Calibration of Capacitance Sensors to Precisely Measure Water Availability in Soilless Substrates

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February 06, 2008

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Overview

1) Relationship between substrate physical properties and water-holding capacity

2) Sensor Calibration
   - methodology
   - accuracy and precision

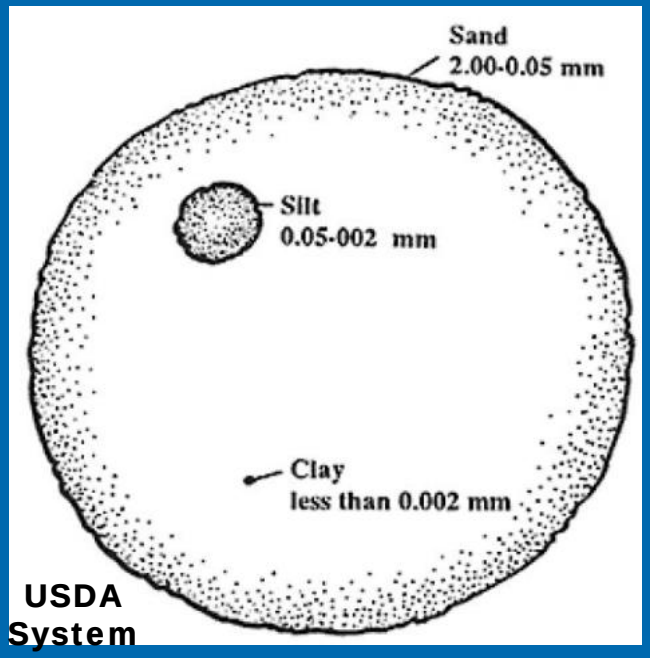
3) Comparison of calibration data

Soilless Media Physical Properties

Soilless Substrates

- Particle Size
- Composition

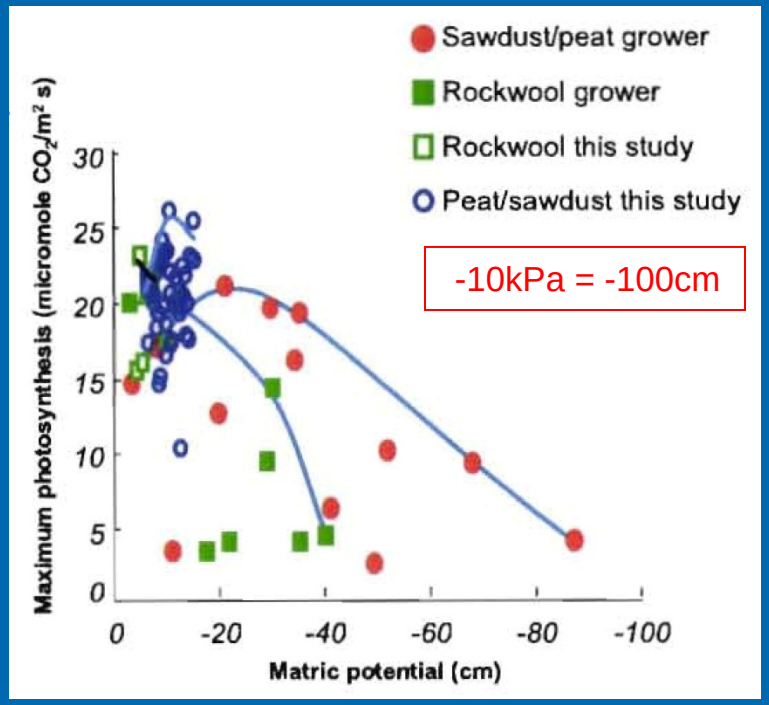
Soils



- Texture
- Structure

Soilless Media Physical Properties

Author	Matric potential proposed as minimal for plant growth
	kPa
Raviv et al. 2004 deBoot and Verdonck, 1972	-10
Kiehl et al. 1992	-16
Milks et al. 1989	-30



* Tomato plants Caron et al., (2007)

- ➔ Plant species
- ➔ Container volume
- ➔ Low root : shoot ratio
- ➔ Plant age
- ➔ Leaf area

Why Capacitance Sensors?

