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 Patrick Brown fertigation study (08-WATER3-Brown Development of a Nutrient Budget Approach to Fertilizer Management in Almond). This includes the collection of data related to ETc, monitoring 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 will be made in the contrasting fertilizer treatments being applied in order to document whether fertilizer management can also influence tree water demand. 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:

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" (08-WATER3-Brown). 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 (Table 1). All of these sites are micro-sprinkler or drip irrigated, and two (Belridge) are a side-to-side comparison of micro-sprinkler and drip, combined with multiple levels of N and K application rates. Individual tree yields were also collected from approximately 100 trees at each site, but 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. Water meters were installed at the Arbuckle, Salida, and Madera sites in late April and early May. One Madera meter was damaged by a tree limb and re-installed following repairs. This information was used to document the amounts (Table 2) and timings of irrigation water applied, and to estimate the degree of spatial variation within the irrigation system, at least to the level of the irrigation lateral. 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 developed by Shackel (http://groups.ucanr.org/fnric/General_Management/The_Pressure_Chamber,_aka_The_Bomb.htm). Water meters were read and data from the dataloggers collected periodically during the season, at least as often as SWP measurements are made. Data from nearby CIMIS stations was obtained and the seasonal pattern of water applied was related to calculated values of almond ETc. At one site (Belridge), neutron access tubes were installed and calibrated in selected treatments so that soil moisture can be accurately monitored and a tree water budget estimated.

Table 1. Information for the 5 study sites monitored in 2008, with "monitoring period" referring to the period of time covered as of this report.

Site Name	Irrigation System	Tree Spacing (ft)	Row Spacing (ft)	2008 Full Bloom Date	2008 Monitoring Period
Arbuckle	drip	18	22	Feb. 29th	4/24/08-8/28/08
Salida	micro-sprinkler	20	22	Mar. 3rd	4/29/08-9/8/08
Madera	micro-sprinkler	15	22	Mar. 4th	5/5/08-9/9/08
Belridge (fanjet)	micro-sprinkler	21	24	Feb. 29th	2/7/08-9/30/08
Belridge (drip)	drip	21	24	Feb. 29th	2/7/08-9/30/08

Table 2. Water applied and CIMIS ETo for the monitoring period, and baseline and measured midday stem water potential (SWP) for the same period. The SWP difference between the measured and baseline values is a relative indicator of average stress experienced at that site (a more negative value means more stress). Also shown is a statistic indicating the significance of tree-to-tree variation at each site.

Site Name	Applied Water (in.)	CIMIS Cumulative ETo (in.)	Applied Water (% ETo)	Baseline SWP (Bars)	Measured SWP (Bars)	SWP difference (bars)	Tree variation statistic
Arbuckle	25.5	30.7	83.00	-8.9	-13.7	-4.8	0.1989
Salida	40.0	33.5	119.58	-7.0	-12.7	-5.7	<0.0001***
Madera	16.9	35.7	47.26	-7.8	-17.4	-9.6	<0.0001***
Belridge (fanjet)	50.7	49.2	103.1	-8.0	-10.0	-2	<0.0001***
Belridge (drip)	51.7	49.2	105.1	-8.0	-8.8	-0.8	<0.0001***

