Fertigation: Interaction of Water and Nutrient Management in Almonds

Project No.: **08-HORT11-Shackel/Sanden**

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Objectives:

The primary objective of this study is to document the amount of water applied to the experimental plots of the P. Brown fertigation study (including the collection of data related to evapotranspiration crop (ETc), and to monitor the effects of the grower's irrigation management on tree stem water potential (SWP) at these sites. At one site (Belridge), more detailed measurements of soil moisture and ET are made and will be reported separately by Blake Sanden. We anticipate that the SWP data will serve as an important covariate in statistical analyses of the Brown study data, particularly any recommendations based on the relation of applied N to tree N status. A broad objective of this combined research effort is to determine whether there is an optimal combination of tree water and nutrient status to achieve high and sustainable almond yields and quality.

Interpretive Summary:

Methods: The basic experimental approach for this project was established by P. Brown and cooperators in a proposal entitled "Development of a Nutrient Budget Approach to Fertilizer Management in Almond." Brown proposed to take detailed nut/leaf samples 5 times over the season from 10 trees in each of 5 experimental sites,

distributed around the almond growing regions of the state, three of which are the subject of this report (**Table 1**). (For details on the Kern Co. site see: HORT11b-Sanden/Shackel) All of these sites are micro-sprinkler or drip irrigated. Individual tree yields were also collected from approximately 100 trees at each site, but yield values are not yet available. At each site, we installed water meters on two (2) representative lateral irrigation lines, and also a pressure sensor instrument in one line with a datalogger, which recorded system on and off times. This information was used to document the amounts and timings of irrigation water applied, which was compared to nearby CIMIS estimates of ETc. At approximately monthly intervals from May to September, the trees sampled in the Brown study were sampled for midday SWP by us, using the pressure chamber technique. Water meters were read and data from the dataloggers collected periodically during the season, at least as often as SWP measurements are made.

(For additional research related to this project please see:
PREC 2 Brown – Development of Leaf Sampling and Interpretation Methods for Almond/Development of a Nutrient Budget Approach to Fertilizer Management in Almond)
HORT 11(b) Sanden/Shackel – Fertigation: Interaction of Water & Nutrient Management – Kern Co
HORT 13 Lampinen - Development and Testing of a Mobile Platform for Measuring Canopy Light Interception and Water Stress in Almond
Air 2 Smart – Nitrous Oxide Emissions from an Irrigated Almond Orchard)

Table 1. Information for the 3 study sites covered in this report.

Site Name	Irrigation System	Tree Spacing (ft)	Row Spacing (ft)	2009 Full Bloom Date
Arbuckle	drip	18	22	Feb. 25
Salida	micro-sprinkler	20	22	Feb. 26
Madera	micro-sprinkler	15	22	Mar. 8

Results: The 3 sites of this study showed contrasting patterns for both applied water (**Figure 1**) and SWP (**Figure 2**). In **Figure 1**, the upper dashed line represents an upper limit estimate for ETc (based on a full cover crop orchard), and the lower dashed line a lower limit estimate (clean tilled orchard). These lines indicate the degree of uncertainly based on the presence or absence of a cover crop, but it must also be recognized that there is currently some uncertainty regarding the appropriate crop coefficients for almond, and so these reference lines must be regarded as tentative. All of the orchards studied were within these reference limits during 2009, but at the Madera site, irrigation was discontinued for an extended time at the start of harvest (mid-August), and there was a clear decrease in SWP as a result (**Figure 2**).

It is also interesting to note that the mid-August and mid-September SWP readings in Salida showed significant tree stress, and this was associated with the end of a period of 9 and 14 days, respectively, since the last irrigation. In both of these orchards the trees had exhibited a SWP similar to the baseline (non-stressed) value earlier in the season, and the cumulative irrigation applied to both, particularly Salida, were close to the upper estimate of ETc at the time when the trees were exhibiting this stress.

