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September, 2023
Newsletter Vol.9

University of California Cooperative Extension - Siskiyou County

2023 Summer Newsletter

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Hi Siskiyou County, I hope you are doing great. While I have been working in Merced County for some months now, I'd like to share information on one project I still have in Siskiyou County. The idea behind this research was to compare two types of soil moisture sensors in alfalfa and perennial grass cropping systems. The sensors chosen were Watermark (Irrometer) and Teros 11 (Meter Group *Inc.*).

Research Updates

Soil Moisture Sensor Project

1. **Cost**

The cost for a set of sensors will depend on the crop in the field where the sensors will be installed. Three to four sensors per site should be enough in perennial grass fields because the majority of the root system will be in the top two feet of the soil profile. Alfalfa has a deeper root system and requires more sensors per site to capture water movement deeper in the soil profile so four to six sensors are recommended. For this project, a total of six sensors in 6 inches increments (6, 12,18, 24, 30, and 36") per site were installed in a alfalfa field, and four (6, 12, 18, and 24") in a perennial grass field.

Figure 1: Watermark Sensors

Figure 2: Teros 11 Sensors

Teros 11 sensors are more expensive and cost $218 per sensor while Watermark costs $37.50 in 2022. Data loggers are needed if remote measurements are desired. These data loggers collect and store soil moisture data according to a chosen interval. Both systems have the ability to transfer data through the internet so growers can access live data at any time and place. For Teros 11, the ZL6 Cellular data logger costs $729 and the 12-month Zentra Cloud Standard Plan $199, for a total of $928 per site. Similarly, WaterMark's 900M-CGB data logger costs $960 with a year of cellular data service included.

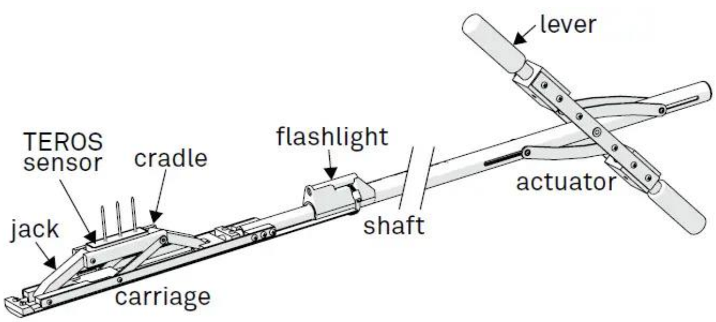
2. Installation

Teros 11: The Teros Borehole Installation tool (Fig. 3) adds a cost to the project. Renting the tool cost $551 for one month but in 2022 Meter Group Inc. gave a discount if the tool was returned within two weeks instead. While Teros 11 sensors can be installed by hand in the top 6-18" of the soil profile, the installation tool is recommended for deeper installation. It works very well and is worth it.

The installation of Teros 11 is relatively simple. You can auger or trench a hole to the desirable soil depth and stick the very sharp needles of the sensor on the wall of the hole. Make sure the hole is big enough to fit the installation tool. Figure 4 shows how the sensor should be placed in the undisturbed soil.

Watermark (WM): While these sensors can be directly buried in the desired depth, it's recommended to glue them to PVC pipes to extend their longevity. I used schedule 315 half-inch PVC pipe and the sensors fit perfectly. Regular PVC glue does the job. Before gluing the sensor to the PVC pipe, I drilled a hole at the bottom of the pipe for venting purposes. I used a half-inch metal pipe to make a hole in the soil to accommodate the PVC pipe. I poured a slurry made of the location's soil and water into the hole to ensure proper contact between the sensor and the soil.

Both technologies similarly connect to loggers through cables. Small solar panels were installed with each data logger to provide power for telemetry.



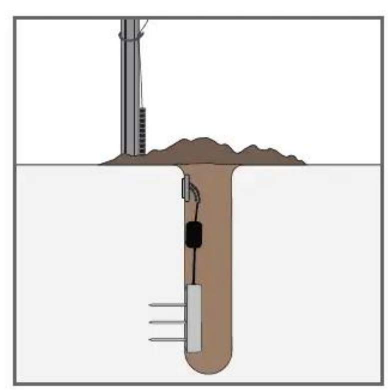


Figure 3 (left) Teros Borehole Installation tool and figure 4 (right) proper Teros 11 sensor placement

3. Maintenance

Both systems have been easy to maintain and had no problems so far. All data has been collected online and the sensors are currently working properly.