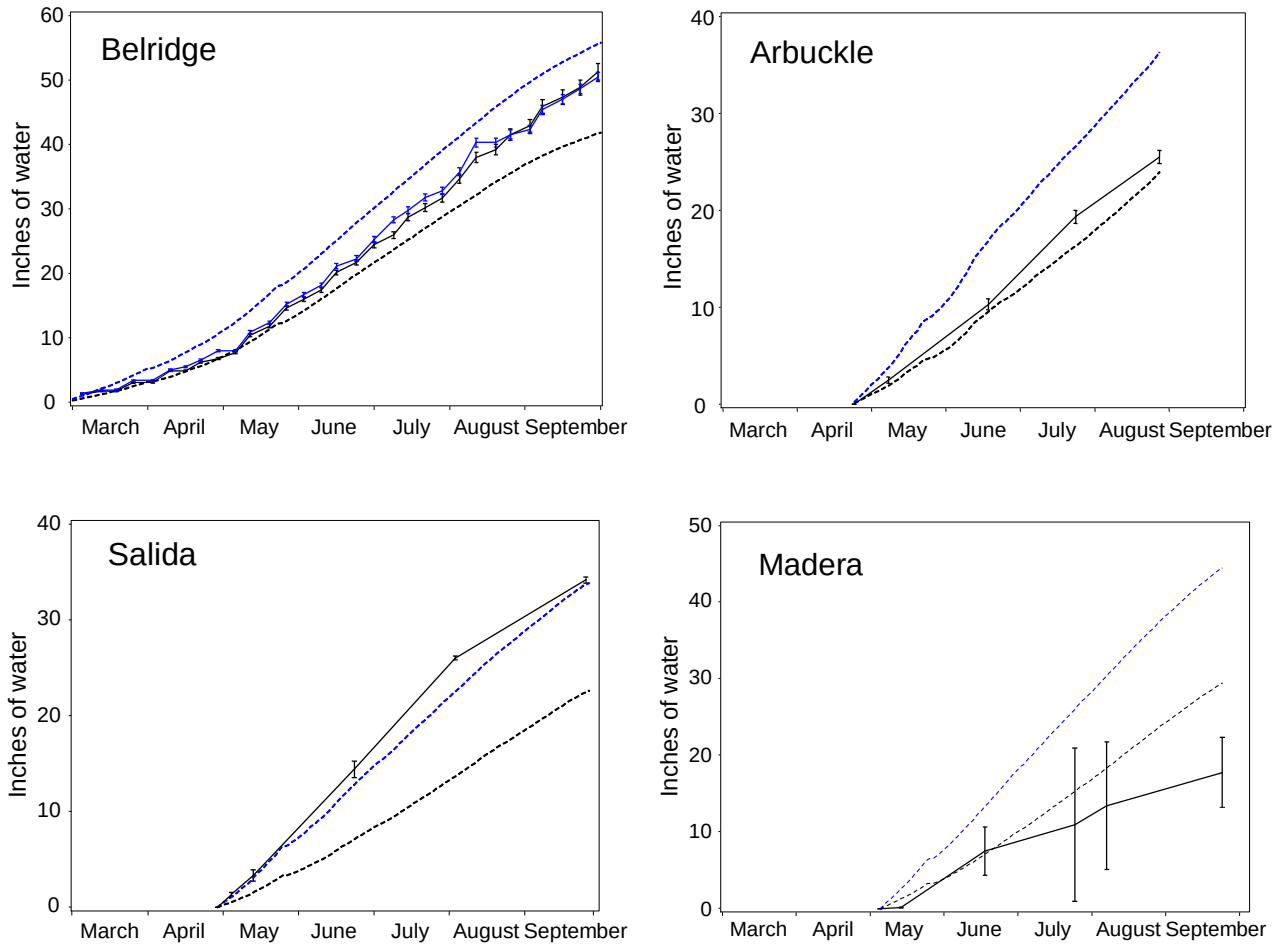

Figure 1. Cumulative inches of water applied during the observation period (starting with water meter installation, solid lines), and upper (full cover) and lower (clean tilled) CIMIS estimates of irrigation requirements (ETc-rain, dashed lines). Error bars are ±2 SE and indicate variation in the water applied through two independent lateral lines.

The 5 sites of this study showed contrasting patterns for both applied water (Fig. 1) and SWP (Fig. 2). In figure 1, the two dashed lines represent a high and a low estimate for ETc (full cover orchard and clean tilled orchard, respectively), with one site near the lower limit (Arbuckle), one near the upper limit (Salida), one between the two limits (Belridge) and one site both below the lower limit and exhibiting a substantial degree of variability (Madera). Normal irrigation management at the Madera site involved long sets and infrequent irrigation compared to multiple irrigations per week at the other sites, but the Madera site also experienced irrigation equipment breakdown during this season, resulting in much lower applied water amounts (Fig. 1) and SWP values (Fig. 2) than the other sites. Belridge generally showed the highest (least stressed) SWP, Madera the lowest SWP and Arbuckle and Salida intermediate stress levels (Fig. 2 and Table 2). At 4 of the 5 sites there were highly significant tree-to-tree differences in SWP (Table 2), and these may be important in explaining tree-to-tree differences in leaf N levels and/or yield (data not yet available).

Tree stress, as measured by SWP, is influenced both by the environment and by soil water availability. The average baseline SWP value shown in Table 2 takes into account the environmental effects of air temperature and humidity on the sampling dates of this study, and hence the SWP difference is an indication of the relative stress levels at each site. The Madera site was clearly affected by the irrigation system breakdown, but among the other sites, it is interesting that the Salida site, which had the highest amount of applied water, was not the site with the lowest stress level. More frequent measurements will be necessary to confirm this trend, and since soil water availability for a give irrigation level may also depend on soil characteristics, future work should include a more thorough analysis of the soil conditions at these locations.

