Lysimeter – Whole Tree ET Response to Mild and Moderate Water Stress

Ken Shackel, Gurreet Barr, Bruce Lampinen, Jim Ayars

Problem and its Significance:

The almond board is currently supporting research to determine a water production function in almonds, which will provide practical information to guide efficient and environmentally sustainable irrigation practice as well as improve our ability to achieve "more crop per drop." The upward revision of what was thought to be a well-established almond Kc, has raised the question of the importance of crop physiological status on Kc. In particular, whether and to what extent Kc decreases when almond trees experience water stress. A reduction in ETc with stress has been described using the "stress coefficient" (Ks) approach, but this approach is based on the level of soil available water, which is difficult or impossible to reliably establish for deep rooted perennials such as almonds. We have consistently found a 50% reduction in stomatal conductance and a 40% reduction in almond photosynthesis, both measured at the leaf level, with a 10 bar reduction in SWP, but canopy ET measurements using micrometeorological techniques have not shown any reduction in ET for this rang of SWP. In order to document the real water savings that are associated with practices such as hull-split RDI in almonds, we need a direct measurement of ET, which requires the use of a lysimeter.

Objective:

The long term objective of this research is to quantify the effect of water stress on almond physiology and ET, and to develop a physiologically-based model of this relation that can be used to predict the water savings associated with practices such as RDI. The goal for 2015 was to renovate the Kearney Ag center west lysimeter facility (previously in grapes) and to establish a 3 acre almond planting at this site.

Results and Discussion:

- The 3 acre lysimeter block was planted Feb. 3, 2015, to a 50% nonpareil, 25% Wood Colony, 25% Monterey orchard at an offset 4m x 6.5m (about 13' x 21') spacing in east/west rows, as determined by the orientation of the lysimeter (Fig. 1). The lysimeter dimensions are 2m wide x 4m long x 2m deep (6.5' x 13' x 6.5'). The lysimeter tree (nonpareil) as well as the other trees in the block grew well (Fig. 1).
- The lysimeter tree was irrigated using the same system as for the rest of the orchard: single line drip with one 8 lph (about 2 gph) emitter per tree, placed about 10" from the trunk. All trees were tanked-in twice at planting, and all but 8 (mainly border) trees were headed at 4-5' with all side shoots removed. The 8 non-pruned, and 10 normally pruned trees were used for SWP measurements at planting and throughout the 2015 season.
- Reference evapotranspiraiton (ETo) was obtained from the Parlier CIMIS station, and daily weight loss from the lysimeter was used to calculate ETc and Kc, based on the planted area (Fig. 2, top).
- Kc showed peaks of 0.3 – 0.4 following spring rain events (Fig. 2, bottom graph), due to soil surface evaporation, but otherwise was on the order of 0.1 in the spring, climbing to values of about 0.3 in the fall.
- Despite tanking and a substantial rain just after planting, the dormant trees initially exhibited a substantial level of water stress (SWP near -20 bars, Fig. 3). The SWP progressively recovered to near baseline values, but declined following leafout (early March) in both pruned and non-pruned trees (Fig. 3). Some irrigation was applied in late March after confirming that nearby mature trees were at or above baseline (blue line, Fig. 3), but this was followed by rain and a recovery of all trees to baseline values. For the remainder of the season however, trees were generally below baseline values, despite irrigation, and a series of pilot experiments were performed to identify whether increases or decreases in irrigation would substantially alter the level of SWP.

Figure 1. Nonpareil almond in the lysimeter on August 26, 2015.