4. Data

Both sensors read the water content in the soil but they use different metrics to do so. Watermark sensors measure water soil tension (WST) in centibars (cb) or kilopascal (kPa) as seen in Figures 5 and 7. In other words, WM sensors measure how much effort plants need to make in order to get water from the soil pores. The reading values range from 0 (wet, saturated soil) to 200 (dry). Teros 11 measures the soil's volumetric water content (VWC) or how much water per volume of soil. The reading units are in percentage (%), usually within the 0.1 and 0.5 range as seen in Figures 4 and 6. Attention is required when comparing both sensors as their data is plotted in opposite ways. For example, higher numbers mean dryer soil when assessing Watermark sensor graphs. On the other hand, higher numbers mean wetter soil in Teros 11 graphs.

5. Location information and soil moisture

The alfalfa field is located in Fort Jones-CA. The soil is classified as silt loam from 0-19 inches deep and silty clay from 19 to 68 inches deep. The average bulk density (dry weight of the soil divided by its volume) calculated on the top 0-19 inches of the soil is 1.28 g/cm3. Relatively limited drainage and good water holding capacity are typical in this soil.

Figure 4 shows soil volumetric water content (VWC) in the alfalfa field. The numbers on the "Y" axis go up during irrigation and slowly go down as the soil dries out. In this specific scenario, the VWC ranged roughly from 15% (driest) to 40% (wettest). Shallower sensors tend to have more variation than the ones deeper in the soil profile.

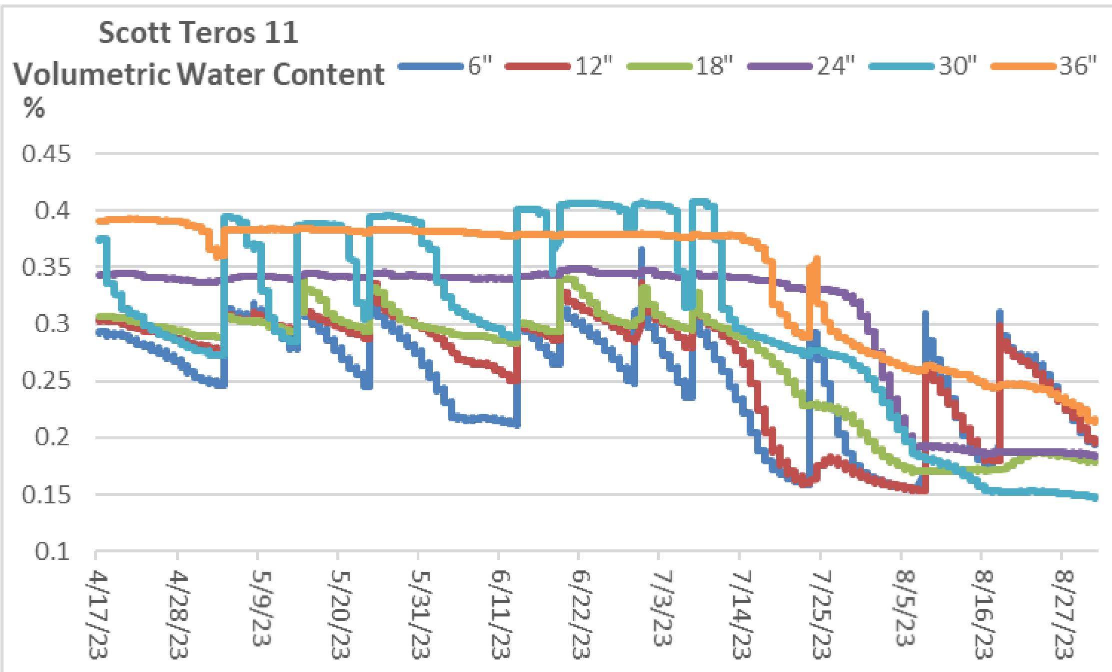


Figure 4: Teros 11 sensors installed in an alfalfa field in Scott Valley-CA.

The graph below represents the same alfalfa field, and the Watermark sensors were installed just a couple of feet apart from the Teros 11 set. However, the data is depicted in soil water tension (SWT), which in this case ranged from close to 0 kPa (wettest) to 240 kPa (driest).

