Defining a Central Valley Almond ET/Yield Production Function for Almonds

Project No.: **12-HORT17-Shackel/Doll/Fulton/Sanden**
(Also reports on activities for project 11-HORT15-Shackel)

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Objectives:

The primary objective of this multi-year research is to define a Central Valley almond ET/yield function for almonds. For this first year, baseline information on the study orchards was obtained under Project 11-HORT15-Shackel:

- Obtain a VERIS map of the three proposed orchard locations.
- Develop a tentative experimental layout for each site.
- Install water meters on irrigation laterals covering the layout to describe grower practice and evaluate system uniformity.
- Make periodic measurements of midday stem water potential (SWP) for trees within the layout during the 2012 growing season.
- Obtain midseason canopy cover (light bar) and harvest values for the 2012 season, including row values from the layout and tree values from the SWP trees.

Interpretive Summary:

In each of three counties (Tehama, Merced, and Kern) a commercial almond orchard was selected representing a cross-section of soils and environmental conditions across the almond growing regions of the state. Beginning with the 2013 season, irrigation treatments ranging from 70% to 110% actual evapotranspiration (ETc) will be imposed at these sites to develop an almond water production function (yield versus water use). In 2012, pre-treatment data on soils, yield, canopy cover, irrigation, and tree water status were collected. At each site, soil maps indicated a significant spatial variability. This information was used in selecting blocks for the 2013 irrigation treatments. Trees at the Tehama and Kern Co. sites were irrigated close to full evapotranspiration (94% to 103% ETc, respectively), and interestingly, even though trees at the Merced site were given relatively less water (75% ETc), the trees at this site exhibited less stress as measured by Stem Water Potential (-12.6 bars seasonal average SWP) than the trees at the Kern and Merced sites (-13.2 and -15.9 bars, respectively). Yields were relatively low in the Kern site because of frost (1420 pounds nutmeats per acre), but comparable at the

Tehama and Merced sites (1940 and 2160 pounds per acre, respectively). However, even at these sites the pounds nutmeats per percent sunlight was 35-38, lower than the benchmark value found by Bruce Lampinen. This may indicate that water is still limiting yield at these sites, and we anticipate answering this question in the following years of this project.

Materials and Methods:

Three commercial almond orchards and grower cooperators were selected representing north, south and central almond growing regions of the state (see **Figure 1**). VERIS soil sampling and maps were obtained from local contractors as seen in the spring as soil moisture conditions allowed. Water meters were installed prior to any in-season irrigation, and applied water was compared to ETc, calculated using established seasonal values of Kc and local CIMIS weather conditions for reference evapotranspiration (ET). SWP was measured approximately bi-weekly in April/May, weekly May/August, and bi-weekly after harvest. Mid-season canopy cover data was collected using the mule light bar, and row and tree harvests collected, weighed, and sub-samples collected for crack-out.

