2014 Irrigation Demonstration - Mid-Season Review

The purpose of this mid-season review is to share some observations as to how weather, soil moisture, and vine stress data provide useful feedback for irrigation management. The Vineyard Team collected weather, soil moisture and vine stress data from two Cabernet Sauvignon blocks at vineyard sites on the east side of Paso Robles. The sites are referred to herein as site 'A' and site 'B.' The soils and irrigation scheduling strategies applied by the growers differ at each site. For example, site 'A' applies shorter, more frequent irrigation sets, and site 'B' applies longer, less frequent irrigation sets.

Data collection began at bud break of 2014 and will continue until harvest. The participating growers did not previously use combined weather, soil moisture and vine stress data in the past. In 2014 the grower is following their typical strategy for vineyard irrigation with a few adjustments based on the data from soil moisture and midday leaf water potential readings. In 2015, the growers will adjust irrigation schedules based on their observations in 2014. Results from the weather, soil moisture, and vine stress data in 2014 support the usefulness of each component.

Weather	Estimated daily crop evapotraspiration (ETc) data tells the grower how much water they are applying relative to ETc. A clear pattern of increased vine stress was observed when large deficits (<50% of full ETc) were imposed.
Soil Moisture	Shallower percolation of water into the root zone was noticed as ETc increased. Tracking the percolation depth of water is helpful for determining the length of time between irrigations, avoiding excessive soil moisture depletion and untimely vine stress.
Vine Stress	Vine water stress measurements verified the impact of deficit irrigation and soil moisture depletion on vine water status.

Weather

Measuring Crop Coefficients

A common method used for vineyard irrigation scheduling is replacement of all or some of the water removed via crop evapotranspiration (ETc). Local reference evapotranspiration (ETo) was downloaded from four weather sources identified in Figure 2. In order to determine the ETc we calculated the crop coefficient (Kc) for each of the two sites by measuring the shaded area under the canopy at solar noon and multiplied this by the daily ETo.

Equation: $ETc = ETo \times Kc$

Crop coefficients were measured 50 days after bud break by visual evaluation of percent shaded area on a 3’x6’ white foam board with 12” grids, then again at 100 days after bud break using a Paso Panel (Figure 1). The Paso Panel was the faster of the two measurement tools.

Figure 1. Crop coefficient (Kc) was determined by measuring shaded area under trellis at solar noon with a grid board, 50 days after bud break (left) and Paso Panel, 100 days after bud break (right). Kc values were 0.34 and 0.24 at 50 days after bud break and 0.34 and .31 at 100 days after bud break for sites ‘A’ and ‘B’ respectively.

Choosing a Weather Station

The ETc was estimated using various weather sources between bud break (March 23rd) and veraison (July 24th) and ranged from 6.0 to 7.4 inches (Table 1).

Weather Station	Location	Miles from Sites A & B	Estimated ETc from Bud Break to Veraison (inches)
CIMIS	Atascadero	13 & 16	6.0
Spatial CIMIS	Site of Block	0 & 0	6.7
Grower Weather Station	Site A, Paso Robles	0 & 5	7.1
Western Weather Group	Paso Robles Airport	5 & 2.5	7.4

Table 1. Comparison of estimated cumulative crop evapotranspiration (ETc) at site ‘A’ from bud break to start of veraison, 2014 using four weather data sources.

It is an interesting exercise to compare the available weather resources surrounding a site to determine the range of ETo values presented. In this instance the onsite weather data from site ‘A’ tracked closely to the nearest weather station (Western Weather – 5 miles NW) which resulted in cumulative seasonal ETc values within 0.3 inches. Wind speed and relative humidity accounted for most of the difference in calculated ETo values from those two sources.

Soil Moisture

Types of Soil Sensors

Those that attended the Vineyard Team tailgate meeting on monitoring soil moisture in March of 2014 will have an idea of the types of sensors used in the demonstration. Recordings from the meeting are posted as a *Virtual Tailgate Meeting* on the Vineyard Team web site. For the purpose of this update we will focus on the AquaCheck, mostly because it has the largest number of sensors to view data in the soil profile (6 sensors at 8 inch intervals to a depth of 48 inches). For more information on selecting locations to place sensors, see the *Vineyard Team Fact Sheet*. The following types of sensors are included in the demonstration:

- AquaCheck (capacitance probe)
- Decagon EC5 (volumetric sensor)
- Irrometer Watermark (matric potential sensor)

