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# Using Soil Water Sensors to Evaluate Plant Available Water in Engineered Landscape Soils

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## INTRODUCTION

The performance of plants is subject to many variables. One key aspect is the availability of water in soil. The team at Midwest Trading's Center for Horticultural Soils Testing and Research have begun a long-term research program investigating the soil water interactions in horticultural soil, specifically for use in container production and landscapes. In soil science, plant available water can be characterized through a moisture release curve that plots moisture content with matric potential. Volumetric moisture content is a measurement of the total volume of water held in a soil. Matric potential is a measurement of how tightly the water is held to the soil surface. Unlike naturally occurring mineral soils, container substrates and engineered landscape soils can vary drastically from one project to another due to site conditions, raw material inputs and recipe.

There is limited understanding of plant available water in these systems, however, there is an opportunity with engineered soils to tailor soil blends to meet project requirements.

This research is the first step in an extensive research program to better understand site conditions and plant available water characteristics of engineered soils. The objectives were:

- Evaluate use of moisture and matric potential sensors.
- Determine how sensors can be used as a tool to automate irrigation systems.
- Use plant available water data to inform engineered soil design.

## MATERIALS AND METHODS

### Site Selection

This research was conducted at the Gardens at Ball Horticultural Company in West Chicago IL. This is a display garden used to showcase varieties offered through Ball Seed. Two sites were selected that contained the same engineered landscape soil but were under different site conditions. Both are in raised beds with drainage tile and are on drip irrigation.

Site 1 is a perennial display bed in the shade near a creek that is prone to flooding. Site 2 is a vegetable display bed at higher ground and in full sun (Fig. 1).

**Figure 1.** Site 1 (left) is a perennial garden plot; Site 2 (right) is vegetable garden plot.

### Soil and Sensors

***Soil***: The soil for each site was PM-35 provided by Midwest Trading. It is a blend of coarse pine back, loam topsoil, sand, and compost.

***Sensors*****:** Sensors for the sites were sourced from Meter Group, Inc of Pullman, Washington. For each site, two Teros 21 and Teros 12 sensors were installed together at depths of 4 in. and 8 in. The T8 sensor was placed at 6-in. depth. Cables were run through garden hose and PVC to protect against damage. The five sensors were connected to a ZL6 data logger. Measurements were taken at 5 min intervals and uploaded to a Zentra Cloud platform.

The system was installed May 24 and data was collected through Oct 1$^{st}$. Teros 21 reports matric potential by measuring the moisture content in a ceramic disk with a known moisture release curve to convert volumetric moisture to matric potential.

The T8 sensor measures matric potential through a sealed column of water with a permeable ceramic cap that allows water to be pulled through creating a tension measurement. Teros 12 measures volumetric moisture content, temperature, and EC.

Teros 12. Moisture, Temperature, EC

Teros 21. Matric Potential, Temperature

T8 Matric Potential

**Figure 2**. Sensors from Meter Group, Inc of Pullman, Washington (www.metergroup.com).

## RESULTS

At time of publication, preliminary analysis was conducted on data sets collected during the course of trial. Figure 3 represents data from Teros 21 matric potential sensor and T12 volumetric moisture sensor. Data is displayed in a scatter plot of the volumetric moisture compared to matric potential. This displays one of the limitations of the Teros 21 showing full saturation at 10 kPa, where the T8 tensiometer will measure at or near 0kPa. The data set for the scatter plot is from both sites and shows water being abundantly available from 50% to 35% moisture content. The crops would start to see some water stress below 35% moisture content when the matric potential increase past 40-60kPa.

