

POSTER SUMMARY

**TIME SAVING CALIBRATION METHODS FOR
SOIL WATER MONITORING SENSORS**

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Abstract

Echo® type sensors are commonly used at SASRI to monitor soil water content and to schedule irrigation. However, to obtain accurate values these sensors need to undergo a costly and time consuming calibration process for each soil in which they will be used. The objective of this study was to evaluate various time saving calibration methods on the performance of three Echo® sensor models (E10, E20 and 10HS). Three calibration procedures (M1, M2 and M3) were evaluated. For M1, each sensor type was calibrated using four volumetric soil water contents (SWC) and their corresponding conductivity readings (mV), collected from three potted soils with clay contents of 11, 22 and 50%. The data were further analysed to address two other calibration scenarios. In the second calibration method (M2) each sensor was calibrated using the pooled data from all three soils to generate a calibration curve covering a much wider SWC range. Thereafter, the calibration curve means of M2 were used as the calibration curve for new uncalibrated sensors, and sensor performance was evaluated (M3). Good results were obtained for M1, M2 and M3 with all sensor models producing r^2 values greater than 0.9.

Keywords: soil water sensor, Echo, calibration, clay content, sugarcane

Introduction

The calibration of equipment in preparation for measurements is an important operation, but also a time consuming process, especially if equipment such as the Echo® type sensors are enquired with irregular intervals. Normally sensors are calibrated only for the soils in which they will be used and have to be calibrated again when used in other soils. The objective of this paper was therefore to investigate the possibility of developing a procedure to calibrate the Echo® type soil water sensors quickly and to establish a universal calibration equation to which all Echo® type sensors will be related.

Materials and Methods

Three types of Echo® soil water sensors were used in this study, viz. E10 (6 units), E20 (8 units) and 10HS (29 units). Each was calibrated using a range of soil water contents (SWC) between field water capacity (FWC) and permanent wilting point (PWP) in three soils with clay contents of 11, 22 and 50%. For each of the three soils types, two 25 L pots were packed with air dried soil to a known density. Each Echo® type sensor was read three times in each pot before the SWC was increased with a predetermined amount

per soil type and packed to the same density as before. Five levels of SWC were prepared for each soil type.

After completion of each set of readings, soil samples were taken from each container and dried for 24 h at 105°C to determine the SWC. All mV readings from the Echo® sensors were recorded with a CR1000 Campbell Scientific data logger.

Three calibration procedures (M1, M2 and M3) were evaluated. M1 represents the conventional calibration method where mV values are regressed against SWC per soil type. In the second calibration method (M2) each sensor was calibrated using the pooled data from all three soils to generate a calibration curve covering a much wider SWC range. Thereafter, the mean of the M2 calibration curves were used as the calibration curve for new uncalibrated sensors and sensor performance was evaluated (M3). To evaluate M3 one third of the sensors (two E10, three E20 and 10 HS10 randomly selected) per model was calibrated using the M2 procedure and the resulting mean calibration curves used on the remainder (four E10, 10 E20 and 19 HS10) of the sensors to estimate SWC.

Results and Discussion

Individual coefficients of determination (r^2) for the conventional calibration procedure (M1) ranged from 0.70 (E10), 0.73 (E20) and 0.76 (10HS) to 1.00 with the means per sensor model and soil type at 0.91 (E10, 11% clay), 0.98 (E10, 22% clay), 0.95 (E10, 50% clay), 0.90 (E20, 11%), 0.98 (E20, 22%), 0.97 (E20, 50%), 0.96 (10HS, 11%), 0.99 (10HS, 22%) and 0.97 (10HS, 50%). All calibrations were thus useful.

Where all data per soil type was pooled (M2) and calibrations recalculated, the mean r^2 values per sensor model were 0.94 (E10), 0.95 (E20) and 0.97 (10HS). It appears thus that a single calibration could be used per sensor model over a range of soils.

The M3 procedure was performed to determine whether it is possible to calibrate some sensors and then use the mean calibration curve for other sensors not included in the calibration process (Table 1). The slope for all sensor models were close to 1.0, the Y-intercept close to 0.0 and the r^2 good, indicating that the variation between sensors is small and a generic calibration equation could be used to estimate SWC.

Conclusions

The soil water sensors proved to be very stable and calibration could be simplified in the following ways:

- Calibration data from soils covering a range of textural properties can be grouped to develop a single calibration per sensor model (no need for a calibration equation per individual sensor). This led to the conclusion below.
- Sensors that were not included in the initial calibration exercise can be used with previously developed calibration curves.
- This applies to the E10, E20 and 10HS Echo® models. Calibration equations should be kept within sensor models and not used across models.

Table 1. Calibration curves for three sensor models and statistics for the estimation of soil water content (SWC) by an independent group of sensors using the mean calibration curve per sensor model from the first group.

Model	n (n)	Slope	Y-intercept	r ²
Mean calibration equations developed for one third of the sensors per model				
E10	*2 (12)	0.152	-53.41	0.887
E20	*3 (18)	0.136	-53.58	0.883
10HS	*10 (60)	0.091	-44.86	0.931
Mean evaluation regression statistics of laboratory determined versus sensor estimated SWC using the calibration curves above				
E10	*4 (96)	1.023	0.602	0.886
E20	*10 (240)	0.979	0.510	0.880
10HS	*19 (456)	0.984	-0.194	0.926

*One third of sensors used to develop the calibration equations. The values in brackets represent the number data points per sensor model from the equation

$$(n) = n \times \text{soil types} \times \text{soil replicates} = n \times 3 \times 2.$$

*Two thirds of sensors used in the evaluation process. The values in brackets represent the number of data points per sensor model from the equation

$$(n) = n \times \text{soil types} \times \text{soil replicates} \times \text{SWC levels} = n \times 3 \times 2 \times 4.$$