METER
ENVIRONMENT

COIR-SPECIFIC CALIBRATION FOR METER SOIL MOISTURE SENSORS

Our experience with custom calibration in coir is that it does not result in the same +/- 1 to 2% accuracy as expected for mineral soils. Generally, it is in the range of 5 to 10% or better. Because coir typically has a gradient of water, the relationship ends up being between sensor output and the water content of the entire coir slab, not the water content at that exact sensor location within the coir.

Use the following step-by-step instruction guide to a obtain calibration curve for coir. For convenience, METER also offers a Custom Calibration Service.

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COIR METHOD INSTRUCTIONS

1. Equipment needed

1.1 **METER soil moisture sensor** (1)

1.1.1 METER sensor output is very similar among sensors of the same type. You can calibrate with a single sensor and apply that calibration to other sensors of that type and maintain excellent accuracy.

1.1.2 TEROS 12 is the preferred sensor for use in coir because of the increased spacing between sensor pins (compared to 5TE/TM). Sharp stainless steel pins also allow for a cleaner insertion.

> 1.1.2.1 Note that the measurement volume of the TEROS 12 is quite large (see Figure 1), which has the advantage of averaging over more of the coir.
>
> 1.1.2.2 Be aware of how close the sensor will be to objects in the grow house that could alter the sensor output. For example, the sides of the metal trough that holds the coir slab could be inside the sensor volume of influence

in the greenhouse, but this situation is not recreated when calibrating.

1.2 **Automated band saw for cutting coir** (1)

1.3 **Permanent marker** (1)

1.4 **Waterproof plastic packaging** (the original coir packaging works well)

1.5 **Waterproof tape** (Gorilla tape works well)

1.6 **Coir slabs** (1 to 2)

1.6.1 Slabs of coir for calibration (1 to 2 depending on expected EC levels. [See 2.1.1])

1.7 **Oven** for drying the sample

1.8 **Large scale** (1)

1.8.1 Make sure the scale used to weigh the slab can accommodate the mass of the saturated coir, the sensor, and the reader/logger.

1.8.2 The scale should have a resolution of 0.1 g or better for best possible calibration.

1.9 **Calipers or measuring stick/tape** to measure dimensions of the coir (1)

1.10 **Data acquisition system** (1)

1.10.1 Use whatever data acquisition system will be used in the greenhouse (ProCheck, ZL6, EM60G, EM50, Campbell Scientific data logger, etc.).

1.11 **Containers** (2 to 3)

1.11.1 One container just slightly larger than the coir slab to help saturate the sample by creating a containment/shape for the loose bag

1.11.2 One or two containers to catch draining water

1.12 **Capillary tubes** (1 to 2)

1.13 **Utility knife** (1)

1.14 **Sodium chloride** for creating electrical conductivity (EC) solutions

1.15 **EC meter** for verifying the EC of your solution (or use the TEROS 12) (1)

1.16 **Funnel** (1)

1.17 **Beaker 2000-400 mL** (1)

2. Create EC solution(s)

2.1 Create one to two water solution(s) with electrical conductivities (EC) that span the expected range of irrigation water.

2.1.1 It is generally acceptable to conduct the calibration with a solution at one EC level unless the EC in the coir will change dramatically during growing operations.

2.1.2 If this is the case, create a calibration curve for two different coir slabs in two different solutions (one at the highest expected dS/m and one at the lowest expected dS/m), and average.

2.2 Add sodium chloride in small amounts to a container of water until the solution reaches the desired EC level. If two solutions are created, label the containers with the corresponding dS/m value.

2.3 Verify solution EC levels with an EC meter or a TEROS 12 soil moisture sensor.

2.4 Let the solution come to room temperature.

3. Coir preparation

3.1 Cut a section of coir.

3.1.1 Coir should be the appropriate size for the sensor selected (see Figure 1), the scale used for mass measurement, and the container used for saturation (32 cm is a common size).

