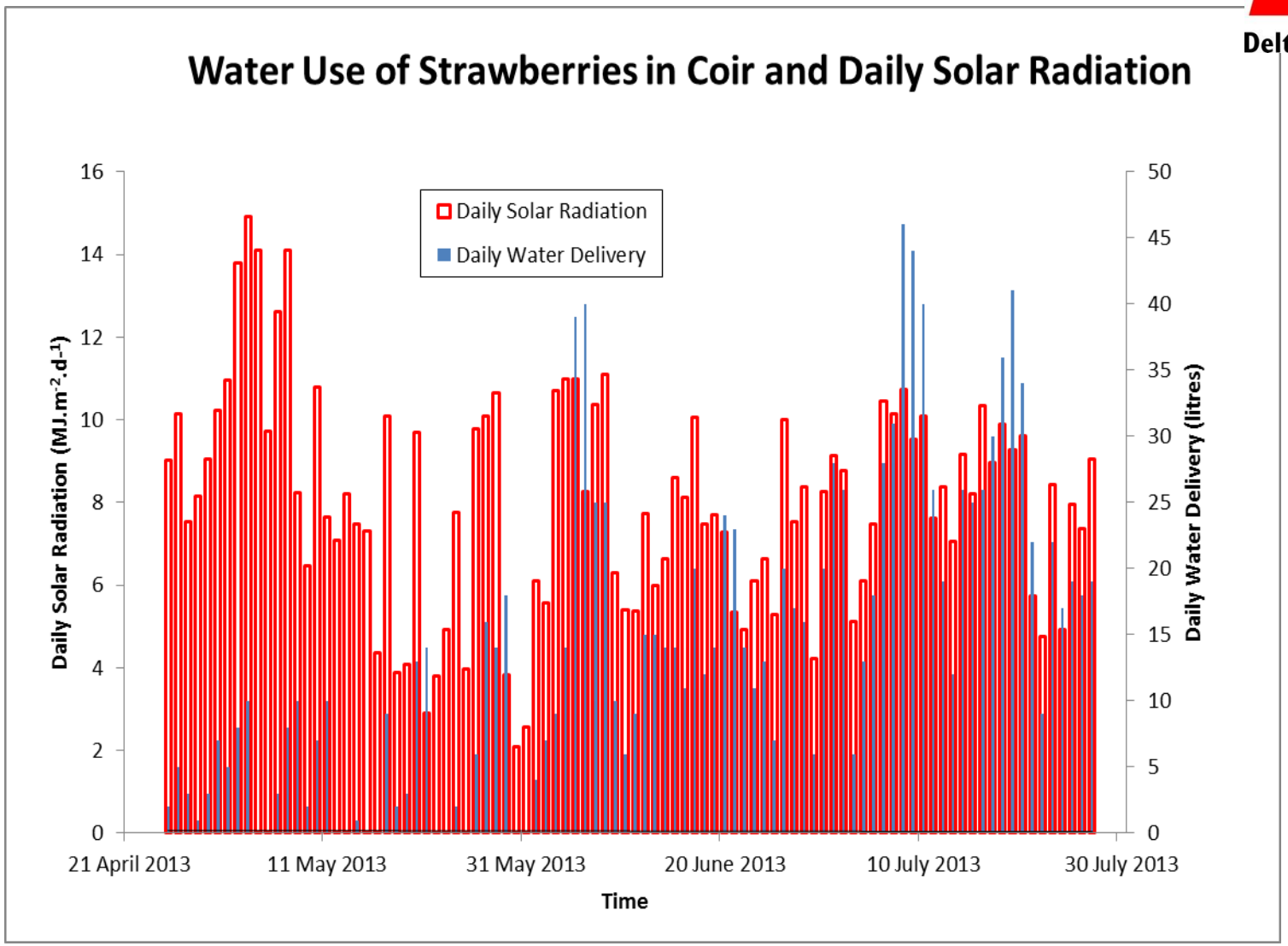


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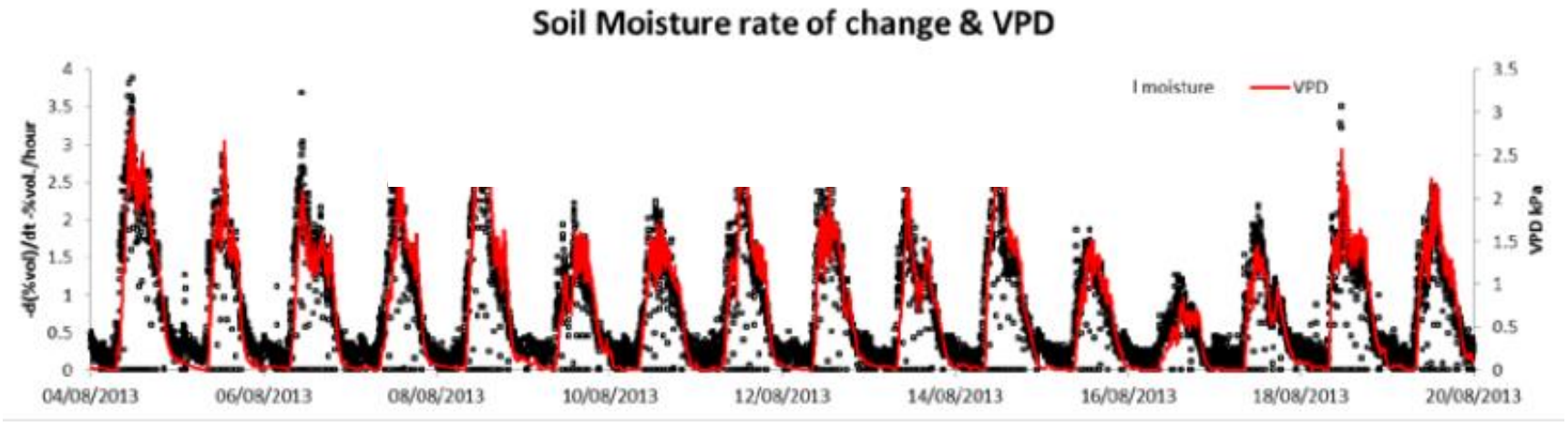


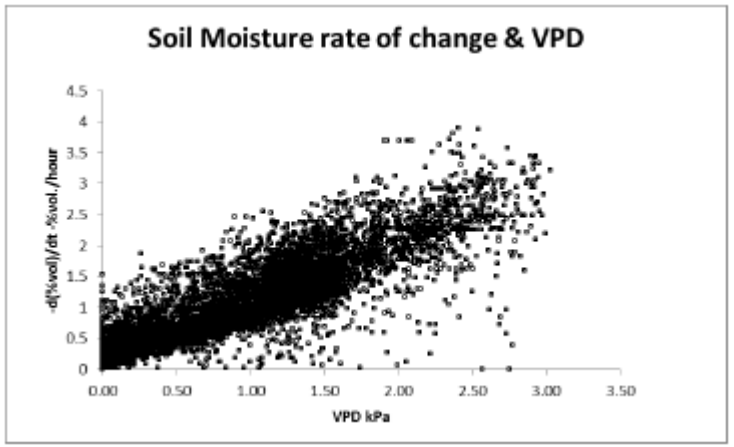
Goodchild M.S. et al (2013) A method for precision closed loop irrigation using a modified PID control algorithm. GP2 Resource page. www.delta-t.co.uk