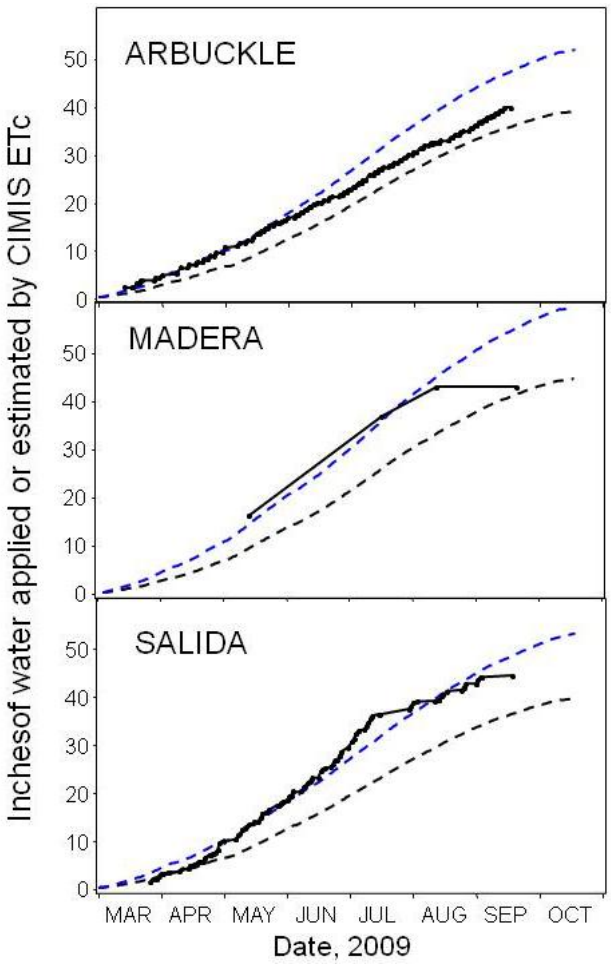

Figure 1. Cumulative inches of water applied by the grower or by rain in 2009, and upper (full cover) and lower (clean tilled) CIMIS estimates of irrigation requirements (ETc, dashed lines) for each site. Points connected by solid lines represent irrigation events, and the solid line shown for Madera is based on periodic water meter readings (irrigation event data was not available).

The fact that the trees in Salida exhibited a level of stress after only 9 or 14 days without irrigation than did the Arbuckle trees in mid-August (around -20 bars), when the Arbuckle trees had been experiencing substantially less cumulative irrigation compared to ETc throughout the season (**Figure 1**), may indicate that some withholding of water and allowing of mild SWP stress to occur early in the season, may be an effective acclimation strategy to avoid substantial drops in SWP over relatively short times when irrigation is withheld later in the season.

As found in 2008, there were significant tree-to-tree differences in SWP at all sites (**Table 2**), but it is not yet clear whether or not these will be related to differences in tree yield. Values for individual tree yields are not yet available.

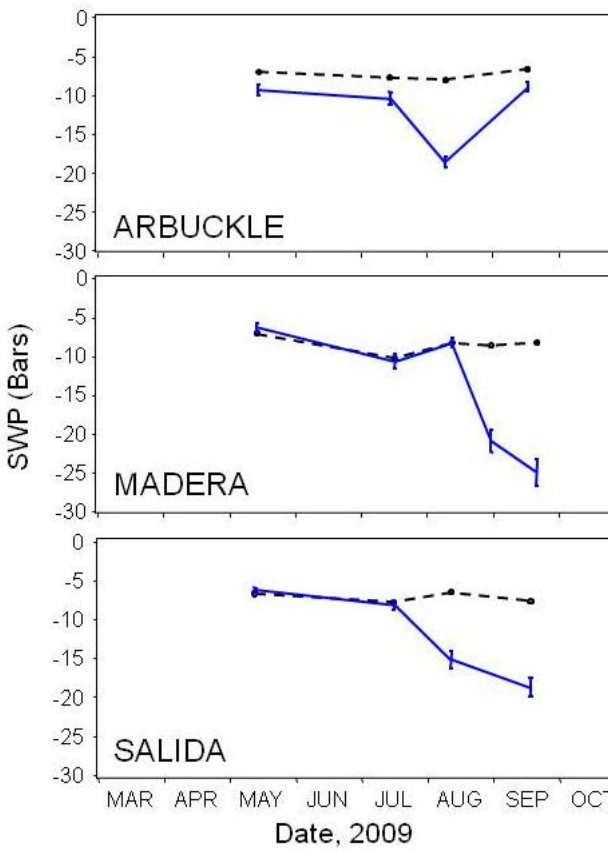

Figure 2. Seasonal pattern of observed stem water potential (SWP), and for reference, the SWP expected for fully irrigated almond trees (non-stressed baseline). Error bars are ±2 SE and indicate variation among trees (N = 24).

Table 2. SWP (bar) range in observed tree stress within each site, and the overall average SWP for all trees at each site, compared to that expected for non-stressed almond trees (baseline). Also shown is a statistic indicating the significance of tree-to-tree variation at each site.

Site Name	Lowest stressed tree SWP (season average)	Highest stressed tree SWP (season average)	Overall seasonal average SWP for all trees	Average seasonal baseline (non-stressed) SWP	Tree variation statistic
Arbuckle	-10.0	-16.4	-11.9	-7.4	0.0001***
Salida	-8.8	-15.4	-14.2	-7.1	0.0016**
Madera	-11.0	-19.2	-12.1	-8.5	<0.0001***