Depth of Water Percolation

Relative water content of the soil (% volume, non-calibrated) was recorded every 15 minutes by the AquaCheck probe, allowing the grower to see the percolation depth of water achieved with each irrigation set. At site 'A,' irrigating a deficit of full estimated ETc resulted in shallower percolation of water (<16 inches – Figure 2). Under conditions of high water demand by vines it is possible that 100% replenishment of ETc may not push water to the lowest depth of the effective rooting area. The grower will also need to consider the amount of available water in the "tank" at the time of watering, as each soil layer must reach field capacity before water will percolate deeper. Data from continuous measurement by soil moisture sensors can show the depth of percolation and patterns of depletion (Figure 2), allowing the grower to see the soil depth and "tank" size being replenished for each irrigation.

If the goal of the grower is to replace the full estimated ETc since the previous irrigation, they can calculate the required run time of the irrigation based on the number of emitters per vine, output of each emitter, and dripper uniformity of the block. A useful calculator is available from UC Cooperative Extension.

Example: Site A

Vine spacing = 6 x 10 ft.

Emitters/vine: 6 ft in-row vine spacing/ 2.5 ft emitter spacing = 2.4 emitters/vine

Gal/vine/hour: 2.4 emitters/vine x 0.5 gph = 1.2 gal/vine/hr

In/hour: 1.60 x 1hr x 1.2 gph/60 ft^2/vine = 0.032 in/hr

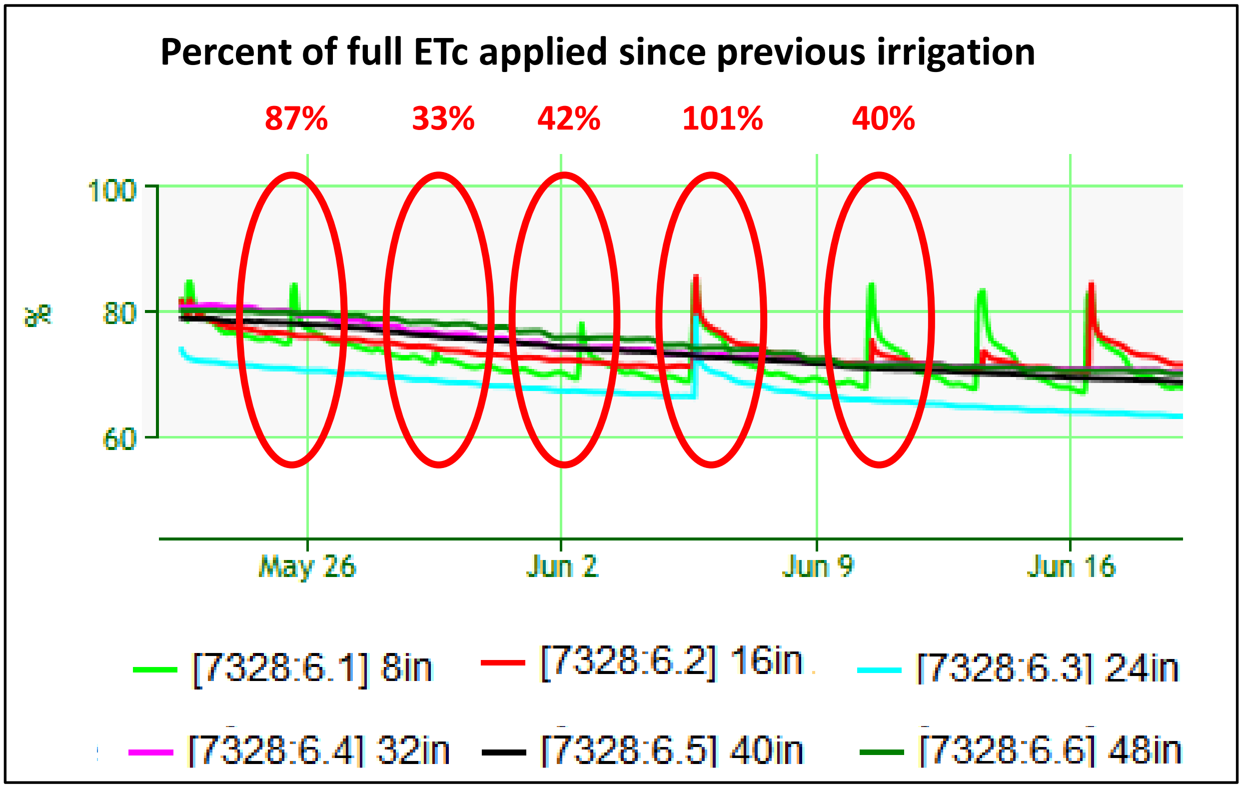

Figure 2. Depth of water percolation shown by AcuaCheck probe sensors at 6 depths, with greater deficit irrigation (less of full ETc) resulting in shallower percolation. An irrigation of 101% of full ETc reached 24 inch depth. Percent volume of water shown is a relative measurement and the sensor is not calibrated to soil type. Shoot tips started slowing on June 2nd.