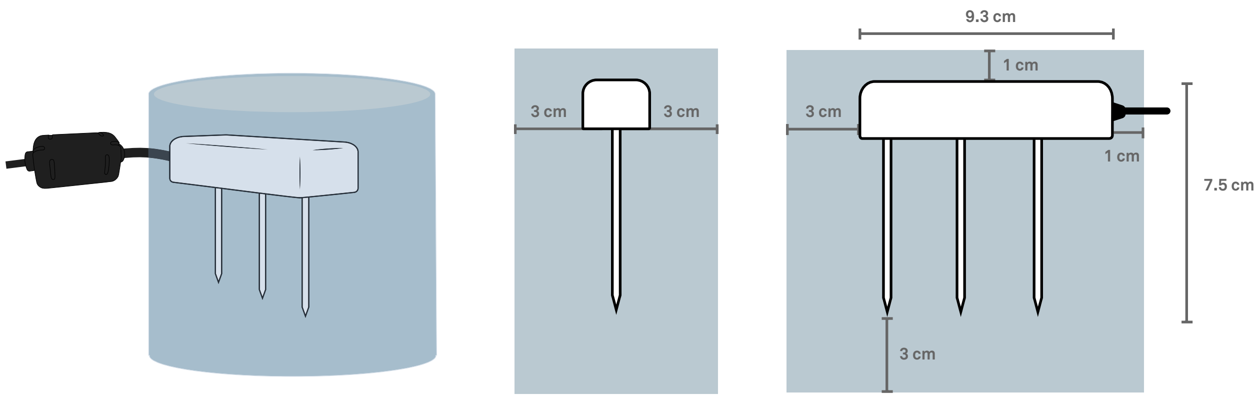

Figure 1. Idealized measurement volume of METER TEROS 12 sensor

3.1.2 An automated band saw works best for cutting the coir. A precise cut will make dimension measurements easier and more consistent.

3.2 Cut a piece of the original coir packaging to fit the coir sample.

3.2.1 Cut the packaging to be the length of the coir sample plus 2x the height that it will expand to when water is added (i.e., enough packaging to close up the ends).

3.3 Place the sample in the bag.

3.4 Tape both open ends of the bag using waterproof tape. The ends should be watertight.

3.5 Use a permanent marker to label the slab with the intended dS/m value.

3.6 Use a utility knife to make three or more parallel 3-inch slits in the top of the bag (if there is not already an opening in the coir packaging).

3.7 Weigh the wrapped, dry slab (m_{slab}).

3.8 Label the coir slab with its weight.

3.9 Record the slab weight in Table 1 (see downloadable spreadsheet below).

3.10 Weigh the sensor (m_{sensor}), including the cable.

3.11 Record sensor weight in Table 1.

3.12 Place the coir sample in a container that is just slightly larger than the sample
.

3.13 Use a beaker and a funnel to add the EC solution to the coir slab.

3.13.1 Wet the whole slab evenly as quickly as possible or there will be an uneven expansion of the coir slab.

3.13.2 Add solution until the entire container is full.

3.14 Soak the calibration slab in the EC solution (slit facing up) for 30 minutes to one hour until fully saturated.

3.15 After the slab has finished expanding, remove the coir sample from the container.

3.16 Use tape to tighten up any loose portions of the bag. Avoid putting tape over areas where you intend to insert the sensor.

