DPI&F note

Capacitance moisture probes – to calibrate or not?

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Recent efforts to improve on-farm water use efficiencies have resulted in more use of soil moisture monitoring tools, particularly capacitance probes such as C-probe, Enviroscan and Diviner.

Probes are typically used to:

1. Schedule irrigations – determining when irrigation is required.
2. Calculate soil water deficit to work out how much water to apply.

The question arises: 'Do probes need to be calibrated in the field'? Whilst the answer depends on how they will be used, the answer is **usually** "No!" However they do need to be **"**normalised".

Normalisation

Probes are normalised by matching the raw readings from each sensor at both 0% (held in air) and 100% water levels (submerged in water). Without normalising, these devices would only provide a range of irrelevant raw data that varies slightly with each sensor. By matching the raw reading from each sensor to both 0% and 100% water levels, a comparison of readings taken by different sensors can be made on a common scale. Equipment suppliers should provide you with procedures for normalising their product.

Probes for irrigation scheduling

Following the normalisation process, readings can be displayed (typically graphically), permitting irrigators to monitor their soil water levels based on trend changes. This accepted practice, utilising a **default calibration equation** within a product's software, negates the requirement for a complex site specific calibration.

In many cases the graphs employ "millimetres" as the vertical axis units. Herein lies a problem - the readings from probes, presented as "millimetres", are actually only an **estimation** of volumetric soil moisture levels and therefore should not be taken literally.

In most irrigation scheduling the main aim is to identify when to apply the next irrigation. The optimum time to irrigate can be determined by observing soil water levels as they move from field capacity to the refill point. Field capacity and the refill point can be determined through relating known soil moisture conditions to probe values, and analysis of soil moisture trends.

Uncalibrated capacitance probes will show changes in soil water content over time and will easily satisfy the requirements of an irrigator seeking to schedule irrigations based on variation in plant water use. Probes do not require a calibrated unit of measurement in order to achieve this task, as the change in **rate** of water extraction is used instead. Scheduling irrigation based on the slope of the line is acceptable; however it must be recognized that a change in the slope of the line can be due to soil moisture availability, change in evaporative demand in response to cooler or cloudy weather, or other factors.

Probes for calculating soil water content

Where a more accurate unit of measurement is required, there are higher order calibration methods available to correlate the relationship between the raw data counts, actual soil water content levels and the water-holding capacity of the soil. This calibration is rarely done in a commercial situation as it is possible to schedule irrigations using soil moisture trends rather than absolute numbers.

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Calibration becomes necessary when a device is to be used to determine the magnitude of plant water use, soil moisture deficit or to calculate a full soil water balance. Usually this is required in research where a precise control over the amount of irrigation water applied and/or information to calculate a soil water balance is required.

Whilst soil moisture values will differ between a calibrated and uncalibrated probe the pattern of the soil water trends will be similar. Figure 1 shows soil moisture data collected from a calibrated site which is then compared to the same data recalculated using the default calibration equation.

