Understanding Soil Moisture Monitoring

This is Grower Guide #3 in our ***Soil Moisture Sensor Series*** of guides. This guide covers understanding and using the data now that you have selected and installed soil moisture sensors in your vineyard, including:

- Factors in Water Demand
- Interpreting Soil Moisture Data
- Matching Data to Plant Stress
- How to Time Irrigation Sets (Looking for Trends)

Related Guides:

- Soil Moisture Sensor Types & Placement - Guide #1
- Selecting the Location to Install Soil Moisture Sensor - Guide #2
- Installing a Capacitance Soil Moisture Probe in the Vineyard
- Installing Capacitance Soil Moisture Sensors

Factors in Water Demand

Soil structure, seasonal changes, and vineyard age are all key factors in determining water demand for vineyards. By far, soil structure and seasonal changes are the most consistent and common challenges when determining the overall water demand for vineyards.

Soil Structure:
Understanding and accounting for your soil structure is essential for recognizing your vineyard's water demand expectations. The photo below shows a soil with higher clay content in the first 12 inches, clay loam at 24 inches, and silty clay loam at 40 inches depth. Soil moisture retention will be greatest in the top 12 inches in this soil because clay holds onto water more effectively than silt or sand. Soil can be sampled separately and sent to the lab to determine soil texture and potential water-holding capacity.

For sandy textured soil, a 2-inch rain event could supply enough water to permeate down to 8 to 16 inches,

so for a mature vineyard only a short irrigation set after the rain would be needed to push the water to a 24 or 32-inch depth if desired. The same 2-inch rain event for heavy clay soil may not even get past the 8-inch mark thus requiring a longer post-rain irrigation set to push water to a desired 24 or 32-inch depth.

Seasonal changes:
Irrigation goals change throughout the season with regard to the desired frequency and depth of water application. It can be challenging to make effective irrigation decisions without proper information from soil moisture monitoring equipment. Understanding how water moves through a specific soil type can make irrigation decisions more efficient throughout the growing season and can help a grower avoid watering too much (wasting water) or too little (causing loss in vine vigor and yields).

For more information on different soil moisture monitoring equipment types, please see the **Soil Moisture Sensor Types and Placement Grower Guide** (coming soon).