3.17 Measure the exact slab dimensions (length, width, height) with calipers or a measuring stick.

3.18 Record the dimensions in Table 1(see downloadable spreadsheet).

Sample + Sensor(s) + Container Weights		Water wt	Calculated VWC	Sensor Measurements						Average		
				TEROS 12 - 4 cm		TEROS 12 - 6 cm		TEROS 12 - 8 cm		4 cm	6 cm	8 cm
Drying Points	g	g	$m^3 m^{-3}$	A	B	A	B	A	B	RAW	RAW	RAW
Saturation	10383.8	7056.0	0.89	3196	3249	3181	3219	3181	3247	3223	3200	3214
Point 2	9914	6586.2	0.83	3218	3234	3076	3142	3131	3194	3226	3109	3163
Point 3	9245	5917.2	0.74	3081	3201	2739	2801	2735	2804	3141	2770	2770
Point 4	8928.5	5600.7	0.70	2962	3056	2671	2727	2666	2726	3009	2699	2696
Point 5	8712	5384.2	0.68	2842	2960	2645	2698	2632	2687	2901	2672	2660
Point 6	8115.4	4787.6	0.60	2630	2722	2569	2605	2565	2608	2676	2587	2587
Point 7	7728.8	4401.0	0.55	2541	2617	2544	2566	2528	2573	2579	2555	2551
Point 8	6983.9	3656.1	0.46	2284	2247	2269	2332	2270	2298	2266	2301	2284
Point 9	6670	3342.2	0.42	2225	2199	2209	2264	2224	2253	2212	2237	2239
Point 10	6254	2926.2	0.37	2195	2170	2154	2215	2159	2197	2183	2185	2178
Point 11	5774	2446.2	0.31	2095	2098	2044	2121	2038	2078	2097	2083	2058
Point 12	5420	2092.2	0.26	2076	2081	2006	2102	1984	2043	2079	2054	2014
Point 13	5136	1808.2	0.23	2026	2057	1944	2080	1940	2013	2042	2012	1977
Point 14	4677	1349.2	0.17	1939	2003	1869	2055	1889	1957	1971	1962	1923

Table 1. Example of a partial data collection table for coir-specific METER sensor calibration. Download the full spreadsheet below.

Download this excel spreadsheet (with cell operations) for your own use.

4. Calibration procedure

4.1 Insert the sensor through the bag into the saturated coir sample. The sensor should fit snugly against the bag. Use tape to hold the sensor in place if needed.

4.1.1 The sensor should be inserted into the exact same position and orientation you intend to use in the greenhouse.

4.1.2 The sensor can be inserted into the side or top of the slab, but be mindful of spatial variability in coir water content. At mid to high water content levels, there will be a large gradient in water content from the top of the coir to the bottom.

4.1.3 To measure EC more accurately, insert the sensor midway or lower.

4.1.4 It is possible to calibrate multiple sensors at multiple depths. If desired, use multiple sensors and a data logger to take simultaneous readings in the same slab.

4.1.5 Sensor pins should be fully covered by the material. At a minimum, the material should fill the area outlined in Figure 1 above.

4.2 Place the calibration coir (slits facing up) and sensor onto the scale.

4.3 Collect a raw sensor reading in the coir using a Procheck or data logger.

4.4 Record the total weight (m_{total}) and the raw sensor value in Table 1.

4.5 Set a small container next to the scale.

4.6 Poke a small pen-sized hole into a bottom corner of the bag. Let some of the water drain out into the container.

4.6.1 Use a capillary tube to direct the water flow from the hole into the container.

4.6.2 If faster draining is desired, drain two corners simultaneously.

4.7 Watch the scale. Once enough weight is lost to approximately reduce water content by 10%, seal the corner back up with waterproof tape.

4.8 Take another raw sensor reading.

4.9 If the water content has lowered 10%, record the new weight and raw sensor value in Table 1.

Note: Use a column in the Table 1 excel spreadsheet to automatically calculate the decrease in water content percentage each time a reading is entered. This will make it easier to judge when to record the next reading.

4.10 Repeat steps 4.7 to 4.9 until water no longer drains from the bag.

4.10.1 If needed, punch additional holes in the bottom of the bag and set it on top of a towel to draw additional water from the sample.

4.11 Cut larger openings in the top of the sample to allow moisture to escape the bag more easily.

4.12 Place the sample in the oven (leave the sensor inserted) at 65°C for one to two days.

4.13 Measure the weight of the sample once per day to ensure it is not losing more than 10% before your next measurement.

4.14 Allow the sample to cool to room temperature before recording the raw sensor measurement.

4.15 Repeat steps 4.11 to 4.12 until the water content is in the teens or less.

4.16 Record raw sensor readings and weights in Table 1 each time the water content in the calibration coir decreases by 10%.