Patterns of Soil Moisture Depletion

Water uptake by roots increases as the vine's demand for water increases (higher ETc) as a function of warmer weather (ETo) and larger canopy (Kc). We also know that seasonal "feeder" roots will increase in number from bud break through bloom, thus a greater root area will draw more readily from soil moisture reserves and subsequent irrigation sets following fruit set.

Tracking weather and soil moisture data helps growers to evaluate irrigation run time, preventing over or under application of water. Increases in vine water demand are estimated by an increase in daily ETc and observed by shallower percolation of water in soil (greater loss to surface root uptake and evaporation).

For example, a grower that irrigates on a weekly schedule and does not compensate for change in ETc over time may find that the irrigation water does not penetrate as deeply when demand by the vine increases throughout the season. Or they may be over-applying water past the target area. A decrease in relative soil moisture is observed in the deep soil profile over the course of the season (Figure 3).

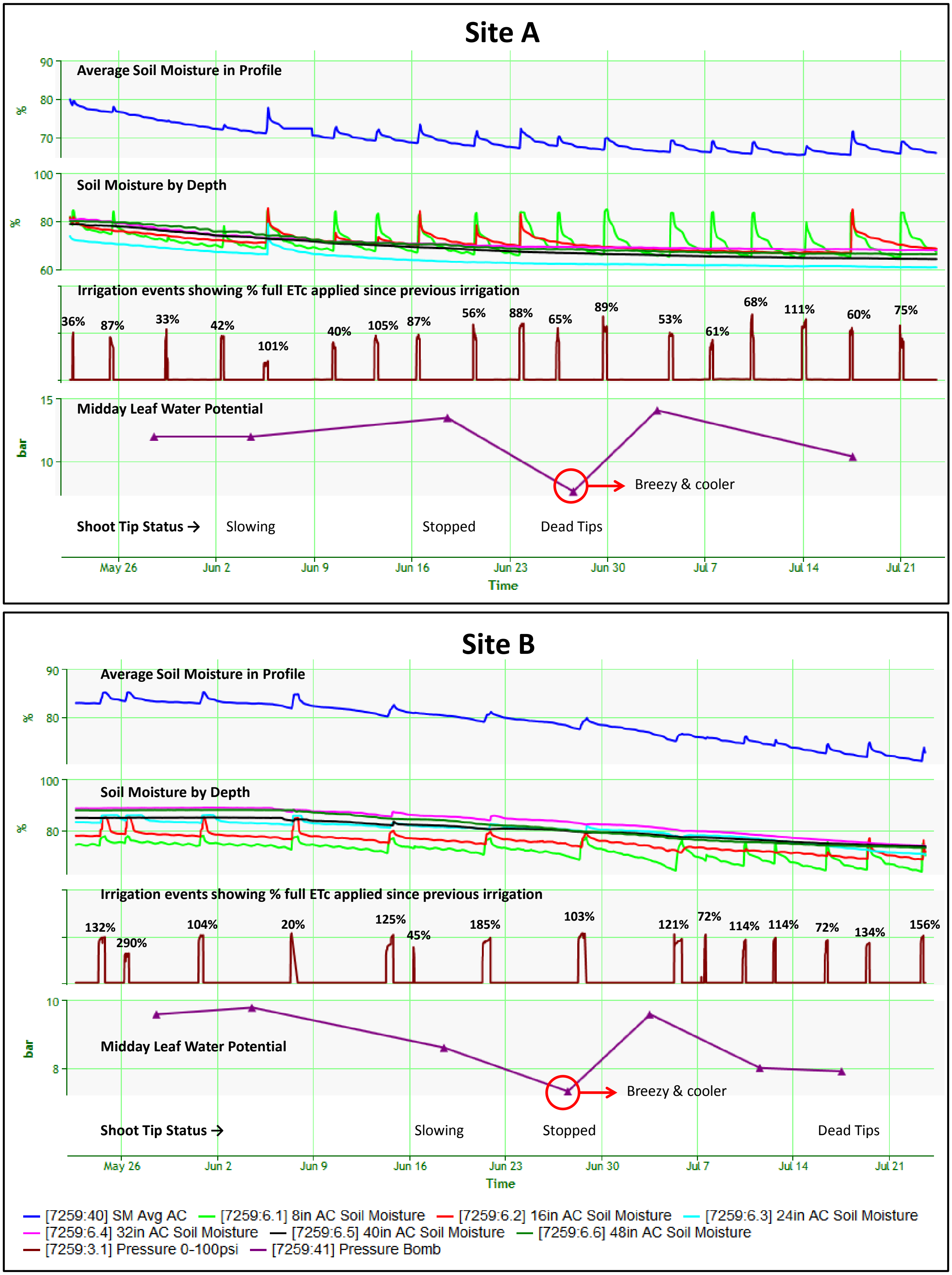

Figure 3. Relative soil moisture content from bud break through veraison is shown alongside of irrigation events, midday leaf water potential, and shoot tip growth status for two vineyard sites. Percent volume of water shown is a relative measurement and the sensors are not calibrated to soil type.

Vine Stress

Midday Leaf Water Potential

Vine water stress can be measured visually, but it is often too late to prevent negative effects of water stress once symptoms are observed. Leaf water potential is a measurement of the water stress a vine is experiencing based on the amount of pressure needed to push water out of the cut end of a petiole.

Levels of winegrape water deficits measured by midday leaf water potential	