Soil Moisture rate of change and VPD

Where VPD = Vapour Pressure Deficit

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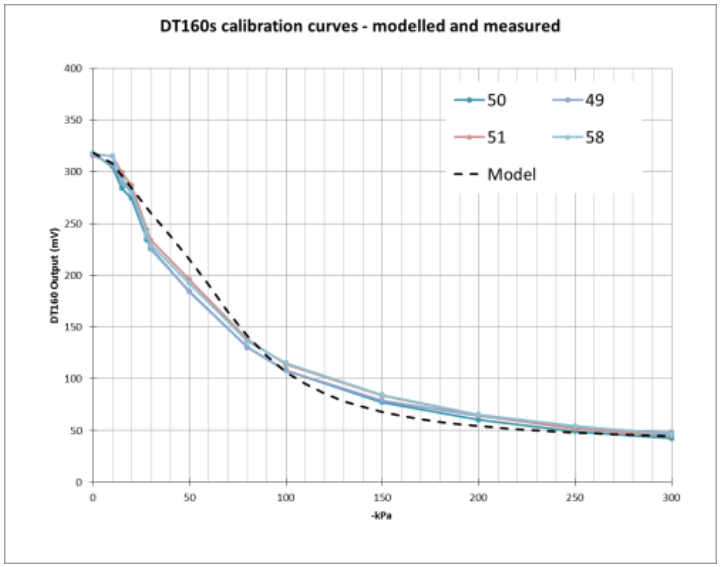






Goodchild M.S. et al. (2014) Soil Moisture responses to vapour pressure deficit in polytunnel-grown tomato under soil moisture triggered irrigation control. A White Paper.
www.delta-t.co.uk.

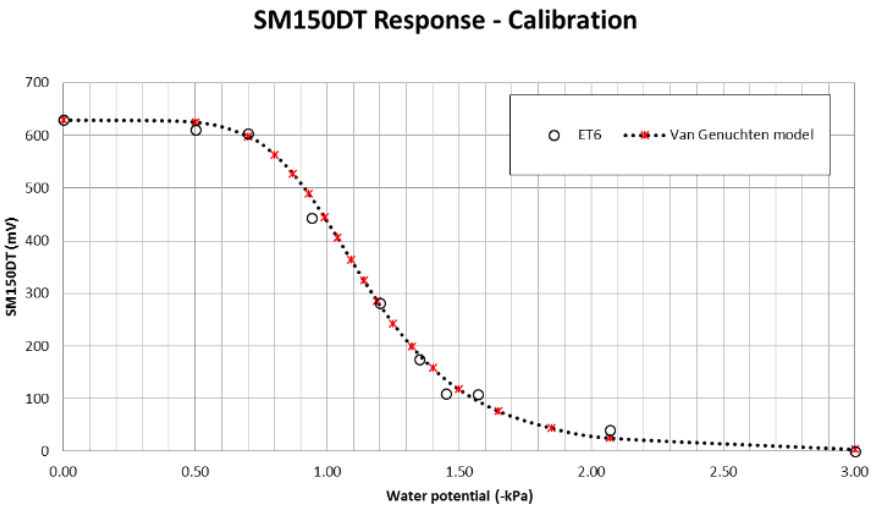




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Pat. App. No. WO2012/175976 A1 & US2014125360