5. Calculations

The volumetric water content is defined as the volume of water per volume of slab

$$\theta = V_w / V_t$$

Equation 1

Where θ is volumetric water content (cm³/cm³), V_w is the volume of water (cm³), and V_t is the total volume of the slab (cm³). V_t of your sample is easily calculated because you measured the dimensions of the slab. To find V_w, take the total weight measured in section 4 (combined slab, sensor, and water weight) and subtract the slab and sensor weight.

$$m_w = m_{total} - m_{slab} - m_{sensor}$$

Equation 2

$$V_w = m_w / \rho_w$$

Equation 3

Where m_w is the mass of water, m_{total} is the mass of the wet and sensor together(g), m_{slab} is the mass of the dry slab, msensor is the mass of the sensor, and ρ_w is the density of water (~1 g/cm³).

The calculations above are most easily done in a spreadsheet program such as MS Excel. The previous Table 1 shows the above calculations performed.

6. Finding and using the calibration function

If the above calculations are performed in a spreadsheet program, then finding the calibration function is quite easy. Simply make a scatter plot with the sensor output on the X-axis and the calculated VWC on the Y-axis (Figure 1). Then use the trendline or curve-fitting function to construct a mathematical model of the relationship. This relationship is often linear, as shown below, but it is sometimes best fit with a quadratic equation.

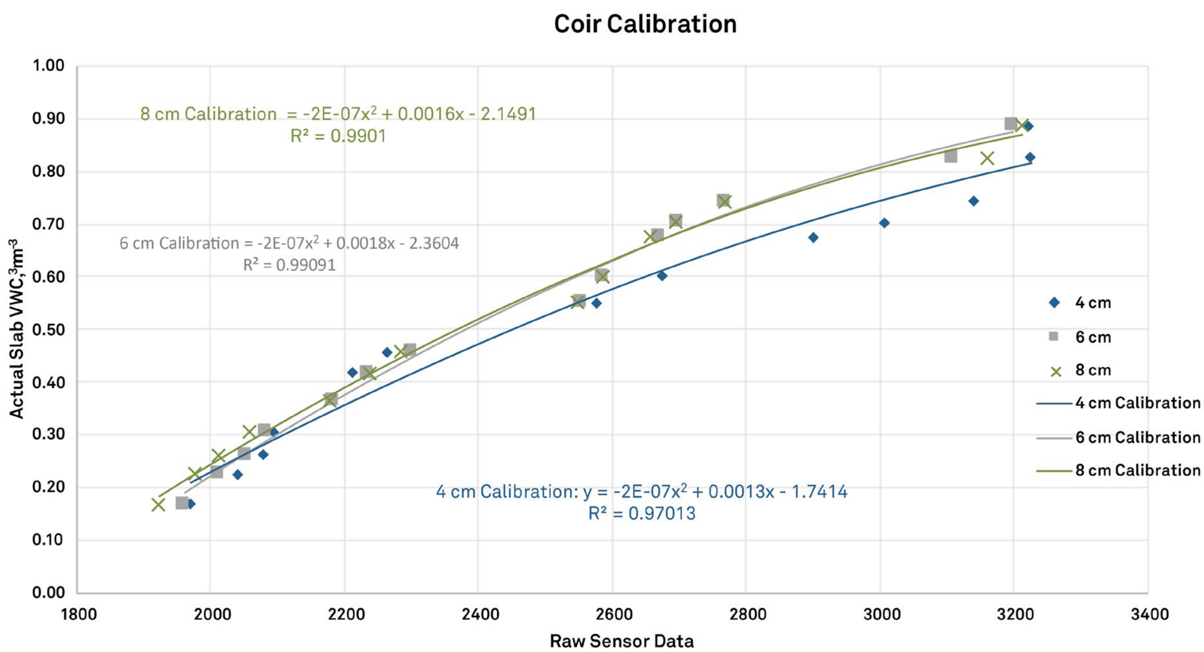

Figure 1. Coir calibration graph

Once the calibration function is constructed, apply it to the METER sensor data. When logging data with the ZL6, EM60G, EM50, and EM5B data loggers, apply this equation to the raw data downloaded from the logger. If using ZENTRA Cloud software, apply the calibration function under the System Settings tab in the Calibration Settings. Simply click the Add Calibration button and type in the coefficients. Remember to apply enough significant figures to the equation. If using the DataTrac software package, apply the calibration function under the setup tab. If using Campbell Scientific data loggers, apply the calibration in the data logger program or during post-processing.