Less than -10 Bars	No stress
-10 to -12 Bars	Mild stress
-12 to -14 Bars	Moderate stress
-14 to -16 Bars	High stress
Above -16 Bars	Severe stress

Table 2. Suggested levels of winegrape water deficits measured by midday leaf water potential. (Recreated from Smith & Prichard, 2002)

Vine stress data was measured weekly by midday leaf water potential using a pressure chamber (pressure bomb). Vine stress readings were lowest just after an irrigation event and were highest when measured farther from irrigation sets and under hotter conditions. Ideally, vine water stress should be measured in the days leading up to an irrigation event to indicate when the maximum level of desired vine stress is achieved. We also noted that vineyards applying a greater deficit had overall higher (more negative) pressure readings (-12 to -14 bars = moderate stress – Table 2). The lowest measurement (least negative) was taken on June 27th when conditions were not favorable for reliable readings (breezy and cooler, Figure 3).

Visual Vine Stress Indicators

Shoot tip growth status, leaf angle, and shoot length are visual cues commonly used to assess vine stress (Figure 4). Shoot tip growth slowed and eventually stopped at each site, which was likely caused by a combination of water stress induced by irrigation deficits, increased temperature, and shallower watering depth. At site ‘A’ the shoot tip growth began slowing and stopped one week before those at site ‘B’ (Figure 3). Shoot tips died back at site ‘A’ on June 27th but did not die back at site ‘B’ until July 17th. It is interesting to note that the average percent of full ETc applied in the month of June was 66% at site ‘A’ and 96% at site ‘B,’ which likely accounted for the earlier shoot dieback at site ‘A.’ We also see that the irrigation set at site ‘A’ did not reach 16” depth beginning on June 26th, just before the dieback was observed.