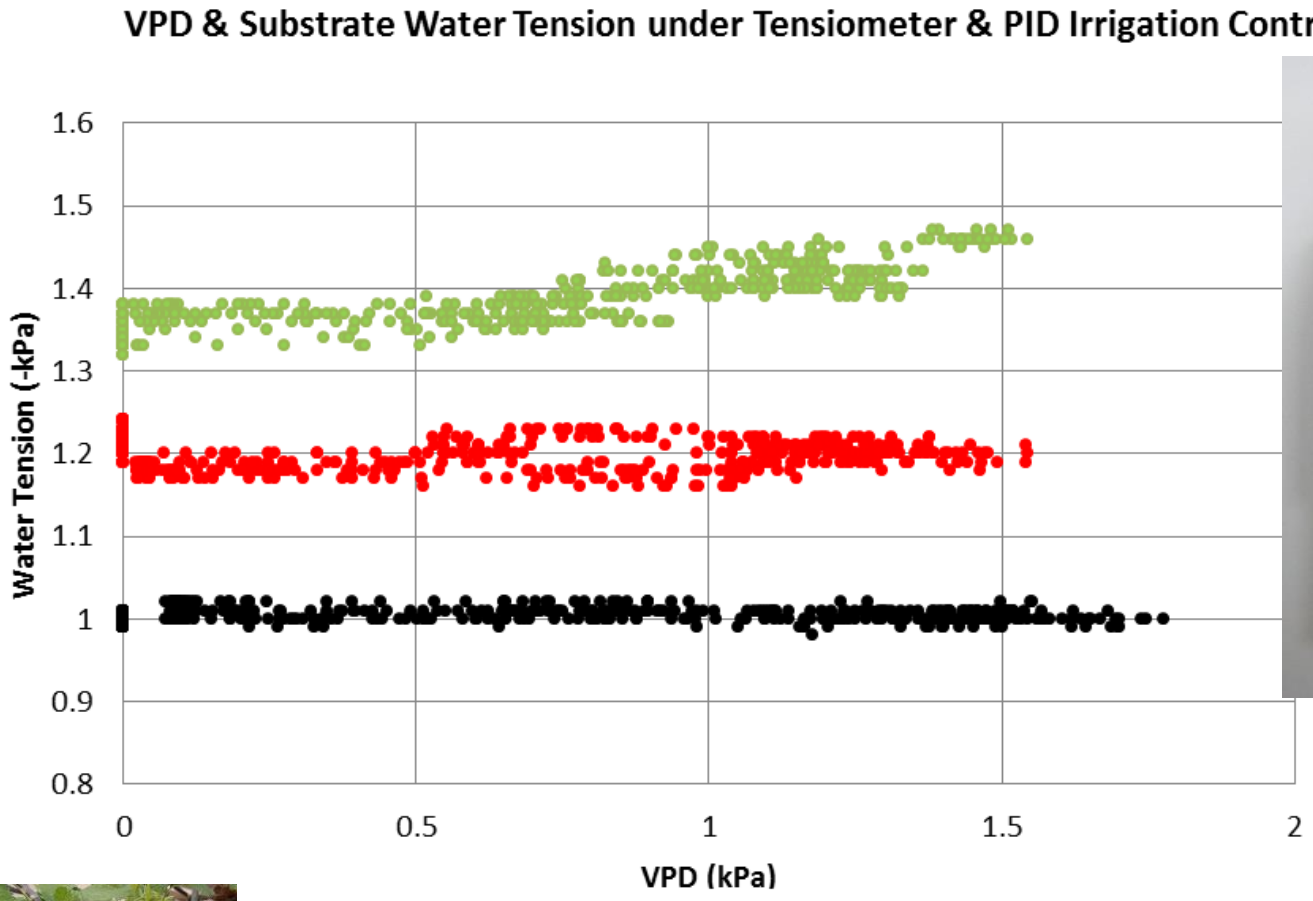


Pat. App. No. GB1414492.7

Dielectric Tensiometers

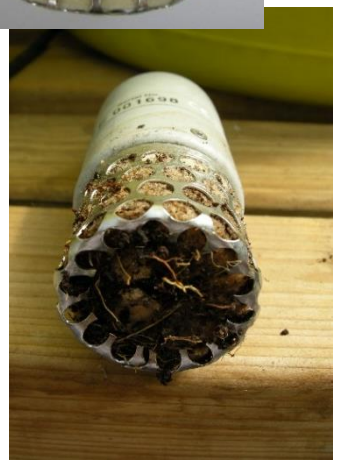
Maintaining water tension against VPD