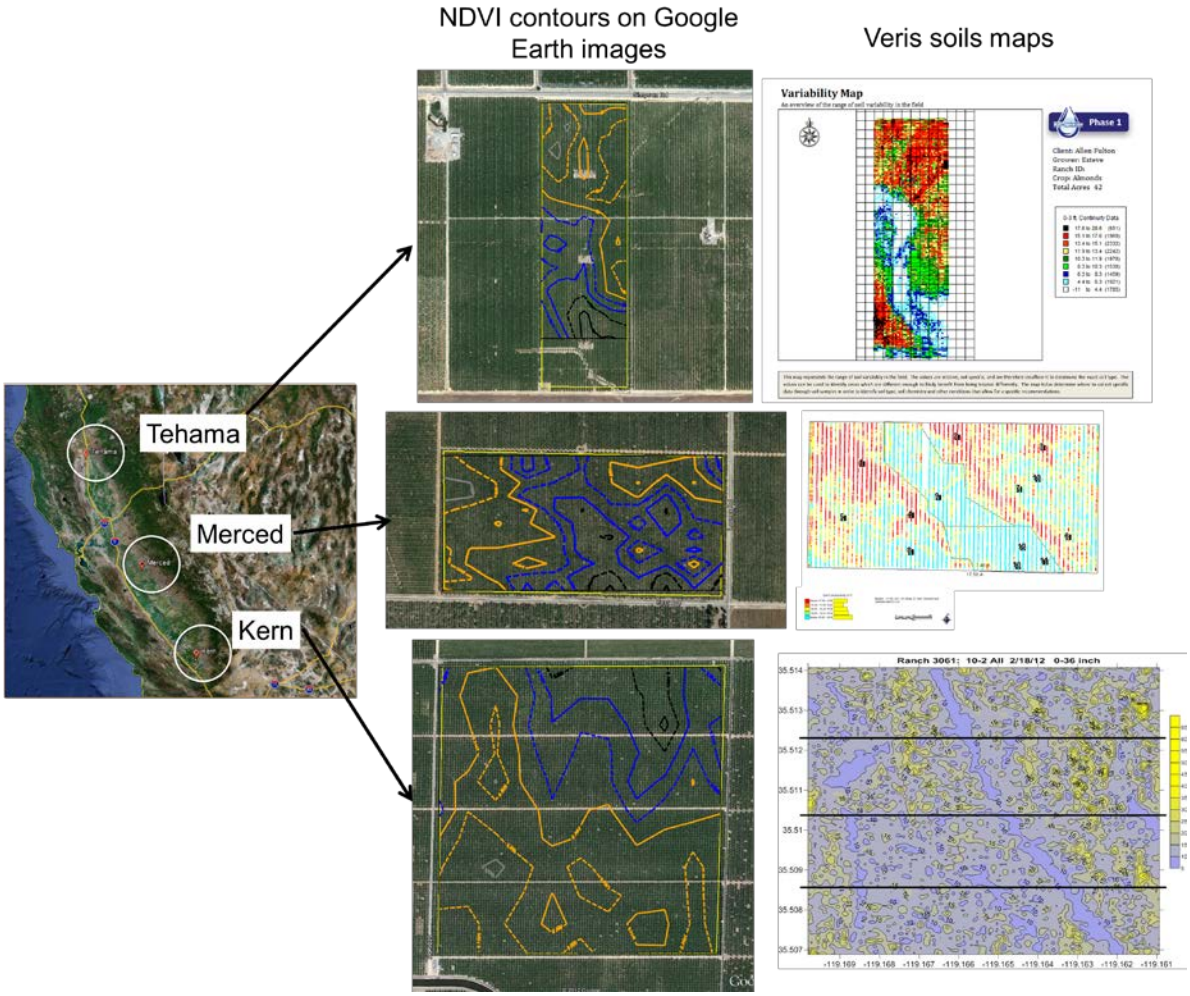

Figure 1. California map showing the location of study sites (left), recent Google Earth images, overlaid with contours derived from satellite images of canopy density (NDVI, center), and Veris soils maps (right).

Results and Discussion:

In this first year we are documenting within- and between-site differences in soils, tree stress and tree productivity, in order to establish treatment blocks designed to cover the available spectrum of conditions at each site. At all sites, but particularly the Merced and Tehama site, differences in vigor across the orchard could be seen on Google Earth images, and in most cases the overall patterns were associated with satellite-based NDVI data and VERIS soils maps (**Figure 1**). For almonds, it can be anticipated that some differences in yield will be associated with differences in canopy size, so mid-summer canopy size, as measured by midday light interception (% interception of PAR (photosynthetically active radiation), **Figure 2**) was measured and used to block the irrigation treatments that will be imposed starting in 2013. Overall, there were clear and consistent north-to-south differences in both rainfall and ETc (**Table 1**), with higher rainfall and lower ETc in the north (Tehama) compared to the south (Kern), with Merced intermediate in