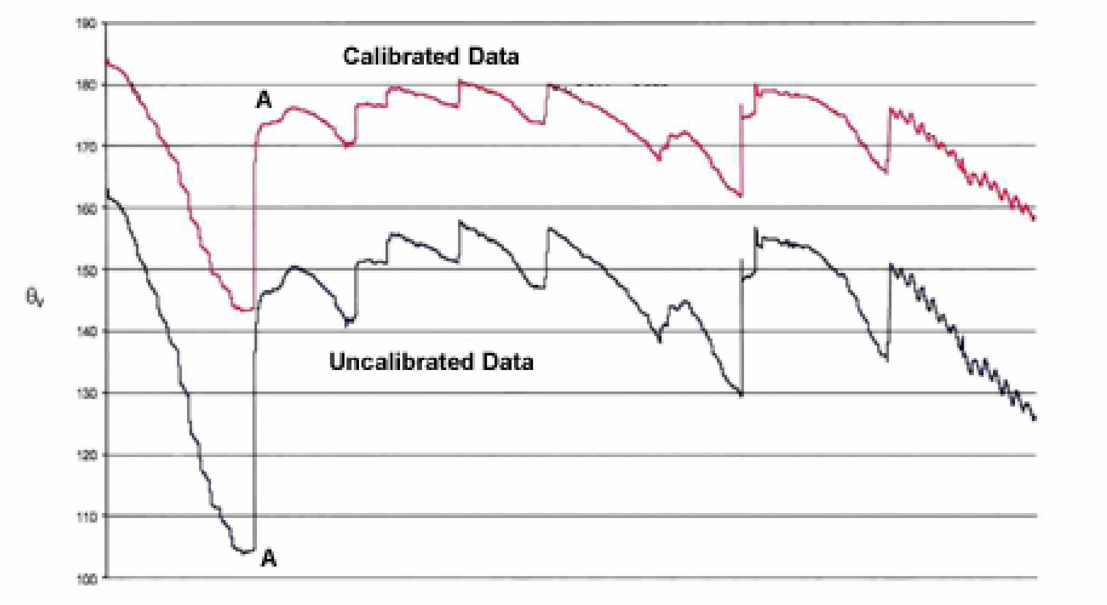

Figure 1: A single data set using a default and site specific calibration (***Source:*** *Anon. (2001) Calibration of the Sentek Pty Ltd Soil Moisture Sensors)*

In this figure, it is clear that the data represents the same trends, regardless of the default or site specific calibration. However if we look at the first irrigation event at point A:

- The calibrated soil moisture (red line) goes from 144mm to 173mm – a change of 29mm
- The default calibration soil moisture (black line) goes from 105mm to 146mm – a change of 41mm

If the default calibration was used and assumed to be correct, the change in soil moisture would be overestimated by 40%.

The calibration of soil water monitoring devices and the comparison of the resulting data requires much more effort than simple irrigation scheduling. The process is both exacting and site specific as it involves the accurate assessment of a range of parameters (including gravimetric water content and bulk density) which can vary significantly between soil types. This often necessitates taking into account changes in the soil profile. WATERpak (www.cotton.crc.org.au) and Sentek Pty Ltd (www.sentek.com.au) provide detailed instructions of the calibration procedure if required. The "Scheduling II" workshops (as part of the Irrigated Cotton and Grains Workshop series) also explain the various parameters required and procedures involved for those interested.

It is important to remember, particularly when not completely refilling the soil profile, that probes give a point source of data only, and even calibrated data may not give an average picture of soil moisture status. Figure 2 shows the field setup of three capacitance probes placed very close to each other: one in the plant line, and one on either side, only 250mm away. Water was placed in the furrow, 500mm from the plant line, as illustrated by the blue arrow. In this case, water was applied by a LEPA sock, but the same effect would be experienced from a deficit surface irrigation event.

