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

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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 practices 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 crop coefficient (K_c), has raised the question of the importance of crop physiological status on K_c. In particular, whether and to what extent K_c decreases when almond trees experience water stress. A reduction in ET_c with stress has been described using the "stress coefficient" (K_s) 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 stem water potential (SWP), but canopy ET measurements using micrometeorological techniques have not shown any reduction in ET for this range of SWP. In order to document the real water savings that are associated with practices such as hull-split regulated deficit irrigation (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 2017 is to continue growing the trees and collecting young tree ET data, and to compare the ET observed in 2015 and 2016 to the model published by Johnson et al, (2004) for young trees.

Background:

The currently accepted method for estimating the water requirements of young trees is based on the assumption that once the canopy cover (mid-summer % shaded area on the orchard floor at midday) reaches about 60%, the orchard will be using 100% of the ET of a mature orchard, and hence the Kc will equal the mature Kc (Fig. 1, Sammis et al, 2004 Pecan Conference proceedings, Las Cruces, NM: 28-33). The most recent Kc estimates for almond are that the maximum midsummer Kc has a value of about 1.15 (Fig. 2). To test this, a weighing lysimeter (D, W, L dimensions of 2mx2mx4m) and the surrounding 3 ac block was planted to a 50% Nonpareil, 25% Wood Colony, 25% Monterey almond orchard (Nemaguard rootstock) at an offset 4m x 6.5m (about 13' x 21') spacing in east/west rows (as determined by the orientation of the lysimeter), at the Kearney Ag. Station in Parlier, CA, on Feb. 3, 2015. In 2015 the measured midsummer canopy cover was about 6%, and the measured Kc was 0.21 (Fig. 3). In 2016 the measured midsummer canopy cover was about 21%, and the measured Kc was 0.7 (Fig. 4). In both years the Kc was about double that expected, based on the most recently published model for young-tree ET (Johnson et al, 2004, Acta Hort., 664 341-346).

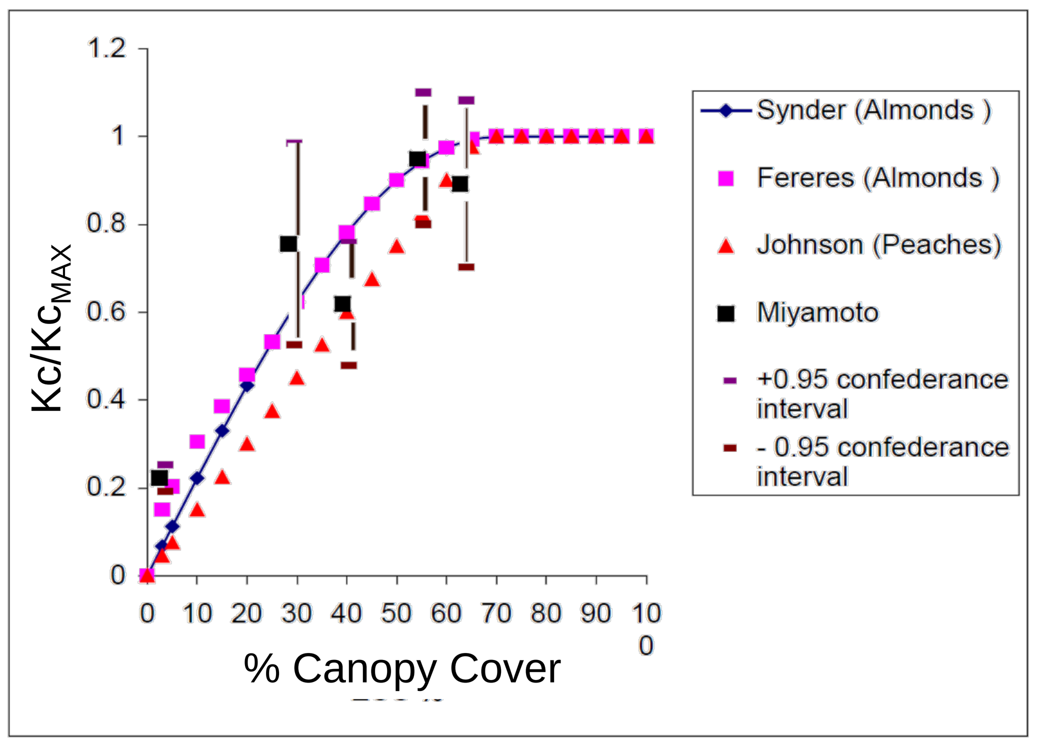

Figure 1. Literature review (Sammis et al, 2004) showing the relation of immature (Kc) to mature (Kc_{MAX}) almond Kc.