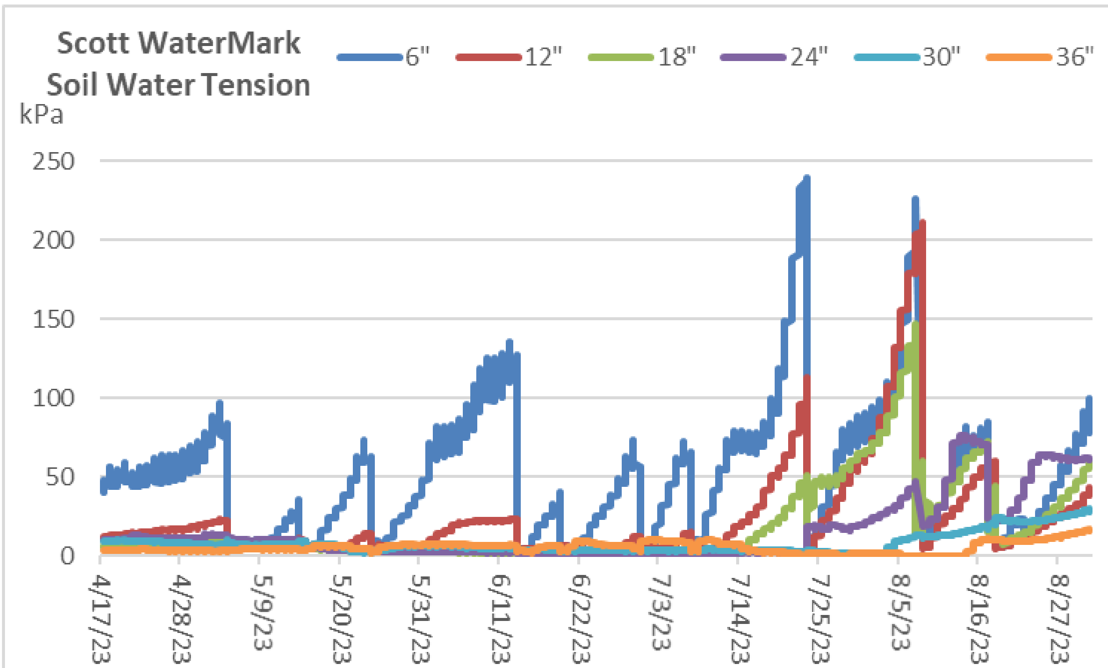


Figure 5: Watermark sensors installed in an alfalfa field in Scott Valley-CA.

The grass field is located in Montague-CA. The soil is classified as stony loan with an average bulk density of 1.17 g/cm3. This soil is typically well-drained and suitable for irrigated agriculture. Figures 6 and 7 show the locations' VWC and SWT data, respectively.