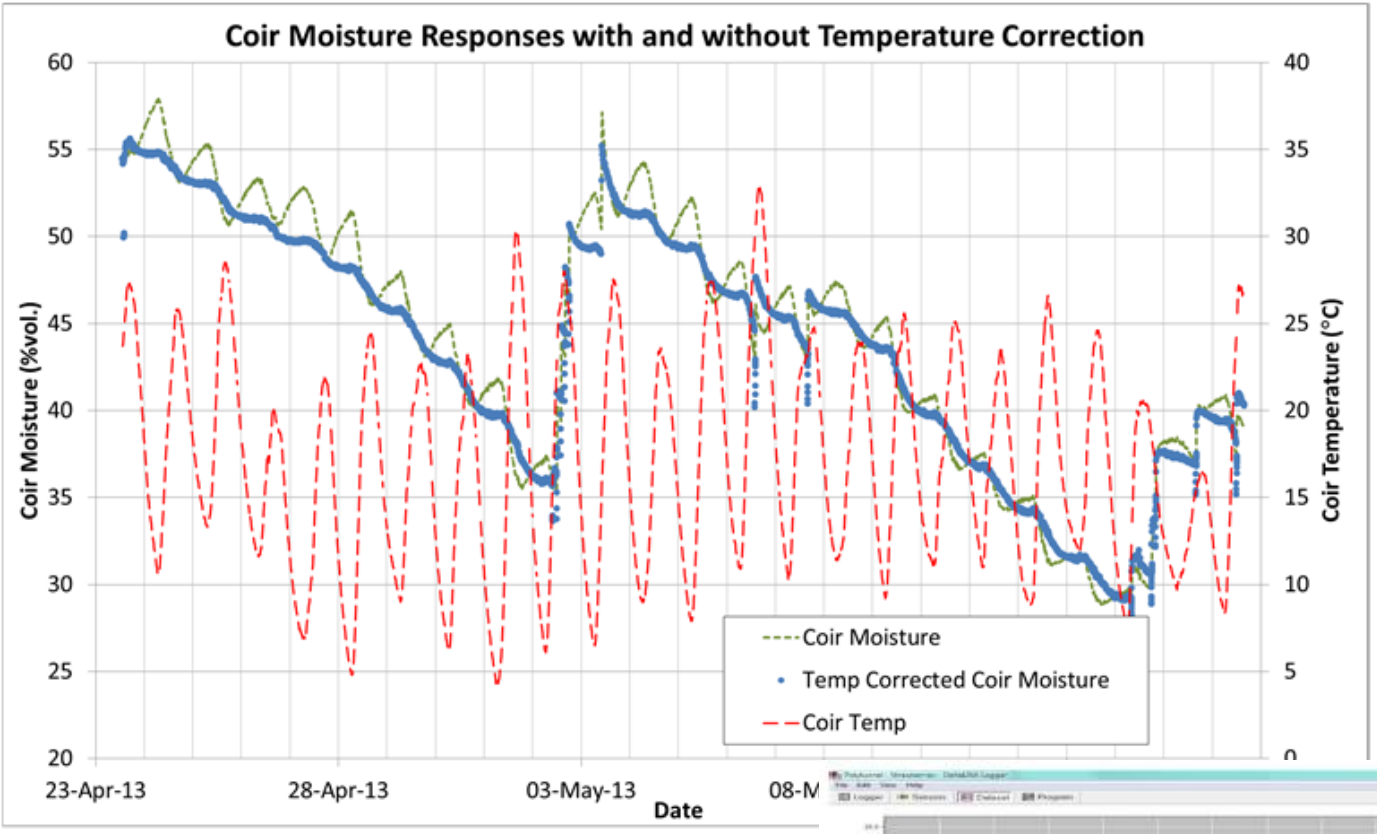
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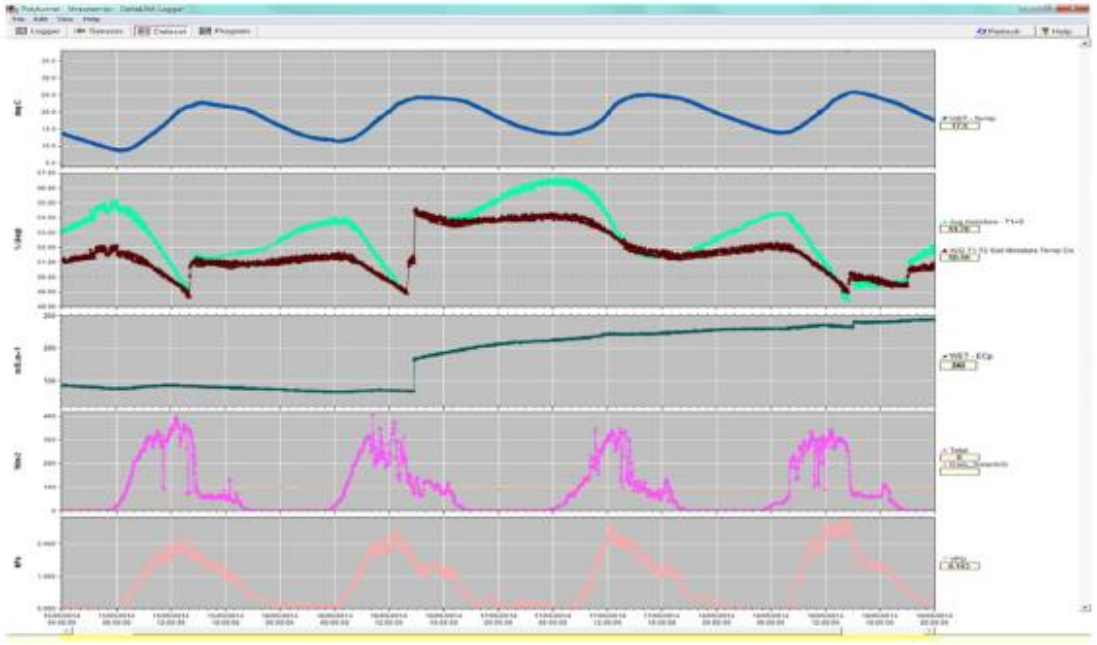