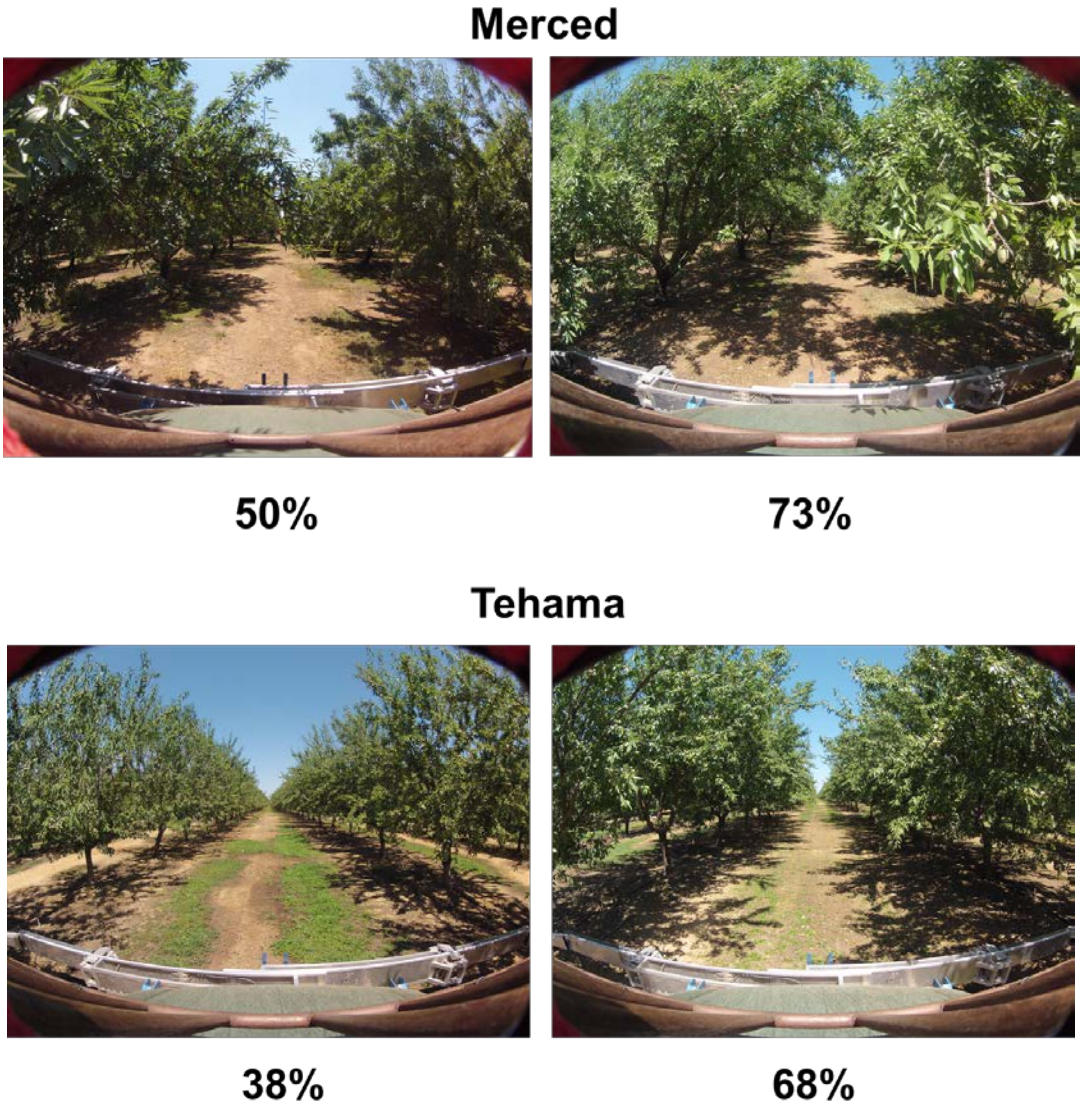

Figure 2. Examples of low and high % PAR interception in different areas of the orchard at the Merced and Tehama sites.

both cases. For normal grower practice at these sites, the seasonal total of rain plus irrigation was similar to ETc at Kern and Tehama, but was only 75% of ETc at Merced (**Table 1**). At all sites the seasonal pattern of irrigation was similar to the pattern in ETc, but especially at the Merced site a progressive irrigation deficit developed over the season (**Figure 3**). Interestingly however, a sufficiency or even excess of applied water compared to ETc did not result in SWP values at the baseline for any site (**Figure 3**). It is not clear yet whether the productivity of mature trees is reduced if SWP is below the baseline, but this question will be addressed over the course of this project. It is also important to note that even though the Merced site had the largest irrigation deficit (**Table 1**), the trees did not exhibit the lowest (most stressed) SWP (**Table 2**), and only experienced a mild to moderate level of stress (-17 bars) during the season (**Figure 3**). One objective of the water production function (WPF) project will be to determine whether orchard productivity is more closely related to SWP than it is to applied water across sites, in which case, instead of a water production function, a SWP production function may be more appropriate for almonds. The seasonal average baseline SWP values were very similar at all sites (**Table 2**), indicating that similar levels of vapor pressure deficit (VPD) prevailed when SWP measurements were made.

Table 1. Comparison of seasonal totals rain+irrigation and ETc for each site.

Site	March 1 – November 23, 2012				
	ETc	Rain	Irrigation	Total	%ETc
North (Tehama)	45.8”	7.7”	35.6”	43.3”	94%
Central (Merced)	49.4”	5.6”	31.6”	37.2”	75%
South (Kern)	51.0”	2.2”	50.5”	52.7”	103%

