Soil moisture responses to vapour pressure deficit in polytunnel-grown tomato under soil moisture triggered irrigation control

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Abstract

This poster presents the innovative Script Editor feature of DeltaLINK 3.0 software when used in combination with the new GP2 Logger and Controller. This powerful new Script Editor function gives the user an accessible way to create sophisticated mathematical functions and models that can be applied in real-time to the measurement data collected by the GP2 - providing useful outputs from the combination of different types of measurements and/or multiple sensors. Potential applications are numerous, including areas such as the calculation of evapotranspiration, irrigation control and disease prediction. In the experimental work shown below we have created a very simple irrigation controller within the DeltaLINK 3.0 Script using a soil moisture sensor. The GP2 also collects data from relative humidity and air temperature sensors and calculates vapour pressure deficit enabling the relationship between rates of change in soil moisture and vapour pressure deficit to be investigated.

Delta-T Devices

GP2-based irrigation controller & Vapour Pressure Deficit Logger

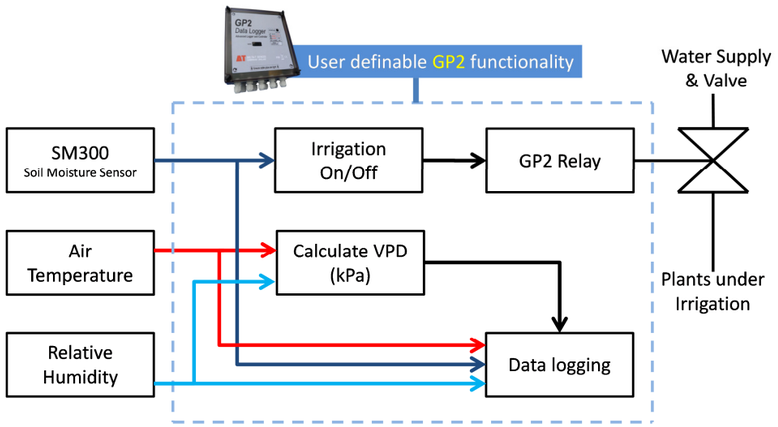

Fig 1 – Block diagram showing irrigation control, VPD calculation and data logging functions implemented in the GP2

Introduction and method

The aim of the experimental work described in this paper is to investigate the relationship between water transport in tomato (by measuring and processing soil moisture data) and the environmental driver of vapour pressure deficit (VPD) in a polytunnel. Whilst many researchers have successfully employed sap flow sensors to determine water uptake by roots and transport through the canopy, the installation of sap flow sensors is non-trivial. This poster presents an alternative method that can be easily integrated with a GP2 based irrigation controller using soil moisture feedback that allows water uptake to be evaluated against the environmental driver of VPD.

The starting point for this measurement method is the Richards flow equation for the movement of water in unsaturated soils [1] where the water uptake in soil is derived from the rate of change of soil moisture in a contained soil environment, assuming there is negligible drainage or run-off. By measuring air temperature and relative humidity close to the plant canopy it is possible to determine the VPD in kPa, which in this evaluation is considered the most significant driver of water transport.

In order to investigate the relationship between water uptake and VPD soil moisture measurements were taken with a resolution of 2 decimal places. Soil moisture, air temperature and relative humidity measurements were logged every 2 minutes. Data processing of the soil moisture was performed in an Excel spread sheet where the rate of change of soil moisture was derived using the Slope function over 5 soil moisture readings.

Irrigation control implemented using DeltaLINK Script Editor

The GP2-based irrigation controller employs the DeltaLINK Script Editor to implement the following simple GP2 relay control algorithm:

Turn Irrigation Valve ON when:

- SM300 Soil Moisture < Soil Moisture Trigger Threshold

Turn Irrigation Valve OFF when:

- Timer ≥ Irrigation Duration

Where:

- Soil Moisture Trigger Threshold: 30% Vol.
- Irrigation Duration Limit: 5 seconds
- Minimum Irrigation Interval: 2 minutes

Experimental arrangement

In this experiment 9 tomato plants were grown in individual pots containing 8.5 litres of John Innes No.1 compost. Each pot was irrigated with a dripper and irrigation control was achieved using a GP2 Data Logger and Controller. The GP2 was configured to provide 3 independent irrigation controllers (3 pots per irrigation controller) using an SM300 soil moisture sensor feedback in each case. The irrigation set-point was chosen to avoid drainage from the pot.