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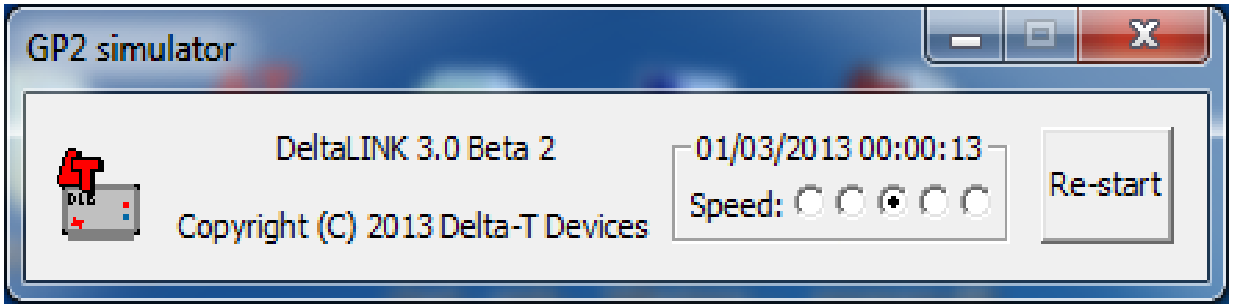




Goodchild M.S, Kuhn K.D, Nicholl C and Jenkins M.D (2014)
Temperature correction of substrate moisture measurements made in coir in polytunnel grown strawberries.
A white paper available from www.delta-t.co.uk.