Tensiometers, electrical resistance blocks, among others.

Answer:

They might have the ability to more accurately sense moisture under soilless substrates

conditions

Why these particular Sensors?

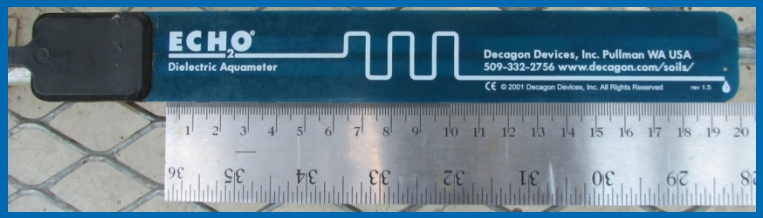
- Ech$_2$O sensors are relatively cheap and robust
- A variety of sensors are available, including high frequency sensors, also a combination water, temperature and EC (perform better in saline conditions)
- Easily integrated with alternative dataloggers

Calibration Objectives:

- Calibrate the performance of Ech_2O sensors in soilless substrates.
- Evaluate the precision of these sensors (reliability and performance)
- Deploy these sensors for precision irrigation scheduling with wireless sensor networks

Sensor Calibration: Materials and Methods

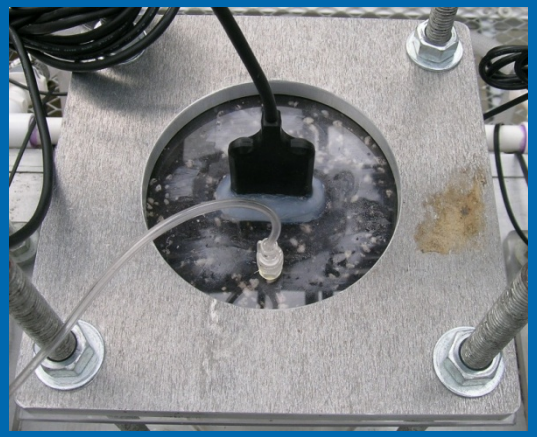
- Desorption curves generated using a custom-built desorption table using 5 and 20cm long Ech_2O capacitance sensors.

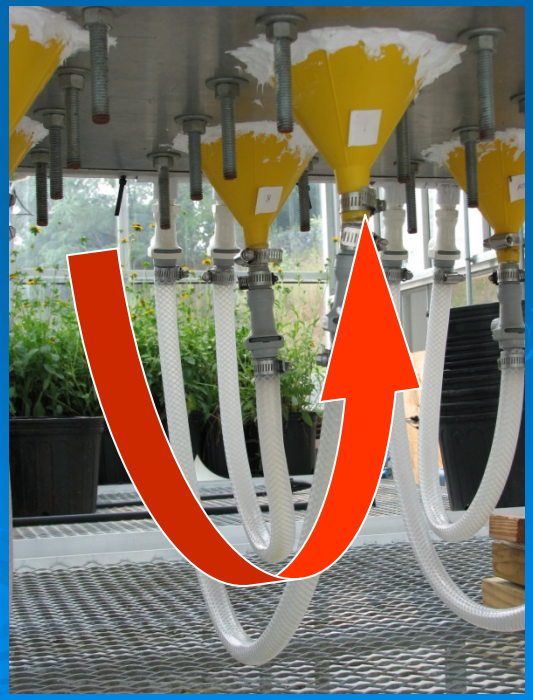


- Ten columns were simultaneously desorbed for each substrate (n=30).