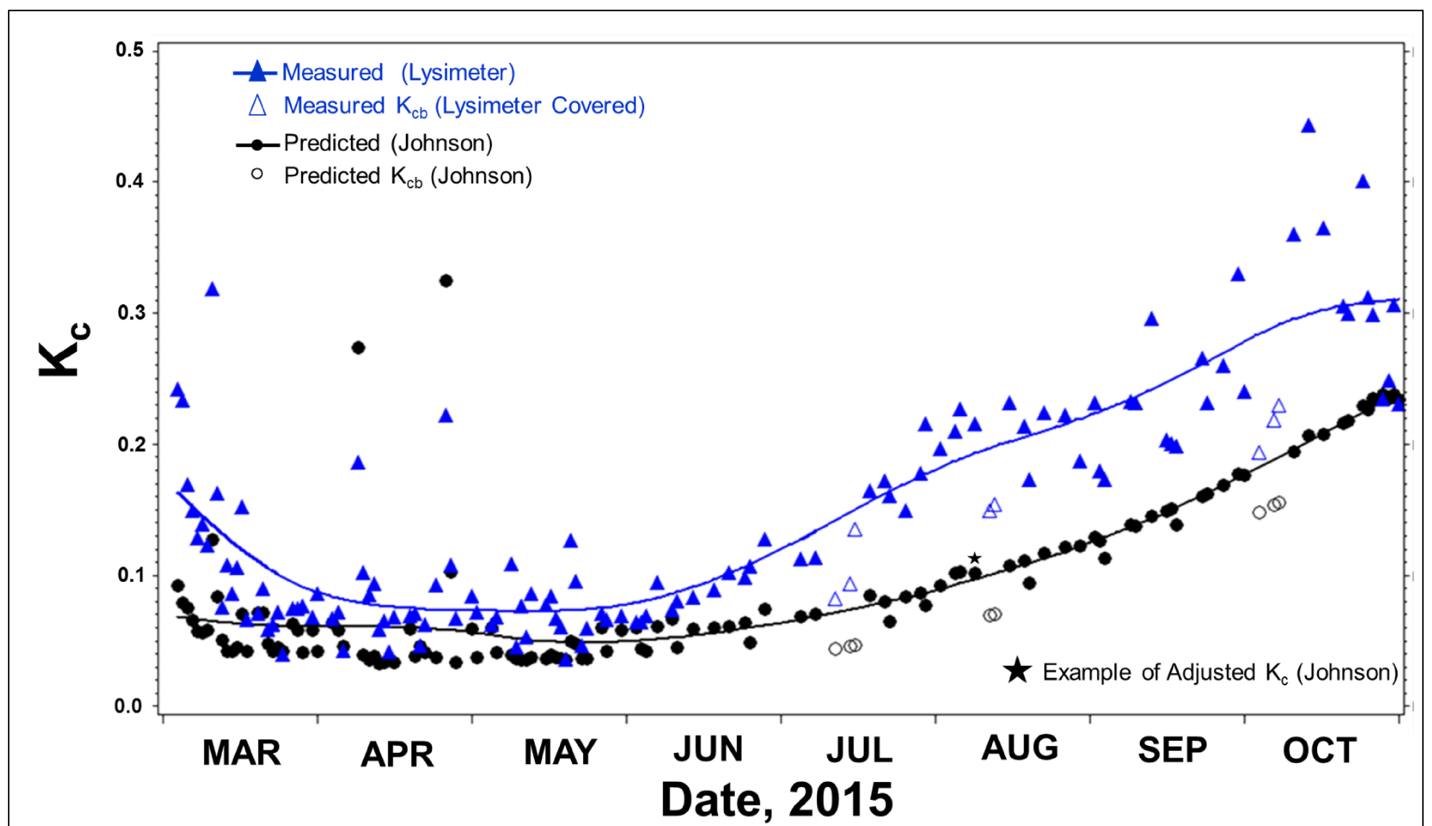

Figure 3. Measured Kc **(blue)** compares to that predicted by the Johnson model **(black)** in 2015 (year 1).