DeltaLINK Data Simulator Tool

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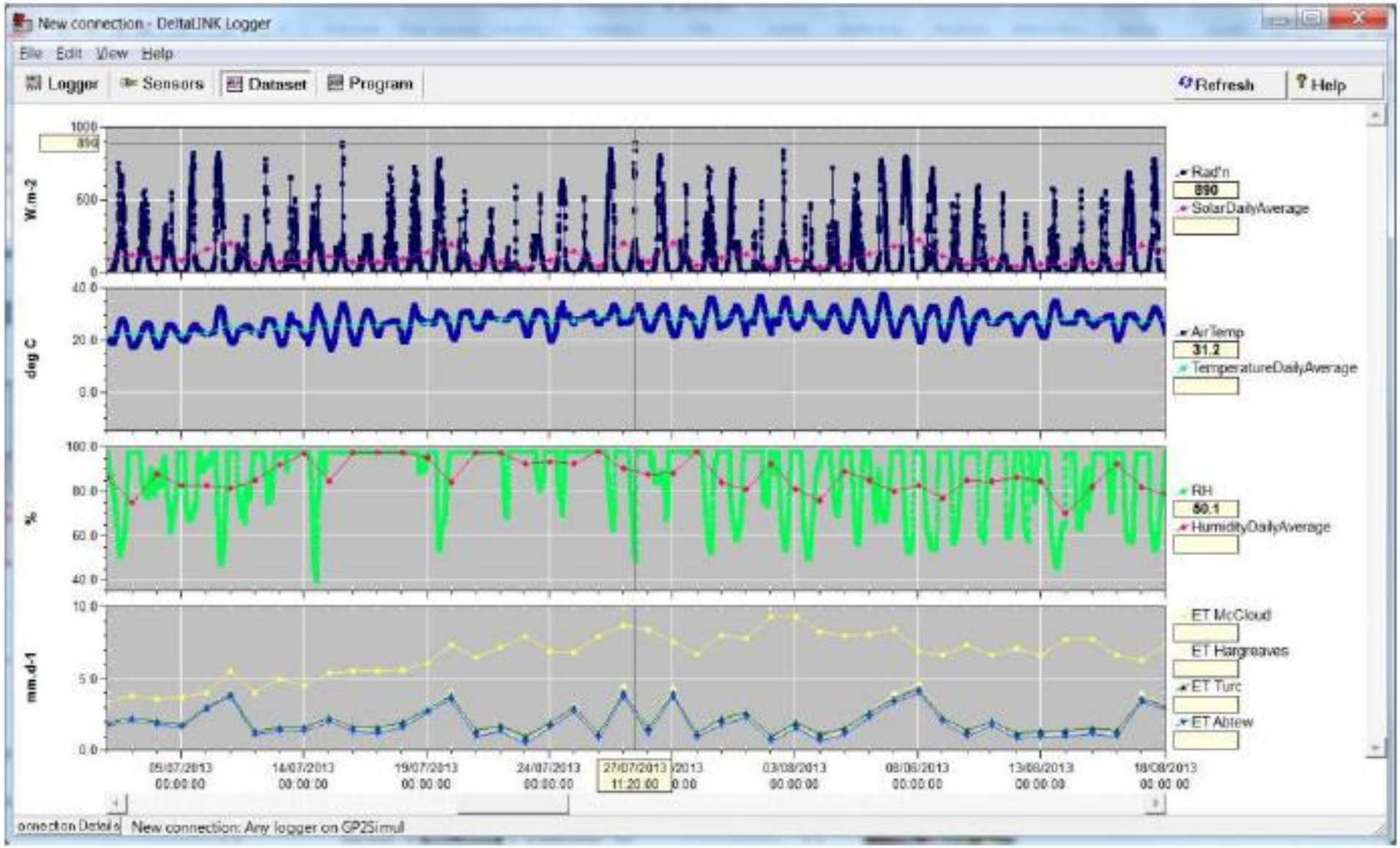


Run logger program through years of virtual weather data in just minutes:

- check program validity
- refine control conditions
- evaluate model performance