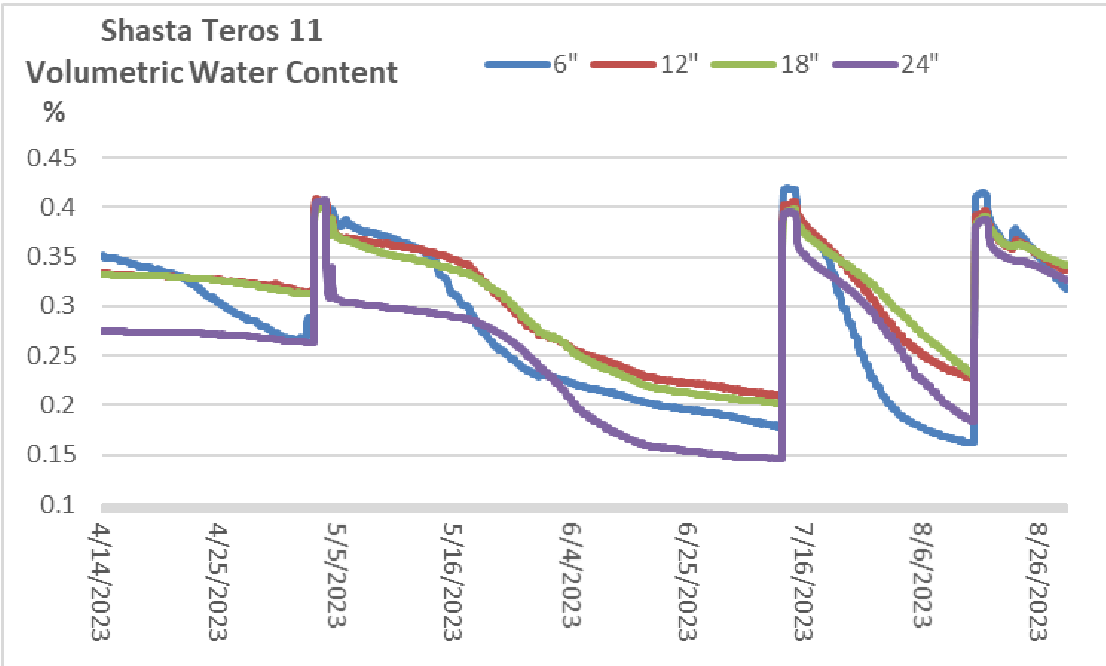


Figure 6: Teros 11 sensors installed in a perennial grass field in Shasta Valley-CA.

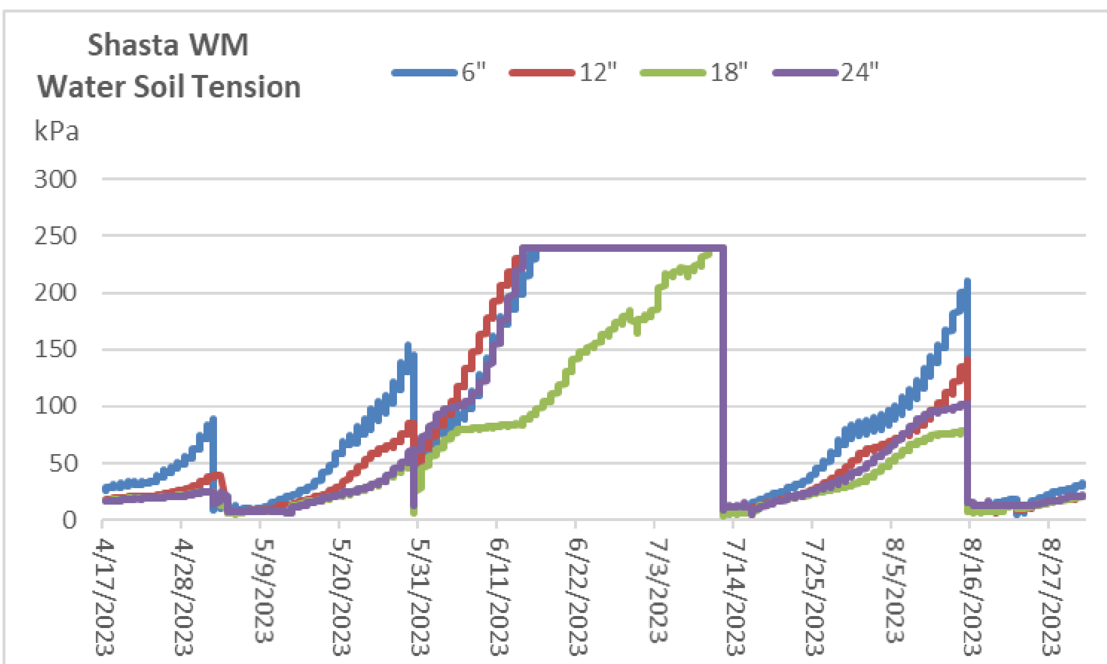


Figure 7: WaterMark sensors installed in a perennial grass field in Shasta Valley-CA.

Watermark and Teros 11 are good tools for monitoring soil moisture throughout the growing season. Teros 11 are more expensive than Watermark sensors, especially if renting the installation tool. Overall both systems have been working flawlessly during the first year of the project, and the data generated become clear and intuitive after a few interactions with the online service. While each system uses different units to inform how wet/dry the soil is, both provide useful information for irrigation scheduling. It's important to remember that volumetric water content (Teros 11) increases with irrigation and the water soil tension (Watermark) decreases. Soil type has an influence on how quickly the water moves through the soil profile and how quickly it dries out. For example, sandy soils have larger pores than clay soils and soil moisture readings will change quicker after irrigation. In addition, sandy soils dry faster so more frequent irrigation with less water per irrigation cycle is recommended. Soil moisture sensors can definitely help with understanding the pattern of water movement in a given soil and lead to higher water use efficiency.

Please don't hesitate to reach out at gcgaldi@ucanr.edu if you have any questions.