Sensor Calibration: Materials and Methods

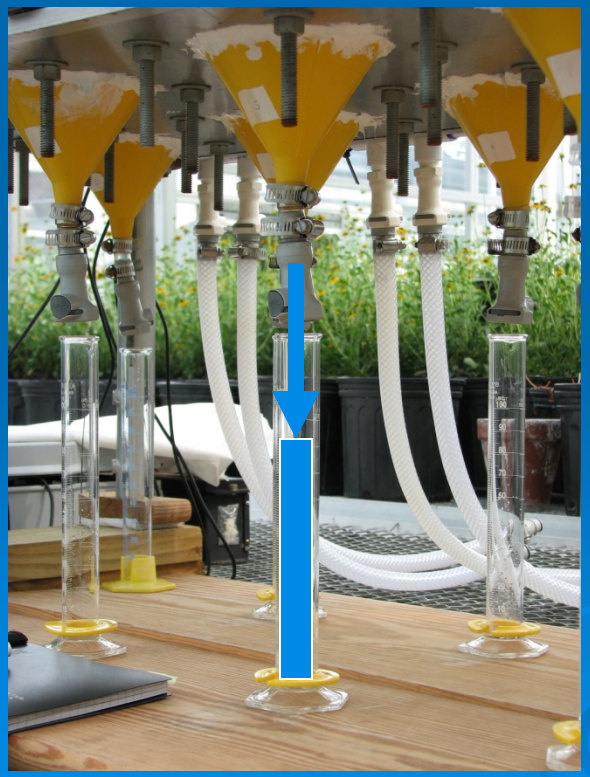
- Each column was packed by slowly adding and settling the substrate with water
- Each column had a capacitance probe sealed into the top polycarbonate lid, positioned centrally and vertically down the column
- Once sealed, each column was slowly hydrated over 6 hours to gradually force the interstitial air out of the substrate





Sensor Calibration: Materials and Methods

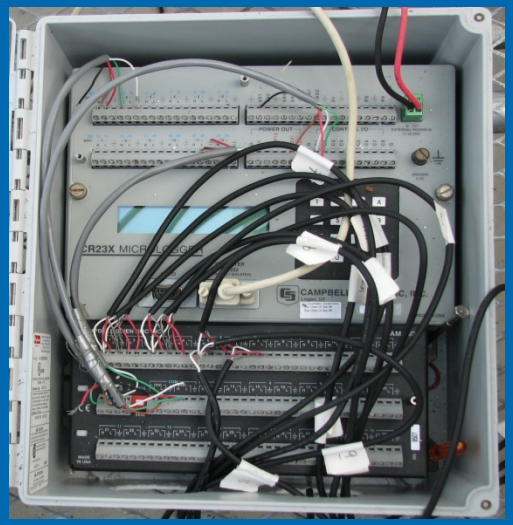
- Positive gas pressure was incrementally applied at 1, 2, 4, 6, 8, 10, 20, 40, 60, 80 and 100 kPa



- The volume of water expressed at each pressure increment was measured for each column