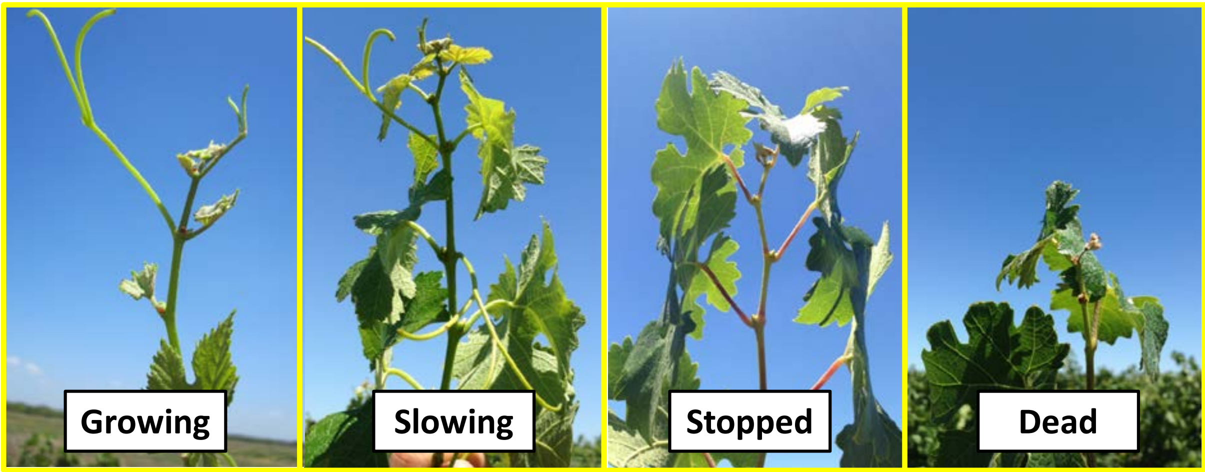

Figure 4. Four stages of shoot tip growth used as a visual indicator of vine stress.

Seasonal high temperatures reached upwards of 100F on several occasions in 2014 (Figure 5). The combination of soil moisture and weather data may have helped the grower at site 'A' to prevent shoot tips from slowing down had they adjusted their irrigation based on the increased ETc value. Conversely, this same data can be used to slow or stop shoot tip growth if that is the goal (such as near veraison).

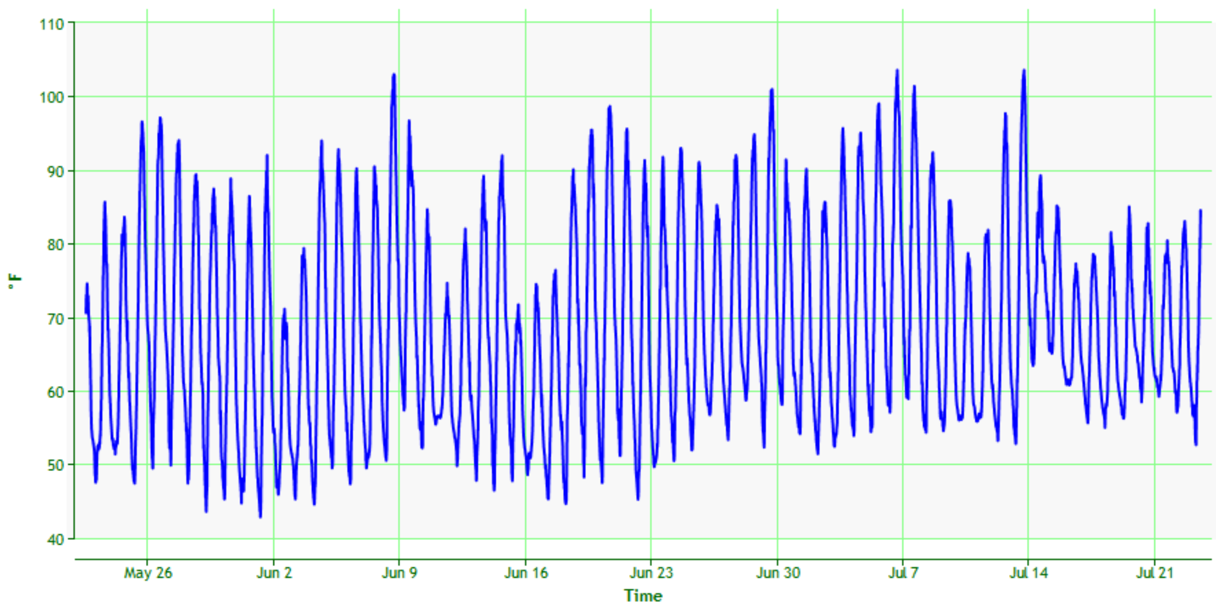

Figure 5. Daily ambient temperatures recorded at site 'A' between bud break and veraison.

Take Home Message

The combination of weather, soil moisture, and vine stress data provides a broad scope of data to help growers schedule irrigation. Visual observations such as shoot tip growth are useful measures for showing vine stress after the process has initiated. The data above indicates that it is possible to predict vine stress prior to visual observation by monitoring daily evapotranspiration of the crop and moisture in the soil profile.

Links to References and Resources

- Using the *Paso Panel* to quickly measure the canopy shaded area and estimate vineyard irrigation crop coefficients. Battany, M. UC Cooperative Extension.
- Using a pressure chamber in wingrapes. Smith, R. & Prichard, T. UC Cooperative Extension.
- Vineyard irrigation converter worksheet. Battany, M. & Tindula, G. UC Cooperative Extension.
- Vineyard Irrigation Scheduling worksheet – Paso Robles area. Smith, R. et al. UC Cooperative Extension.