Fertigation: Interaction of Water Management and Nutrient Management in Almond

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Background: Water and nutrient management are both key factors for maximizing almond yield and minimizing environmental impact. This project focuses on the interplay between these factors, and, among others, the question of whether or not the nutrient status of the plant can influence plant water demand, or the water status of the plant can influence nutrient demand. This effort is part of a multiyear, multidisciplinary, and multi-location project "Revisions to a Nutrient-Budget Approach and to Leaf Sampling Methods for Fertilizer Management in Almonds" being conducted by Patrick Brown and colleagues.

Specific Objectives for 2011

1) **As part of the larger fertilizer study by Patrick Brown, document the amount and timing of water applied to each study site**
2) **Monitor plant water potential at each of the fertilizer/nutrient study sites to determine whether irrigation and fertilization levels independently influence tree nutrient status.**
3) **In the southern San Joaquin Valley site, use soil moisture, meteorological, and satellite-based remote sensing methods to monitor non-stressed almond evapotranspiration (ET) under both drip and microsprinkler irrigation. Assess the impact, if any, of fertility on almond ET through replicated sites in this one orchard.**

Results.

As observed in previous years, early season (May) SWP values were similar at all sites (**figure 1**), and close to the fully irrigated baseline (not shown). As the season progressed, lower values of SWP (more water stress) were observed at most sites (**figure 1**). As also found in previous years, the Madera site showed substantial stress late in the season when irrigation was discontinued (data not shown), which was apparently the normal practice for this grower. All sites exhibited moderate levels of stress (-15 to -19 bars) associated with harvest (July/August), but by the end of the season, the levels of stress at the Madera site (approaching -30 bars) were also sufficient to cause substantial orchard defoliation.

Yields at these sites have been recorded on an individual tree basis, and the average for all trees (54 at each site) are shown in **Table 1** (no yields were measured in 2011). Generally, all orchards are in the 3000 pounds/acre range, but most notably, yields at the Madera site have been declining over time.

Figure 1. Seasonal pattern of SWP for all sites in 2011.

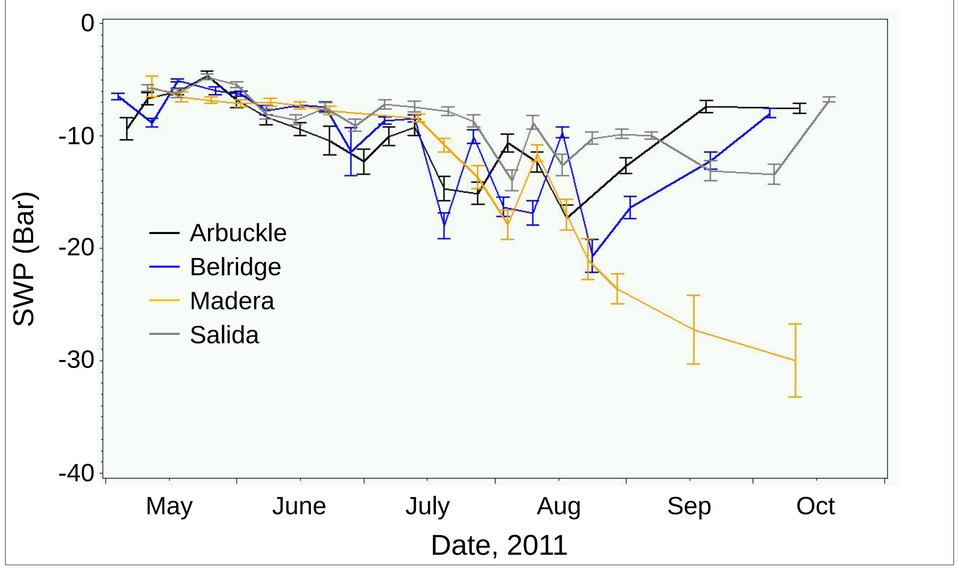
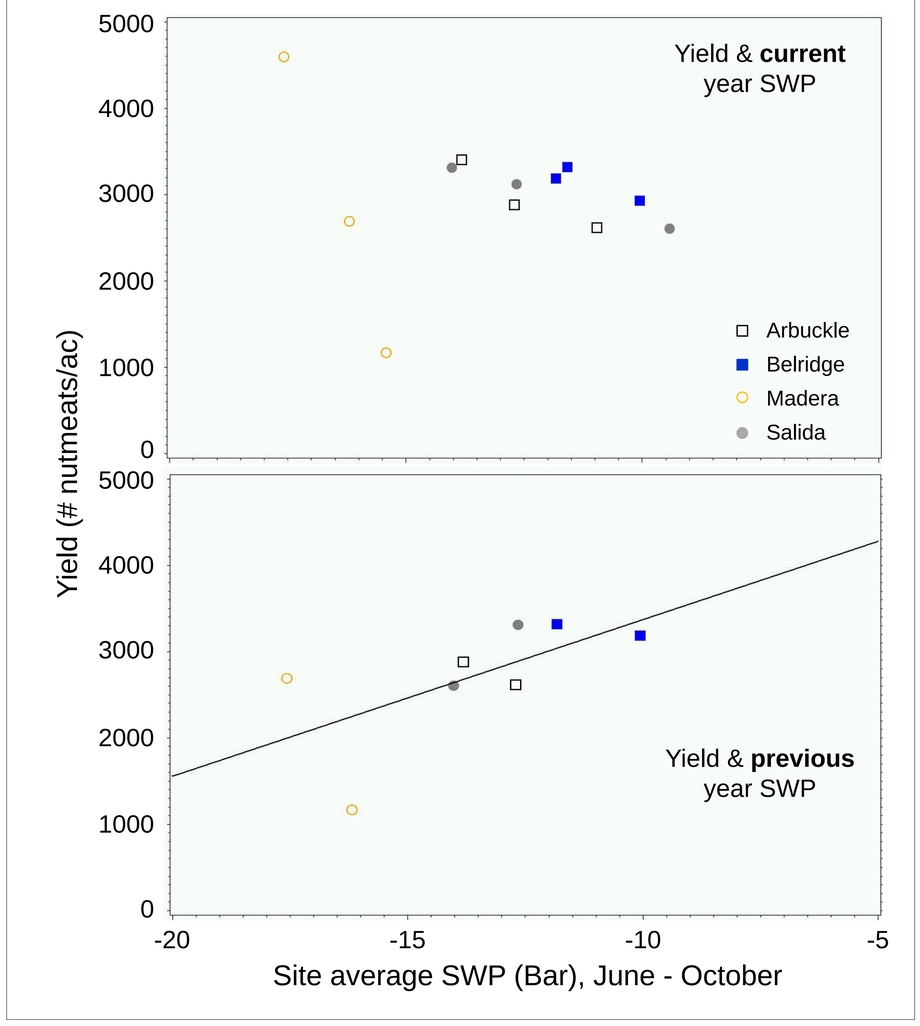