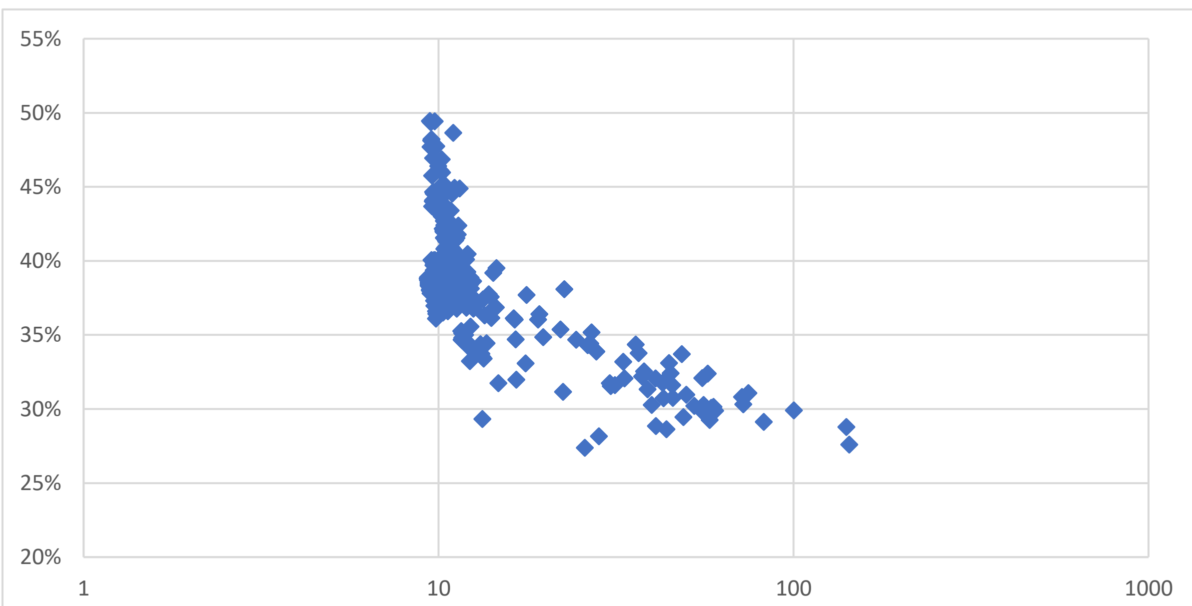


**Figure 3**. PM35 moisture release curve.

With two sites under different exposure conditions we were able to see differences in soil temperature between sites and depths. Plotted in Figure 4 is a 4-day span showing the temperatures in °F on a 24 h cycle. The shallow depth in the sun had dramatic swings in temperature of 10–14 °F during the day. Deeper soils and those in the shade had much more moderate soil temperatures. The sun site is open and more exposed to heat loss during the night resulting in lower night temps for 4 in. vs 8 in. depths.

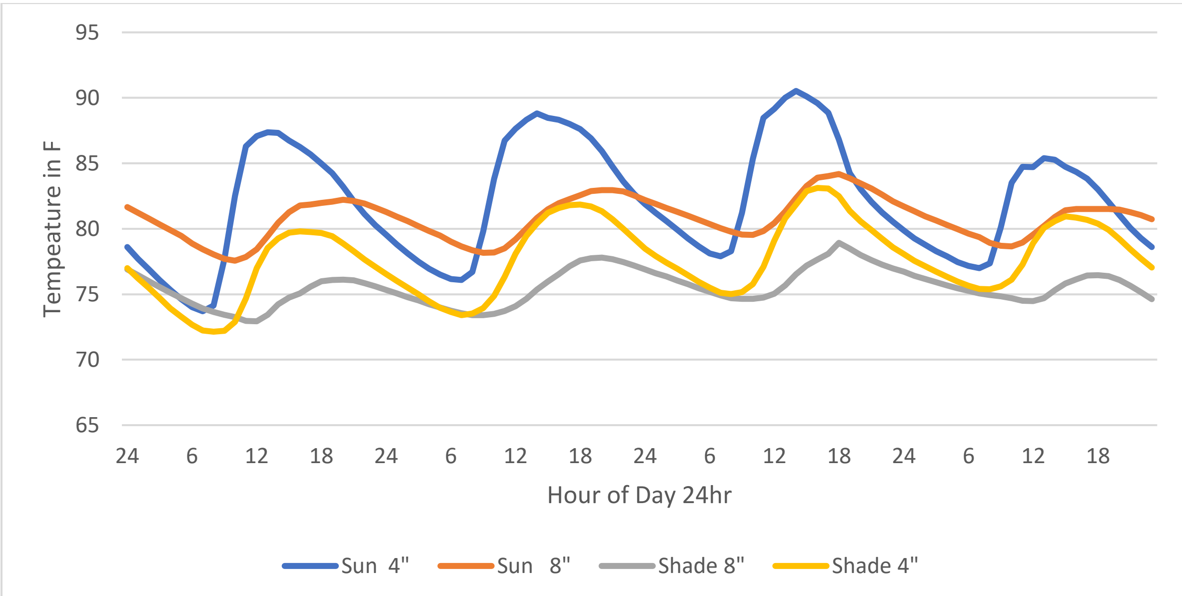


**Figure 4**. Soil temperature in shade and sun.

## First Season Feedback and Next Steps

There were a lot of lessons learned through this first season of field research using these sensors.

- 2019 was a record setting year for rain fall and the soils did not have much time to dry down; this limited the high kPa measurements that could help interpretation of the systems and substrate. Future research will be needed at these sites and in more controlled environments where dry down can be properly tested.
- Usability of sensors for integrating into irrigation controls was one of the main objectives of the study. For a display garden where irrigation is frequent, it is likely a moisture sensor would provide better reactivity compared to a matric potential sensor. Matric potential sensors could be better applied to cropping systems where the soil or the crops will experience more water stress.
- The EC values fluctuated (data not presented) quite a bit from rain events and fertigation through the drip line. This measurement is of interest for the site to better monitor fertility of crops to ensure performance over the summer.
- The sensors were placed at different depths and different places in the beds. With the beds being on drip irrigation, it is possible that there was localized var-

iation based on the proximity of the sensors to the drip line. This would need to be considered in future seasons

- The measurement interval for this research was set at 5min. This interval provided 600,000 data points which can be a challenge to run analysis on. The sensitivity of the measurements does not need to be as detailed. An interval of 15-30 min should be sufficient in the future.
- More analysis is required of the data set and we will be looking into:
  - Correlation of soil EC readings, fertigation of beds and performance of plant material.
  - Identifying conditions that caused water stress.
  - Mapping the impact of temperature on dry down patterns.

## CONCLUSION

This research has promising use for the industry, specifically engineered soil applications. We will continue to work with this sensor technology to evaluate different sites and different types of soils. This will allow us to look at how different raw ingredients impact the functionality of the soil and will influence recipe design to optimize water use.