This was the first year of the project, and data from irrigation application and SWP for each site will be correlated with yields and tree N once the data is available. As a result of significant tree to tree differences in SWP, tree N and yield data will be analyzed for individual trees. A final post-harvest leaf and SWP sampling will be conducted in late October at all sites.

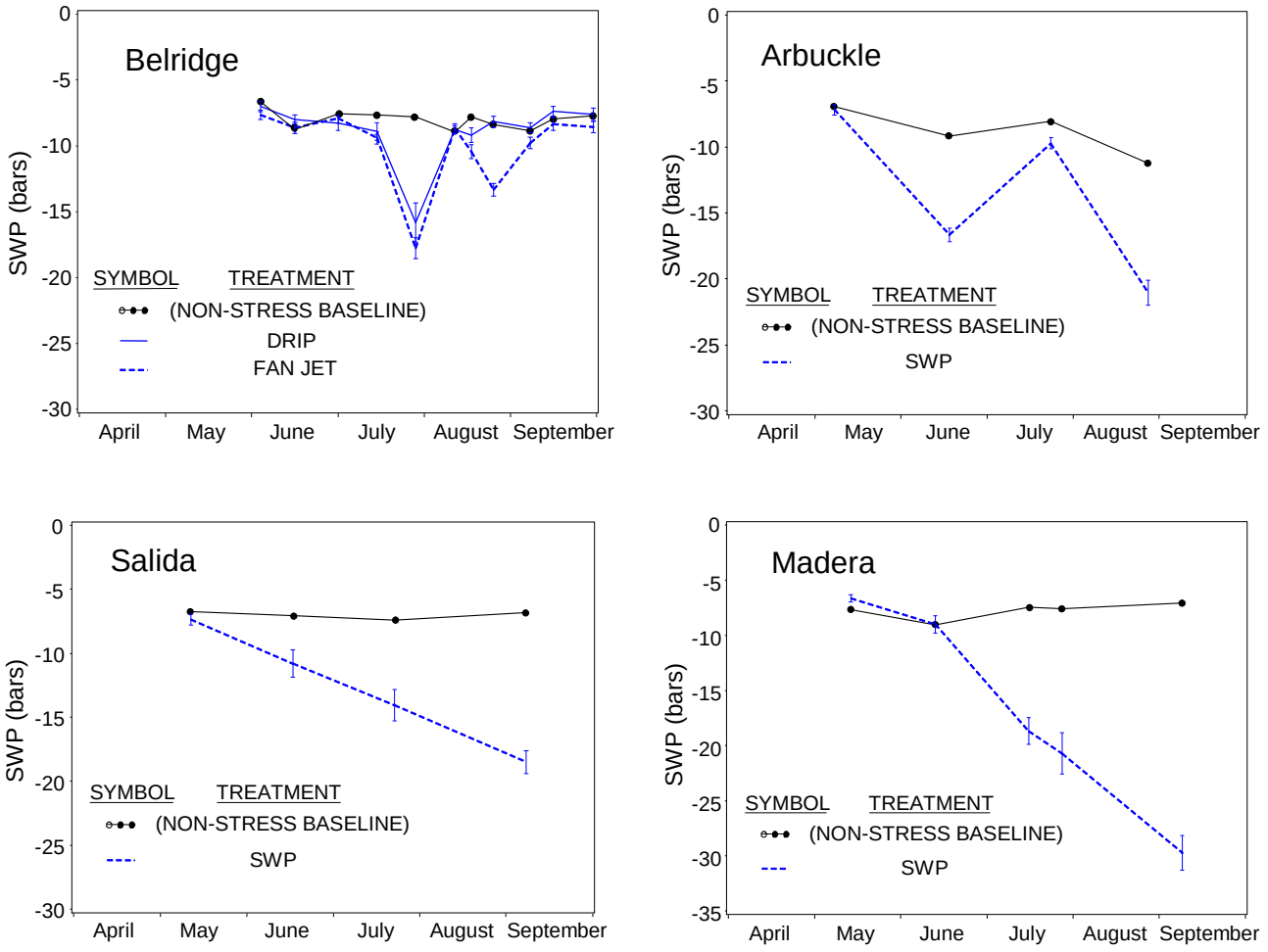

Figure 2. Seasonal pattern of observed stem water potential (SWP), and for reference, the SWP expected for fully irrigated almond trees (non-stressed baseline). Error bars are ±2 SE and indicate variation among trees (N = 30 for Belridge fan jet and N=24 for all others).