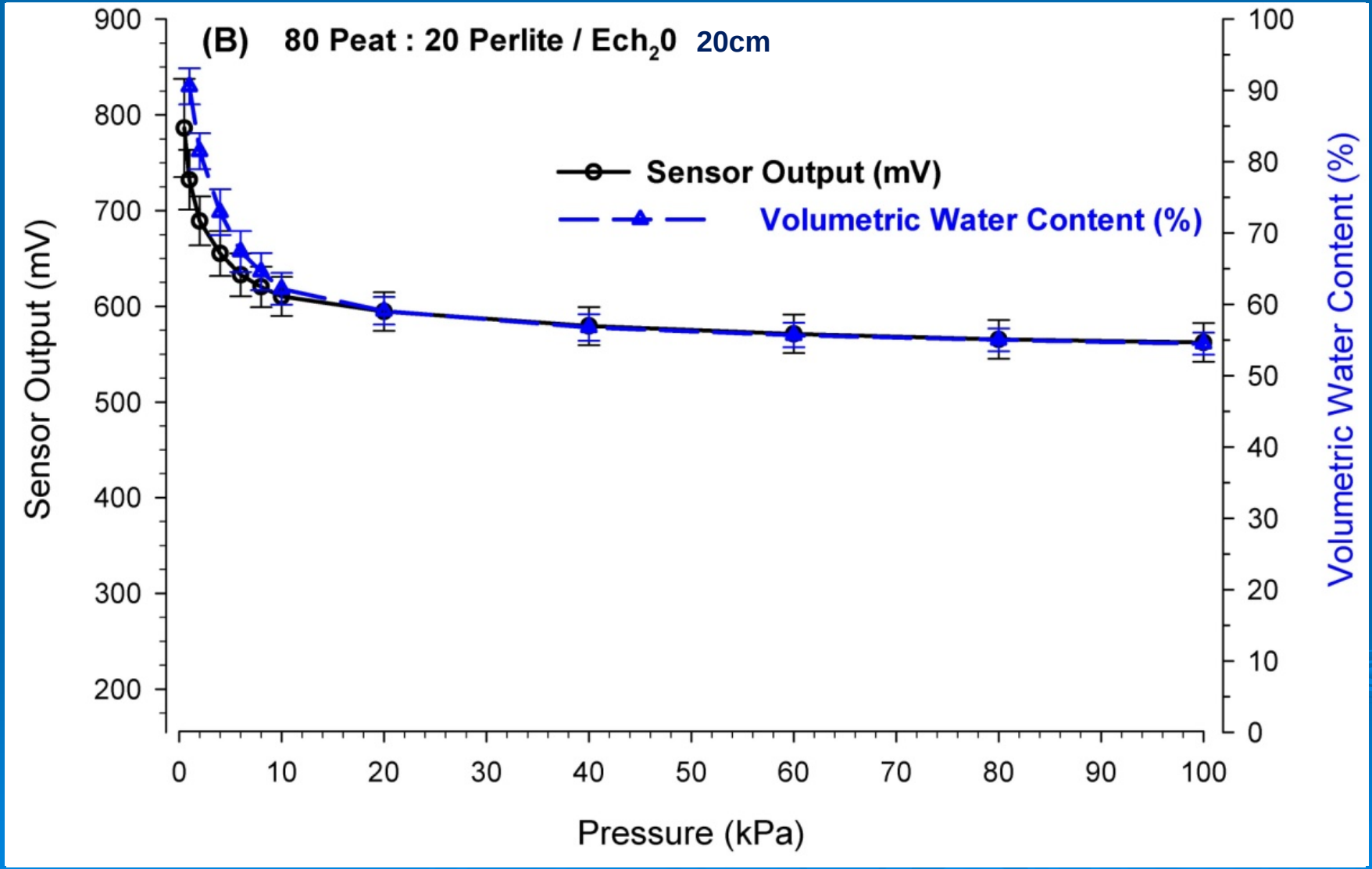
Sensor Calibration: Materials and Methods

- 3V excitation probe, using a AM 16/32A multiplexer and Campbell Scientific CR23X datalogger