Air temperature and relative humidity was measured using an RHT 4nl RH and Air Temperature Sensor that was placed in close proximity to the canopy of the tomato plants, as shown in Figure 2 below. Due to the restricted nature of ventilation in the polytunnel near 100% humidity occurred overnight resulting in close to zero VPD as well as condensation forming on the inside of the polytunnel.

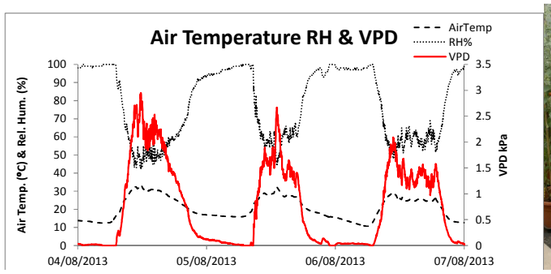

Fig. 2 – The experimental arrangement in the Delta-T polytunnel showing the close proximity of the air temperature and relative humidity sensor to the canopy together with air temperature and RH data over a 3 day period, used to calculate VPD by the GP2 Data Logger and Controller.

Soil moisture responses to vapour pressure deficit

The data collected over a 3 day period is shown in Figure 3 where the GP2 based irrigation controller with feedback from an SM300 soil moisture sensor (black line) has maintained the soil moisture between 30 and 32%. Vapour pressure deficit data is also presented against soil moisture in Figure 3 and against rate of change in soil moisture between irrigations data in Figure 4.

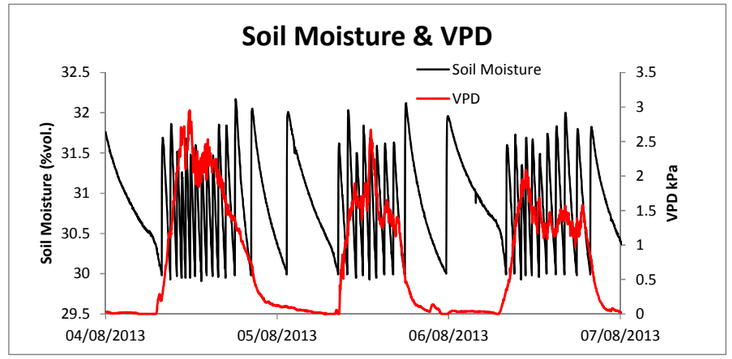

Fig. 3 – SM300 (irrigation Control) and vapour pressure deficit responses

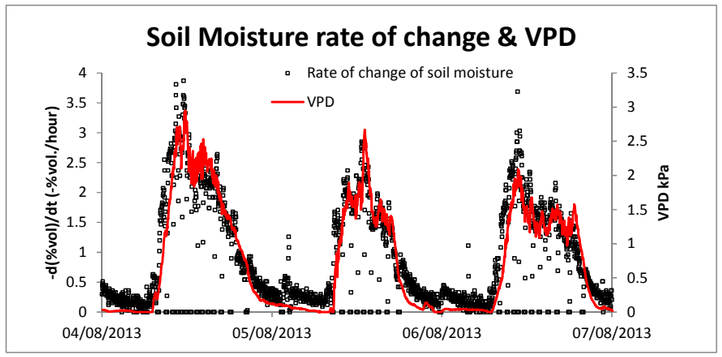

Fig. 4 – Rate of change of soil moisture and vapour pressure deficit responses

Conclusions

A small scale experiment using a GP2-based irrigation controller with feedback from a single SM300 soil moisture sensor was employed to regulate the soil moisture level and assess the water flow from a potted tomato plant. By determining the rate of change in soil moisture between irrigation events it has been possible to observe very good correlation between water uptake and vapour pressure deficit, illustrating the link between plant physiology and environmental conditions.

For more information regarding this and other GP2 Script Editor applications please contact: sales@delta-t.co.uk

DeltaLINK 3.0 Software including the Simulator is available free of charge at the online GP2 Resource centre: http://www.delta-t.co.uk/delta-link-resources.asp

[1] Tuzet A. et al., A coupled model of stomatal conductance, photosynthesis and transpiration, Plant, Cell & Env. 2003, **26**, 1097-1116

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