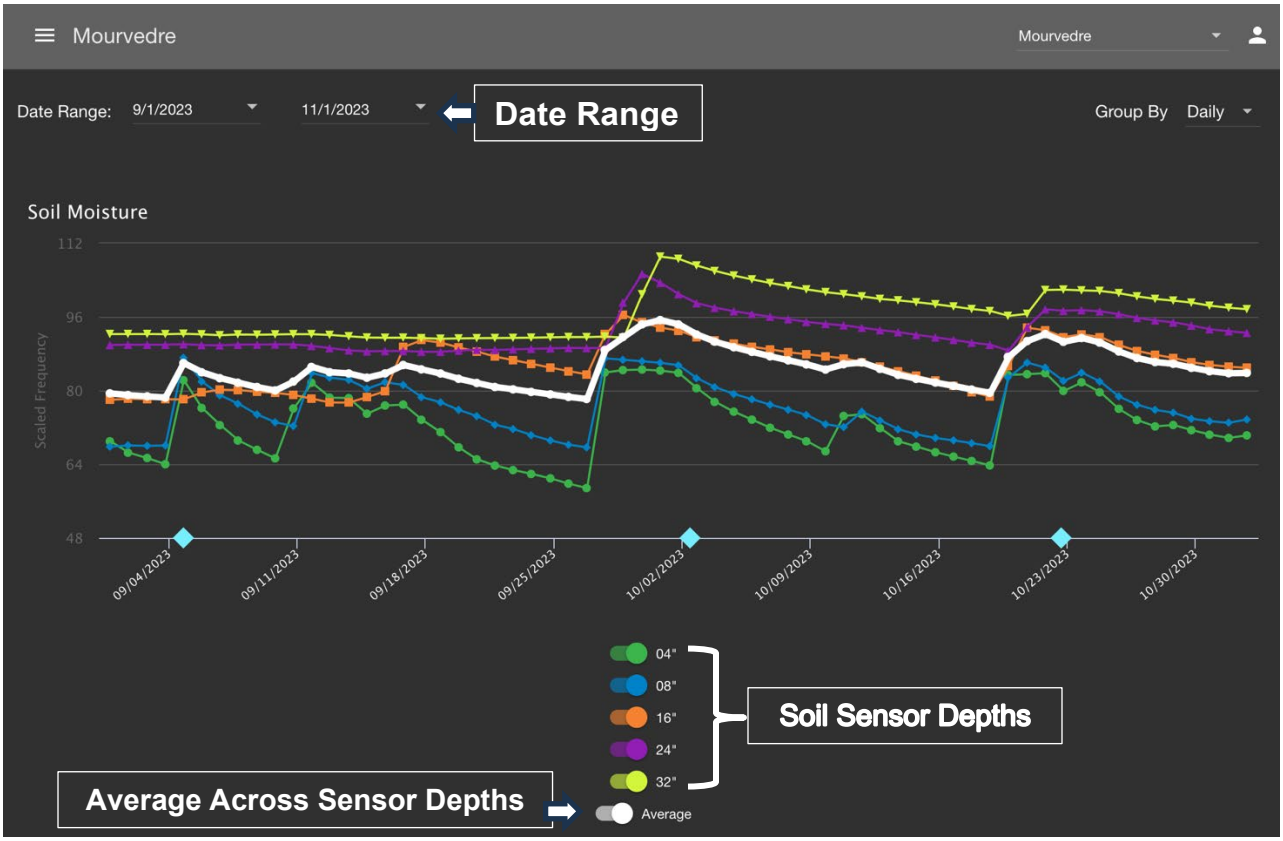
Pre-Budburst	Filling the soil moisture to the full depth of the roots in the soil profile just before bud burst ensures roots have full access to available water coming out of dormancy.
Budburst to Bloom	The soil will gradually dry down as vines progress through bud burst and into bloom due to increased water demand by the growing canopy (transpiration by leaves will draw water from the soil and gradually deplete soil moisture). Water depletion from the soil is also increased by evaporation from the soil surface.
Veraison	Veraison, or color change and softening of the fruit, is the most common growth stage in which water stress is desired to improve potential wine quality, typically just before veraison. The goal is to impose some water stress without causing vine shutdown that could impede ripening. After a brief period of stress, the grower must ensure adequate water is available leading up to harvest to prevent berry shriveling and vine collapse.
Post Harvest / Dormancy	Water demand is lower and less frequent water application is needed after harvest but depending on rain events, growers will want to plan for a few long, deep irrigation sets during this time to ensure that the full root zone is saturated post-harvest and into dormancy.

Interpreting Soil Moisture Data

The example of soil moisture data from a commercial vineyard shown below illustrates how to interpret the data from a **capacitance soil moisture probe**. The probe has 5 built-in sensors that measure soil moisture at 4, 8, 16, 24, and 32-inch depths as shown by the colored lines in the SensorInsight dashboard. Remote soil moisture monitoring allows a grower to see exactly how rain and/or irrigation events change soil moisture levels at various soil depths and relative to vine roots. Regardless of the soil moisture monitoring system you employ, learning to read and interpret trends in your own soil moisture data will allow you to make informed irrigation decisions.

The SensorInsight platform is used here as an example for remote monitoring of vineyard water status. The web-based example is shown below and a grower can access this data from their phone or tablet.

SensorInsight Dashboard – Overview



- The average soil moisture across the profile (the white line) is the number that is commonly used for determining when to initiate an irrigation set and when to shut down the irrigation.
- It is informative to view soil moisture at individual depths to understand how long it takes for water (and possibly injected products or fertilizers) to move to various soil depths and root zones.