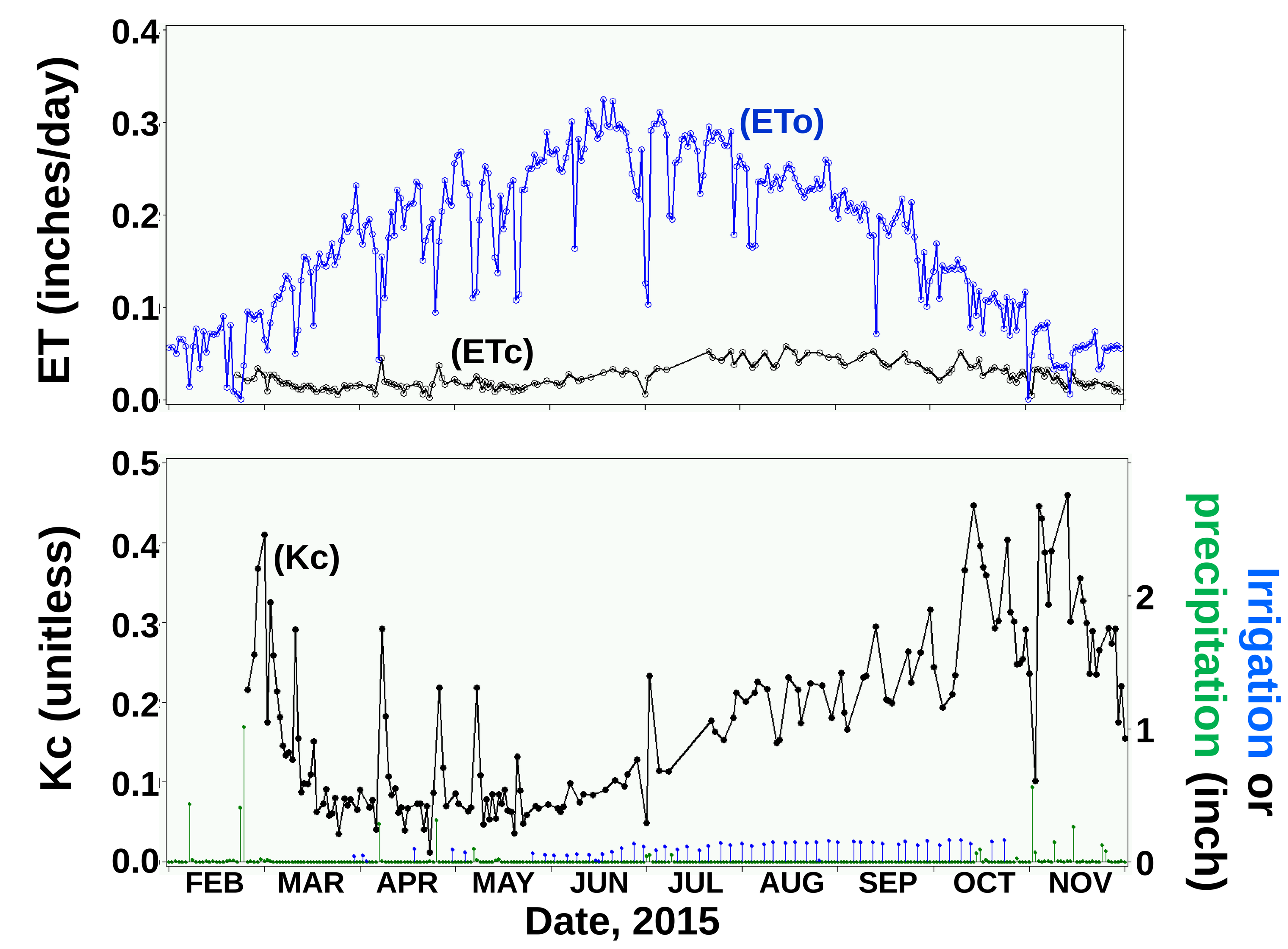

Figure 2. Top graph: daily reference (ETo, blue) and daily lysimeter (ETc, black) evapotranspiraton for 2015. ETc data omits days with irrigation, rainfall, or when the lysimeter was covered to eliminate surface evaporation. Bottom graph: daily almond Kc (left axis) based on the measured ETc. Also shown for reference (right axis and vertical lines at the bottom of the graph) are daily rainfall amounts (green points) and daily irrigation amounts (blue points).