- The output was continuously measured for each sensor

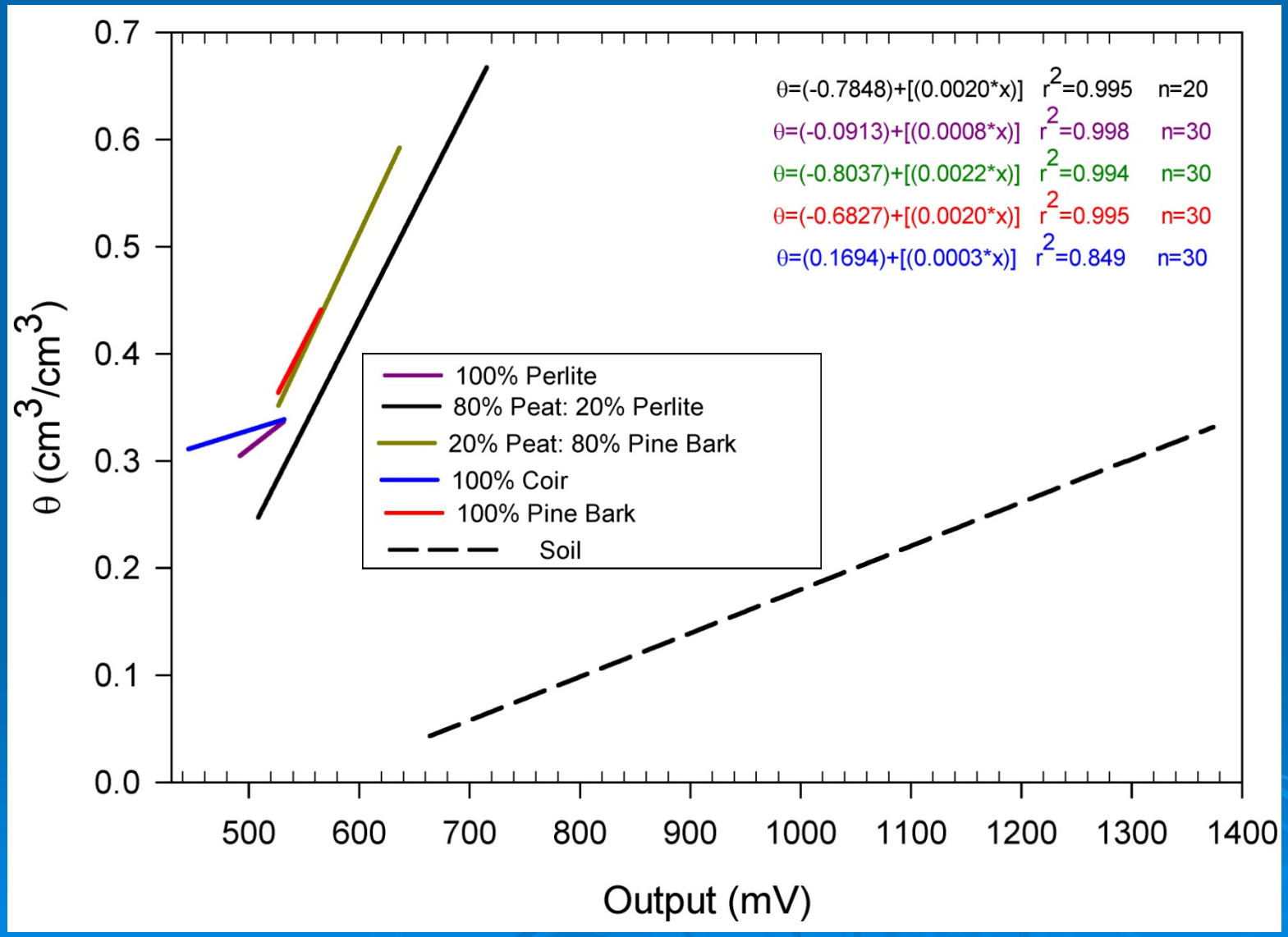
Results – Curve Comparison



Results – Physical Properties (5cm columns)

		100% Perlite	80% Pine Bark: 20% Peat	100% Coir	100% Pine Bark	80% Peat: 20% Perlite
	Pressure (kPa)	Distribution of Water (%)				
EAW	(1 to 5)	36.0	40.0	**32.6**	34.6	**43.7**
WBC	(5 to 10)	1.2	7.0	**2.1**	2.2	**13.1**
PUW	(>10)	62.8	53.0	**65.3**	63.2	**43.2**

Sensor Calibration Regression Equations



Conclusions

- Significant differences in plant-available water exist between substrates, at very low matric potentials
- We have demonstrated that these capacitance sensors have high precision and accuracy
- We need to calibrate these sensors for soilless substrates since these values are completely different from soils
- These results will enable us to more precisely schedule irrigations based on plant water use, to conserve water and reduce nutrient runoff.

Questions ?