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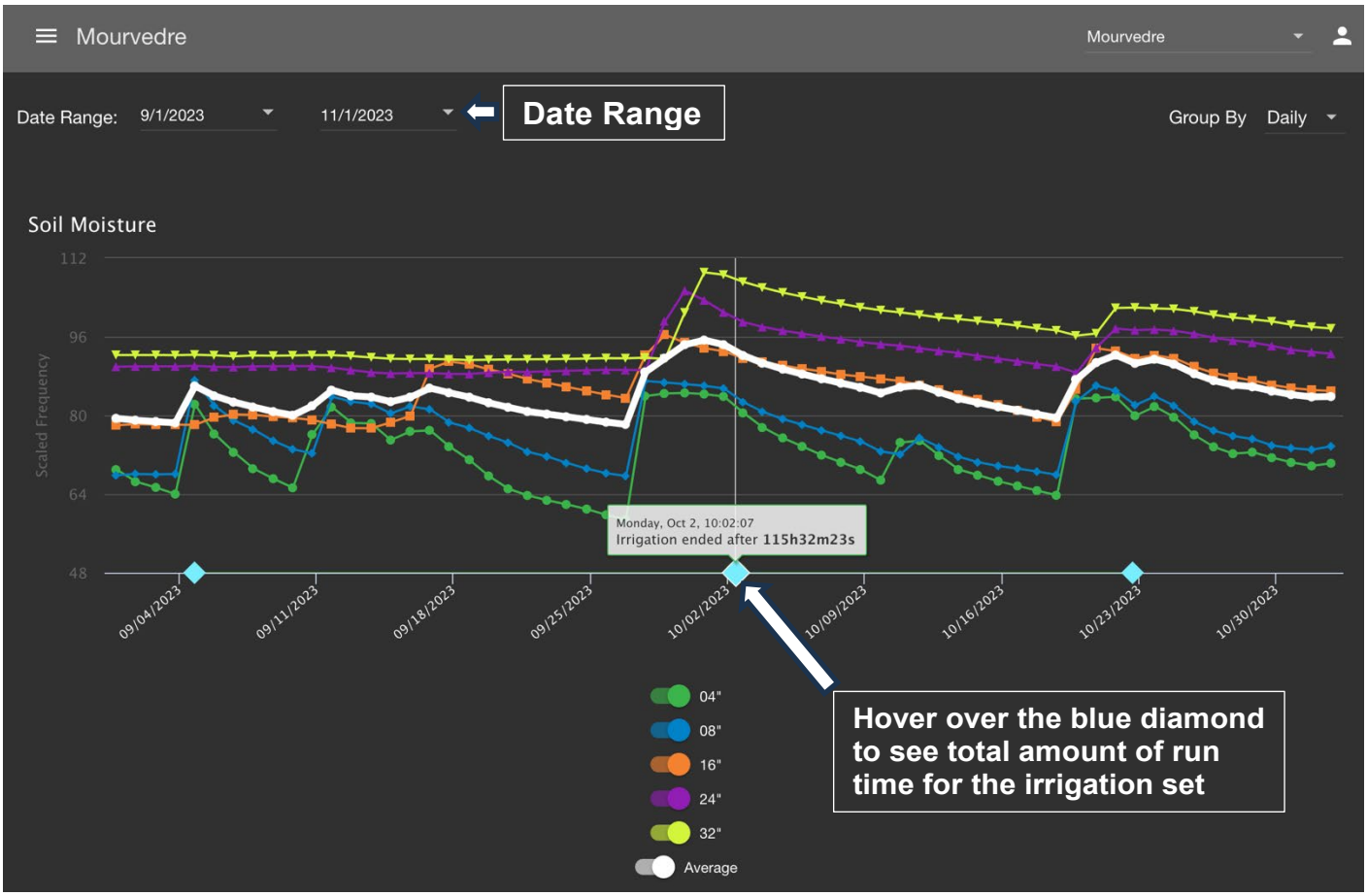
SensorInsight Dashboard – Duration

The duration of irrigation sets should be measured to understand how long the system must run to push water to the desired soil depth. The duration of irrigation sets is measured in the SensorInsight kit by use of a pressure switch installed in the irrigation line, near the soil moisture sensor station.



- In the weeks before harvest, a short irrigation set was initiated near September 4th to push water to a maximum depth of 16 inches as the grower did not want to "overwater" the vines just before harvest. This irrigation set was followed by two rain events (one just before September 11th and another before September 18th) which also pushed water to the 16-inch depth. The sensor data from the two rain events allowed the grower to see that the rain replaced irrigation water to the desired depth of 16 inches. The grower determined that irrigation was not necessary, resulting in water savings.

- The blue diamond, shown on October 2nd, indicates the time of completion of a long irrigation set lasting over 115 hours. This irrigation set was applied just after harvest to fully replenish soil moisture to 32 inches or deeper.