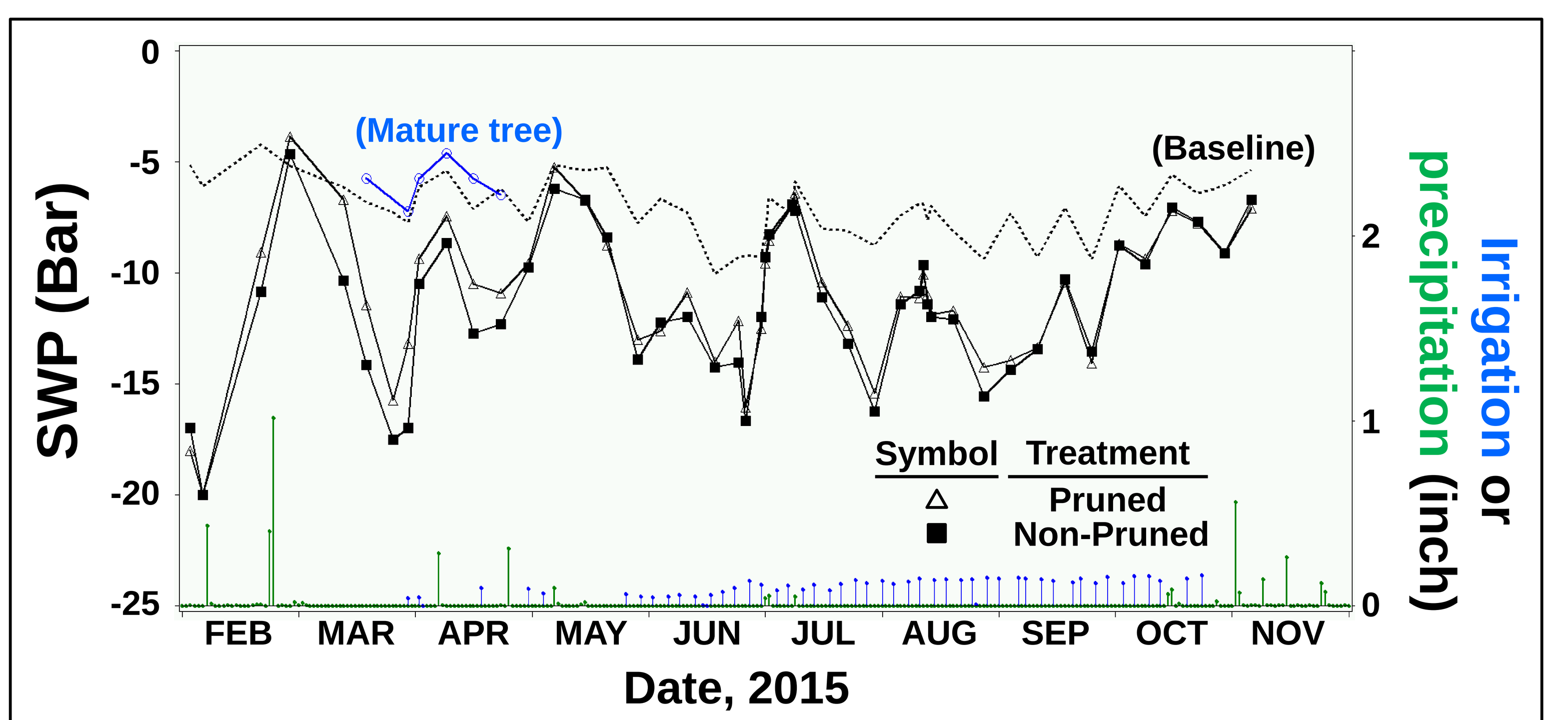

Figure 3. Mean midday stem water potential (SWP, left axis) for pruned (N=10) and non-pruned (N=8) first leaf almonds in the lysimeter orchard for 2015. Also shown for reference are mean SWP values for nearby mature almond trees (blue, N=4) and baseline SWP values (dashed line). As in Fig. 1 (right axis and vertical lines at the bottom of the graph) are daily rainfall amounts (green points) and daily irrigation amounts (blue points).

- Some of the eight monitored trees exhibited consistently low SWP from planting through May, and these trees also exhibited reduced vigor compared to the majority of trees. Drip emitter uniformity was checked, and the differences in SWP were not due to a difference in irrigation amounts (Fig. 4).
- In order to determine if low SWP could be reversed by a change in irrigation strategy, a number of small scale treatments (N=3 trees) were performed, including a microsprinkler application designed to wet the entire root zone (Fig. 5).
- Surprisingly, SWP was not influenced by treatments designed to add water, such as doubling irrigation by adding a second dripper to the opposite side of the tree or saturating the root zone with microsprinklers, nor was it influenced by treatments designed to move the wetted area to a different location farther from the trunk (Fig. 6). All trees gradually approached baseline as the season progressed.

Tree #1: SWP through May: -12.6 bar, Emitter flow: 2.20 gph

Tree #2: SWP through May: -9.3 bar, Emitter flow: 2.16 gph

Figure 4. Adjacent trees pictured on August 28, 2015, that had exhibited substantial differences in SWP from planting through May, despite essentially identical irrigation. In this case, the surface wetting pattern of the low SWP tree indicated that the wetted zone may not have matched the root zone well, but this was not the case for all the low SWP trees.

Figure 5. Adjacent trees pictured on September 1, 2015, following a 31 h microsprinkler irrigation, equivalent to about 4" of rain. Soil permiability is very high at this site, so there was essentially no ponding.