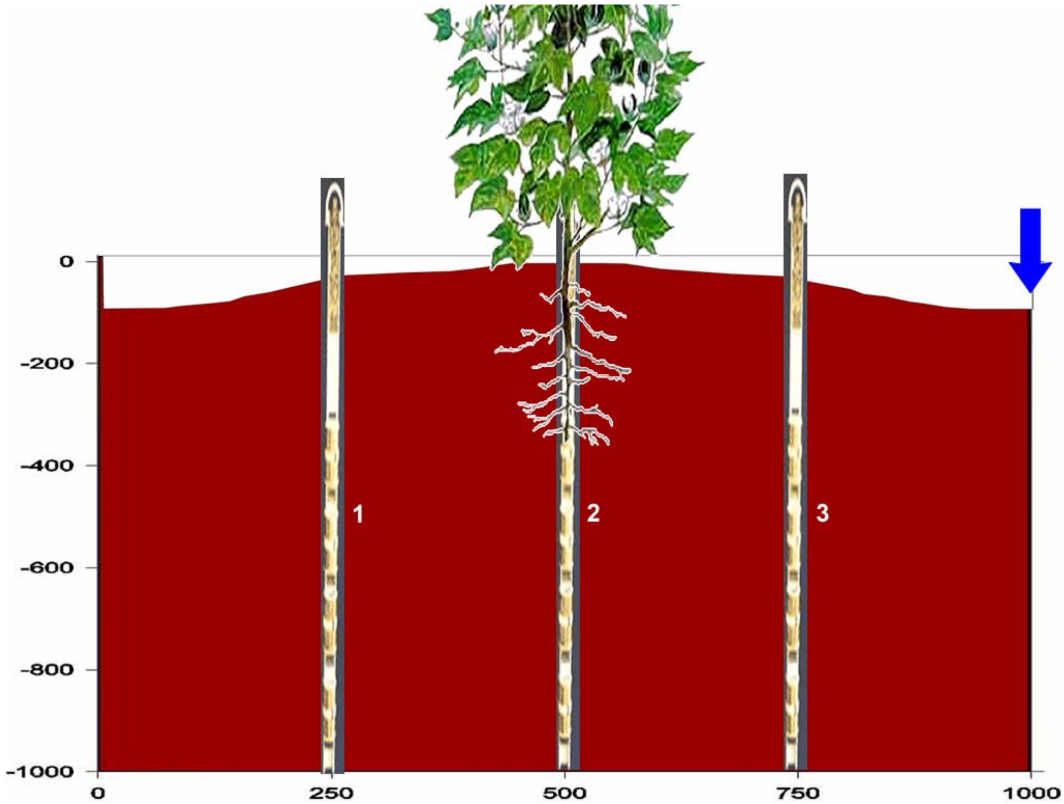

Figure 2: Probe setup for data in Figure 3 (***Source:*** *David Wigginton formerly National Centre for Engineering in Agriculture, University of Southern Queensland, courtesy Cotton Research and Development Corporation, Narrabri*)

Figure 3 illustrates the data obtained from the three probes. The blue line indicates probe position 1 from Figure 3, with the pink line indicating probe position 2 and the yellow line indicating probe position 3. As demonstrated, the soil water response varies between probes indicating spatial variability will have an impact on the accuracy of probe data, regardless of the accuracy of calibration.

During the irrigation indicated at point A, you can clearly see that increase in soil moisture is greatest in the pink and yellow lines, compared with the blue line. Obviously with such variations in soil moisture across even a 0.5 metre cross section, the variation over a field of many hectares could be significant.

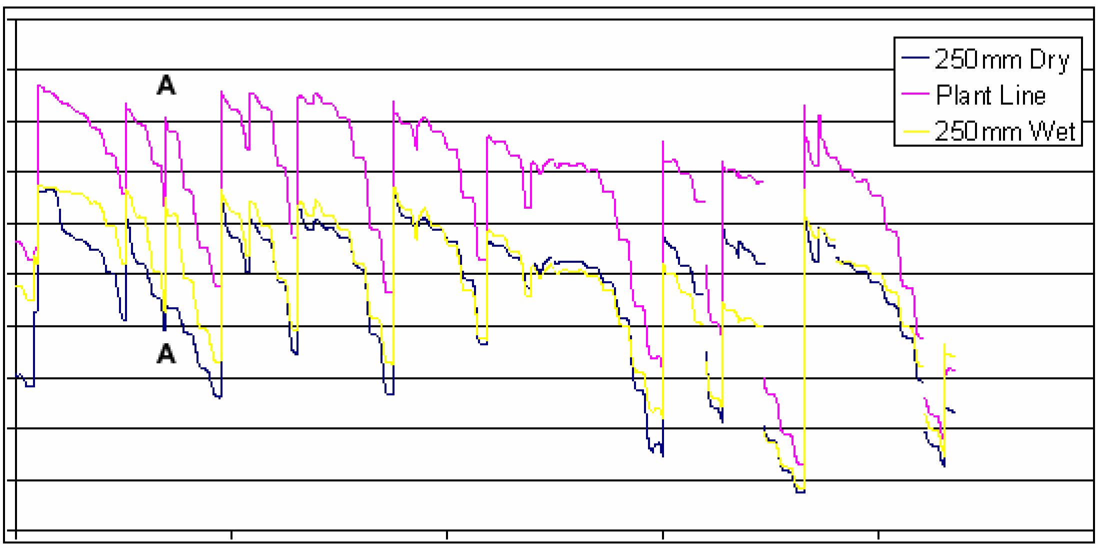

Figure 3: Even calibrated probes may not give a good picture of average soil moisture due to spatial variability (***Source:*** *David Wigginton formerly National Centre for Engineering in Agriculture, University of Southern Queensland, Toowoomba*)

Summary

Capacitance probes are extensively used for scheduling of irrigation events based on changes in soil water levels over time. Most irrigators with scheduling devices determine irrigation events based on graphed data depicting actual plant water use over time.

The debate over calibration should not detract from this ability to support the process of day-to-day irrigation management. It should, however, highlight the dangers in taking uncalibrated data literally.

Calibration may be undertaken to obtain more accurate soil moisture data, although the likelihood for spatial variability should be considered when considering the onerous task of calibration.

Further information

- Anon. (2001) Calibration of Sentek Pty Ltd Soil Moisture Sensors, Sentek Pty Ltd (accessible through www.sentek.com.au)
- Goyne, P. and Williams, D. (2004) Calibrating soil water monitoring devices. In *WATERpak: a guide for irrigation management in cotton*, pp101-106, Australian Cooperative Research Centre, Narrabri (accessible through the Cotton Catchment Communities CRC website at www.cotton.crc.org.au)
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