Table 1. Site average SWP (June – October) and kernel yield for 2008 – 2010.

Site	2008		2009		2010	
	SWP (bar)	Yield (#/ac)	SWP (bar)	Yield (#/ac)	SWP (bar)	Yield (#/ac)
Arbuckle	-13.8	3400	-12.7	2880	-10.9	2620
Belridge	-10.0	2920	-11.8	3180	-11.6	3310
Madera	-17.6	4590	-16.1	2690	-15.4	1160
Salida	-12.6	3110	-14.0	3310	-9.4	2600

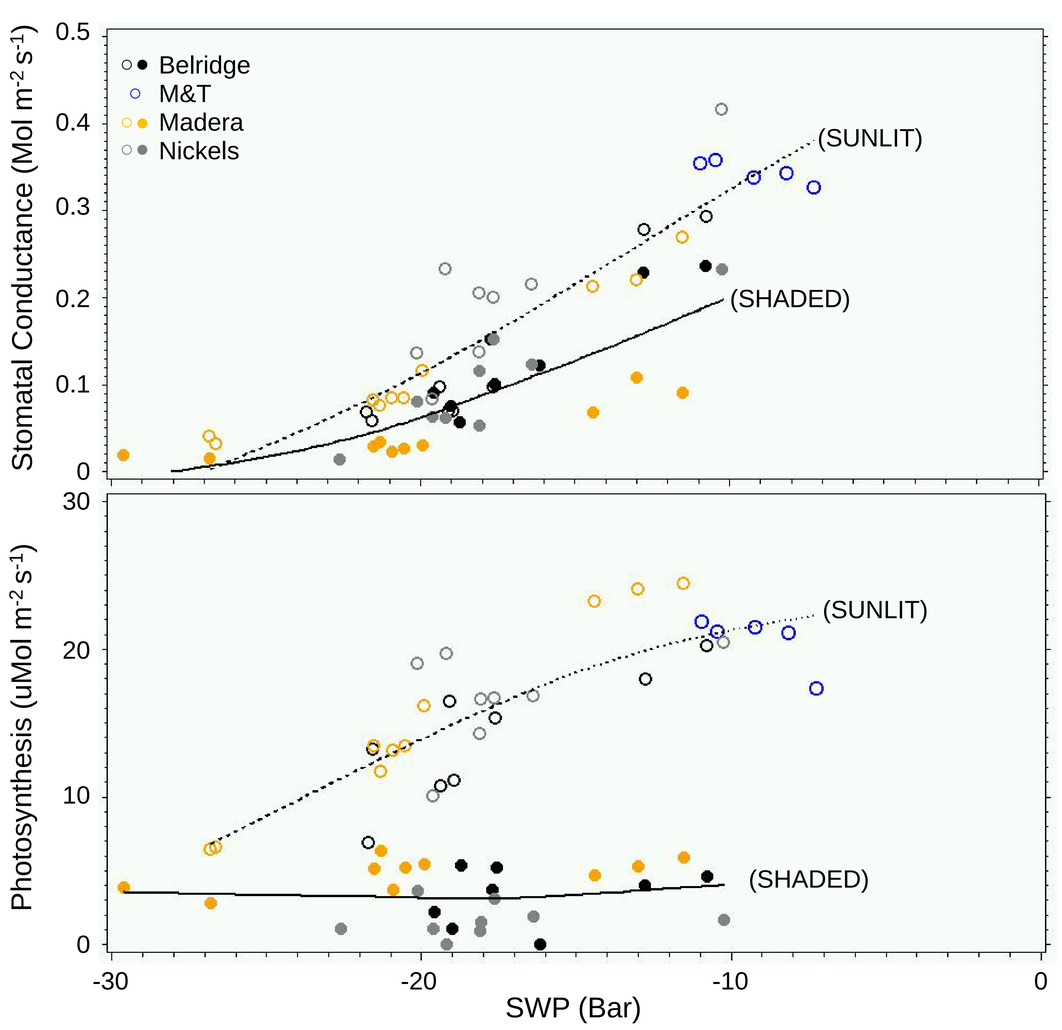
Based on previous results obtained from a drought stress study in the Arbuckle area, we suspected that almond yield may be more determined by carryover (previous year) effects of water stress than by current season water stress, and consistent with this hypothesis, for the data shown in Table 1, there was no clear relation of current year yield to current year SWP, but an indication of a positive relation of current year yield to previous year SWP (**figure 2**). Overall yield in almonds is determined by many factors, but this indicates that irrigation management may be more important in the long run than in the short run.

Figure 2. Relation of site average current year yield to either current year SWP (top) or previous year SWP (bottom). Values from Table 1.



An important objective of this research is to quantify the water use (evapotranspiration, or **ET**) of almond orchards, and the relation of tree stress (as measured by SWP), and orchard ET. In previous reports, we have found that there is little or no reduction in orchard ET as SWP declined from baseline values (around -8 bars) to moderate stress levels (around -18 bars), even though at the leaf level in almond we have found that this change in SWP should be associated with about a 50% reduction in stomatal opening (stomatal conductance) at the leaf level. Such a reduction has also been found in canopy ET for peach trees grown in a lysimeter. In 2011 we measured both conductance and photosynthesis in almond leaves at multiple sites, and for both sunlit and shaded leaves. We found that both shaded and sunlit leaves responded to SWP by reducing stomatal conductance, with about -30 bars SWP corresponding to essentially full stomatal closure, as previously reported (**figure 3, top**). As expected, shaded leaves had low levels of photosynthesis compared to sunlit leaves, but in both types of leaves, photosynthesis (**figure 3, bottom**) was much less responsive to SWP than was stomatal conductance (**figure 3, top**). This is an important result because at the leaf level it indicates that almond water use efficiency (photosynthesis per unit of water lost in transpiration) is predicted to increase with water stress . This is in contrast to the conclusion which may be reached based on the canopy ET data, and that is that water use efficiency may not change, or may actually decrease, with water stress. Because of competition for water resources, it is important to understand the relation of water stress to water use efficiency in almonds, and hence gaining this information will become an important part of future research.

Figure 3. Relation of conductance (top) and photosynthesis (bottom) to SWP for naturally sunlit and shaded leaves.



Conclusions:

1) To date we have not found evidence of a strong link between fertility and SWP.
2) Across sites and years, there is evidence that irrigation management and SWP have the strongest influence on yield as a 1-year carryover effect, rather than a current season effect.
3) Stomatal opening and hence leaf transpiration appears to be primarily influenced by SWP and only secondarily influenced by leaf exposure, whereas for leaf photosynthesis the opposite is the case.
4) Water use efficiency may respond differently to stress at the leaf and canopy level.