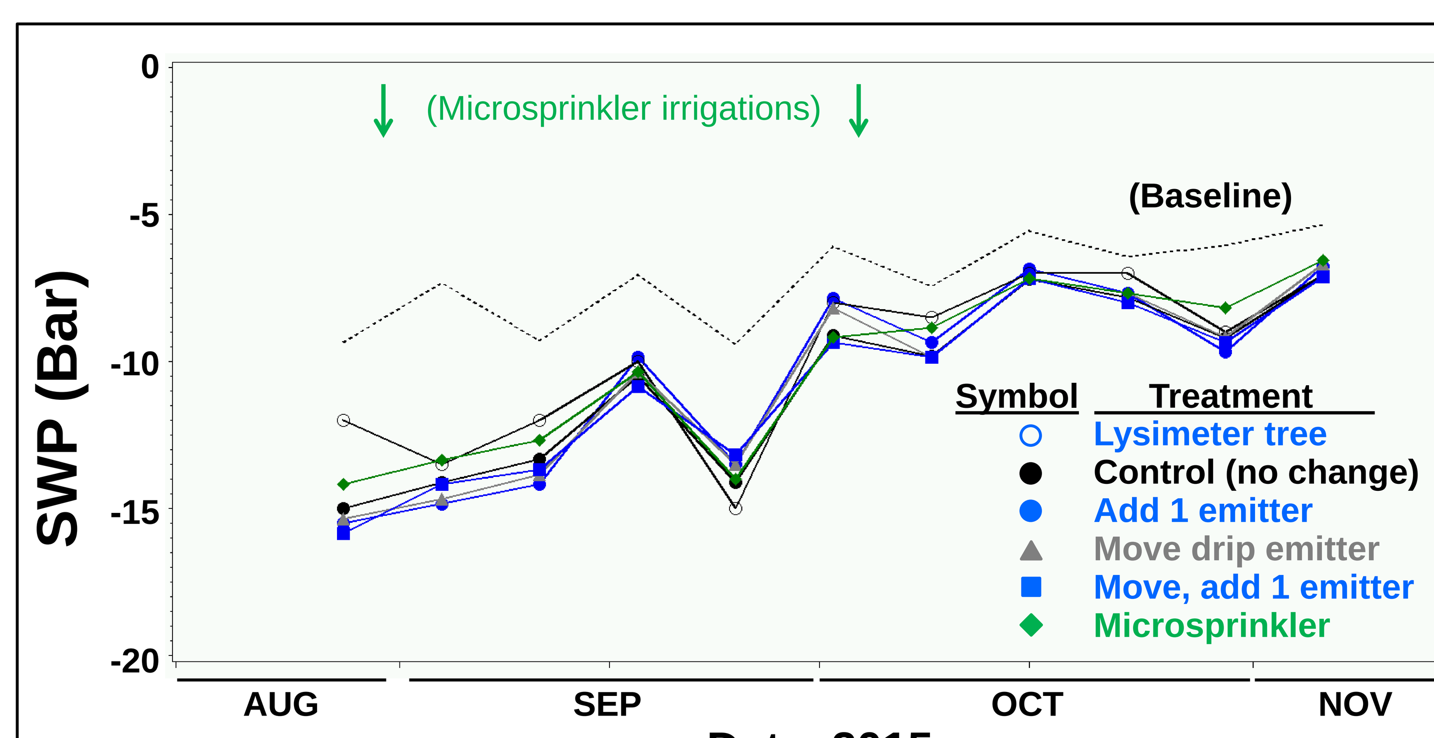

Figure 6. Comparison of late summer to fall average SWP in a pilot test to determine if a change in emitter placement and/or wetted root zone volume would improve almond tree water status. Each SWP point for the lysimeter tree is a single value, but N=5 for the controls and N=3 for all other treatments. For the two treatments involving emitter movement, the emitter was moved perpendicularly to the tree row from a location about 10" from the trunk, to a location about 1.5' from the trunk. Also shown for reference are the baseline SWP values (dashed line) and dates of the microsprinkler irrigations.

Conclusions:

These first year trees grew well, but the soil conditions at this site (fine sandy loam over a dense hardpan at about 1') may have limited the performance of the roots in this establishment year, even when the soil was well supplied with water. The irrigation system was designed as a double line drip system with multiple emitters per tree, and it may be necessary to bring the system to it's designed capacity in the second year. Once a full canopy is established, we will be able to test whether ETc is reduced by deficit irrigation in almonds.