- Another long irrigation set was completed on October 23rd to maintain soil moisture at the deeper soil levels as vines progressed into dormancy. Sensor data allowed the grower to plan irrigation sets to achieve the goal of fully replenishing soil moisture in the root zone just before dormancy was initiated in November.

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SensorInsight Dashboard – Depth & Customization

The SensorInsight dashboard can be customized to exclude data from the soil depths of choice allowing the grower to focus on specific depths based on vine age, soil profiles, and overall seasonal water demands.

- The deepest depths of 24 and 32 inches can be excluded from the graphed data for a block that is planted to young vines, which may not have roots at those depths yet. This allows the grower to focus on soil moisture right in the zone of greatest water uptake by roots.
- In this example, the grower established a lower scaled frequency of 70 as their indicator to initiate an irrigation set (time to replenish soil moisture) and a scaled frequency of approximately 80-85 as the goal for filling the soil moisture in the profile on average (the soil moisture is adequately filled).
- By excluding the deeper sensor depths, the white line shows the average soil moisture of only the depths of interest and is used as the number for indicating when to start and stop an irrigation set.

Matching Soil Moisture Data with Plant Stress Analysis

Using plant stress indicators, particularly in the first year after installing soil moisture sensors, can help a grower understand trends in vine water use, which allows for more accurate estimations of the best times to water and helps ensure vines are getting adequate water for the time of the season.

You can measure plant stress using any of the following methods:

Plant Stress Tip:

Vine water stress can occur very quickly during the peak heat of the summer with a full vine canopy and crop vs. earlier in the season when the temperatures are cooler, and the canopy is smaller and requires less water overall.

Method	How it Works	Best For…
Pressure Bomb	**Measures the leaf water potential of a vine:** • Water potential equates to how well the vine is taking in water from the soil and then transpiring it through the leaves. • The drier the soil is, the harder the vine must work to get the water from the soil (and less soil moisture becomes available), equating to more vine stress.	Large commercial vineyards and researchers
Leaf Porometers	**Measures the stomatal conductance in a small area of a leaf:** • Stomatal conductance is a measurement of how open or closed the stomata are, which in turn can tell the grower how much a vine is transpiring or actively exchanging water and gases with the atmosphere. • Closed or closing stomata generally indicate higher vine stress as vines close stomata to reduce water loss during low water availability or heat stress.	Large commercial vineyards and researchers
Visual Analysis	**Visual assessment of leaf stress:** • Leaves tilting away from the sun, are hot to the touch during mid-day, or wilting are all indicators of water or heat stress. • Actively growing shoot tips are good indicators of sufficient soil moisture whereas shoot tips that are slowing or dead indicate water stress has already occurred.	All vineyards that are concerned about water availability and plant stress

Shoot tips are also a good indicator of water stress, but often by the time a grower sees shoot tip stress or dieback, it is too late to water to avoid excessive stress.

Guide to Judging Shoot Tip Growth

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How to Time Irrigation Sets (Looking for Trends)

Using both soil moisture monitoring equipment and plant stress analysis a grower can determine their “full” and “empty” marks for their specific site, soil, and equipment. In most cases, a scaled frequency of 85 or greater indicates a full soil moisture profile for grapevines. Growers can determine the full mark early in the growing season via a long irrigation set such as 48 hours or more.

Scaled Frequency

The reading off of most volumetric or capacitance soil moisture monitoring equipment will be in scaled frequency (mHz or kHz). A high scaled frequency corresponds to a wet soil whereas a low scaled frequency corresponds to a dry soil.

Without access to plant water stress data, it is difficult to determine the empty mark, which is the number that indicates when a grower should turn on the irrigation. By the time you start to see visible signs of plant stress, it can be too late to irrigate and prevent negative symptoms like fruit shriveling (like the photo shown here) or canopy decline.

Usually, a scaled frequency reading of less than 70 indicates that an irrigation set is needed or will be needed soon, however, it may be lower or higher than 70 depending on the soil type. Growers who wish to impose controlled water stress at strategic times of the season (such as just before veraison) may choose to allow the scaled frequency reading to drop below the “normal” limit (e.g. <70) for a short amount of time or may keep the number lingering at the lower end of the scale for an extended period. After installing soil moisture monitoring equipment, a little trial and error is needed to establish numbers to assign to the “full” and “empty” marks for each site and soil type.

Related Grower Guides

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