GP2 Weather simulator being used to compare PET models

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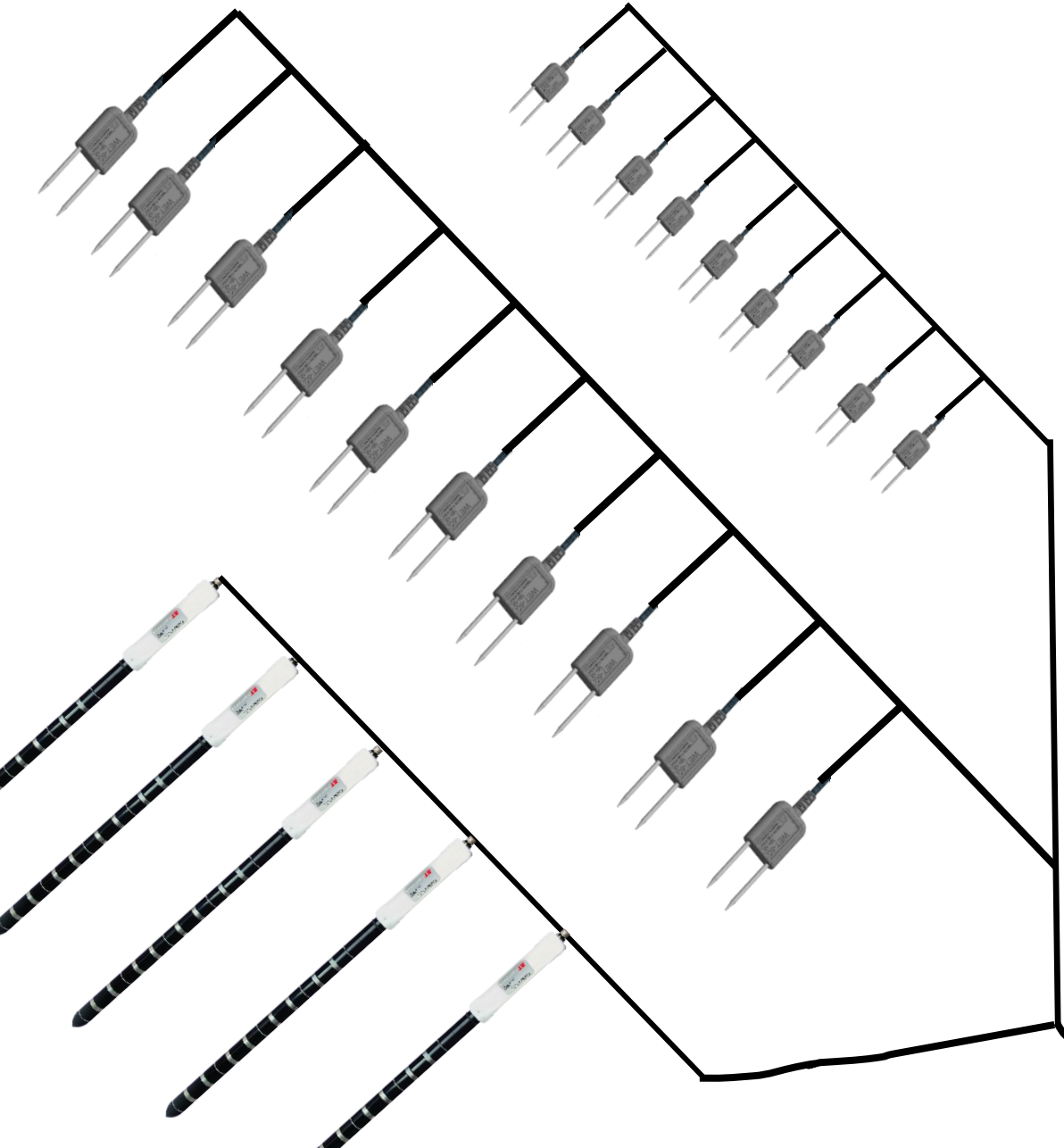


Multi parameter/Multi depth SDI-12 sensors

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GP2 with SDI-12 protocol

and analogue weather station







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At a variety of scales and using a variety of technology, *Precision Irrigation* techniques are able to consistently improve water use efficiencies in agricultural and horticultural systems, thus improving our understanding of the soil - plant – atmosphere continuum, whilst commercially cutting costs and improving margins and profitability.

This biggest problem seems to be disseminating this information








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Precision Sensing and Control for Improved Water Use Efficiency



Thank you



2015
International
Year of Soils

IAgrE Annual Conference 2015