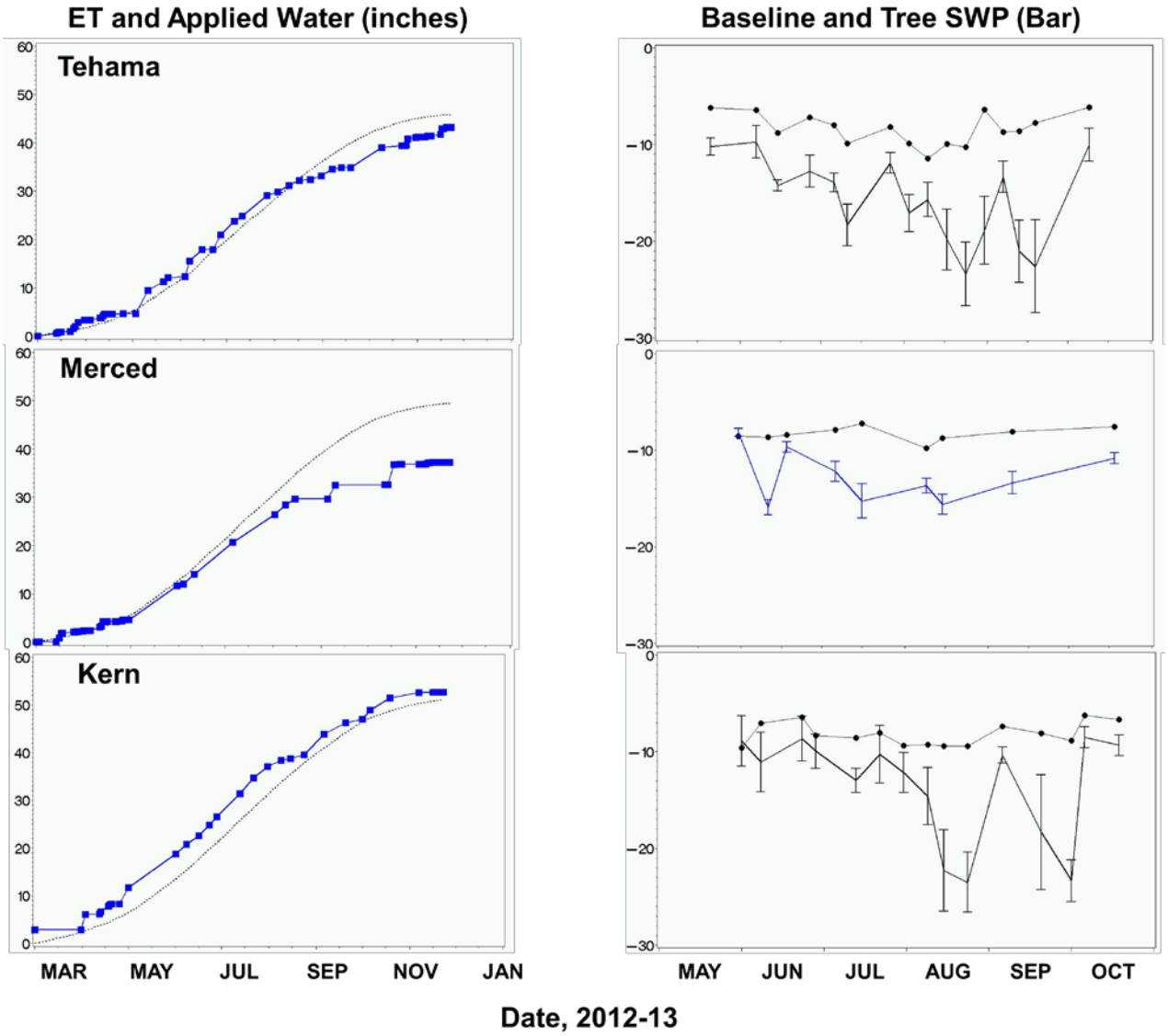

Figure 3. Seasonal patterns of ET (dash line) and applied water (solid line and filled squares, left) and non-stressed baseline SWP (black line and dots) with observed orchard SWP (+/- 2SE, right) at each site.

Table 2. Comparison of seasonal average baseline and observed SWP values at each site.

Site	Stem water potential (bar)	
	Baseline	Tree water stress average (& range)
North (Tehama)	-8.4	-15.9 (13-18)
Central (Merced)	-8.3	-12.6 (9-15)
South (Kern)	-8.1	-13.2 (11-16)

Orchard yields were reduced at the Kern site due to frost. Hence, even though it had the highest %PAR, it did not have the highest yields (**Table 3**). Even at the other two sites, the yield/%PAR was below the benchmark of 50 typically found in almonds (**Table 3**). Once irrigation treatments are imposed in 2013, we will be able to determine whether these yields have been historically limited by water.

Table 3. Mid-summer % sunlight (PAR) interception by the nutmeat yield, canopy, and yield per unit PAR for each site.

Site	Nutmeat Yield (Lbs./ac)	% PAR Interception Average (& range)	Lbs./%PAR
North (Tehama)	1940	51% (25-75)	38
Central (Merced)	2160	61% (53-67)	35
South (Kern)	1420	69% (61-78)	21

Our sites represent a wide cross-section of almond growing areas and conditions, and hence should provide a good context for the development of an almond water production function (WPF). Our preliminary data has indicated that different amounts of water compared to ETc may be required for different locations/soils to achieve the same level of tree water status. Hence, it is possible that an almond WPF may be soil specific which will have important implications for water management throughout the state.

Research Effort Recent Publications:

None at this time.