Results:

- The Nonpareil trees (every other row, starting with the outside rows) are clearly larger than the pollinizer trees (Fig. 5).
- The lysimeter tree is slightly larger than the tree to its west and slightly smaller than the tree to its east, but all modeling and relations to % canopy cover have been based on the shaded area of the lysimeter tree itself.

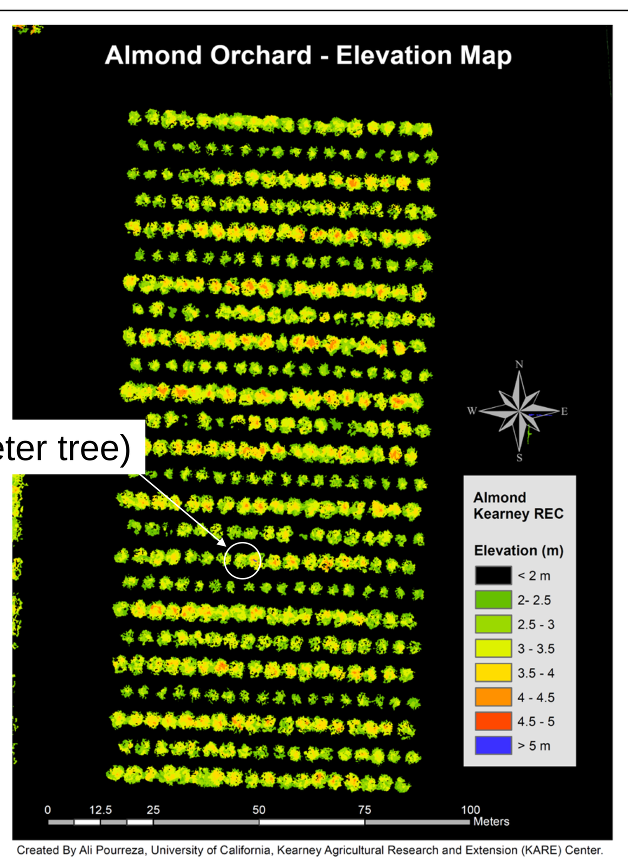

Figure 5. Orchard scan performed in August, 2017 by Alireza Pourreza. The >5m height readings are for an ET tower in the canopy of the tree adjacent to the lysimeter tree.

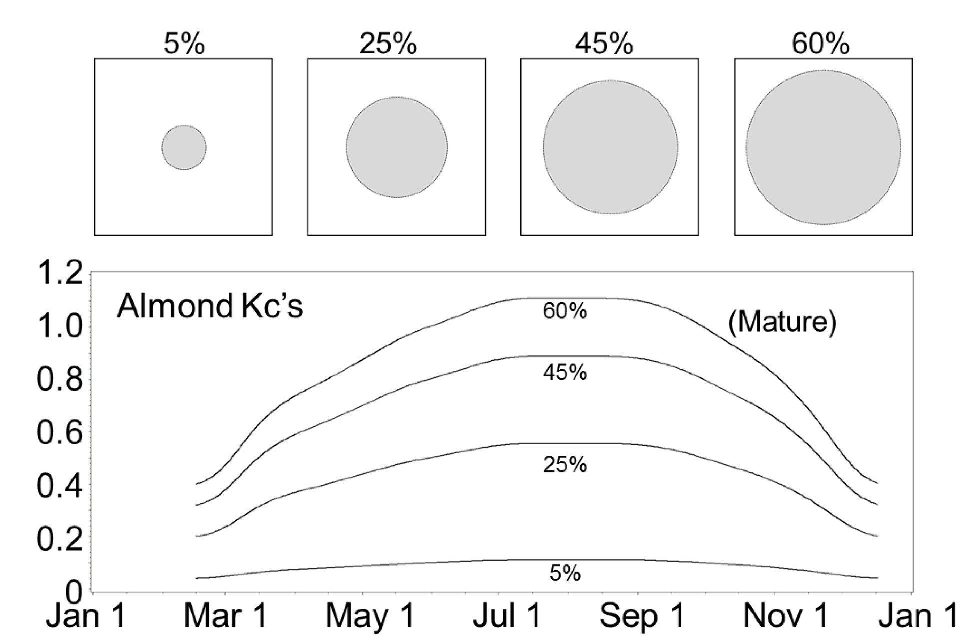

Figure 2. Examples of % orchard floor shaded area and the corresponding predicted values for almond Kc over the season.

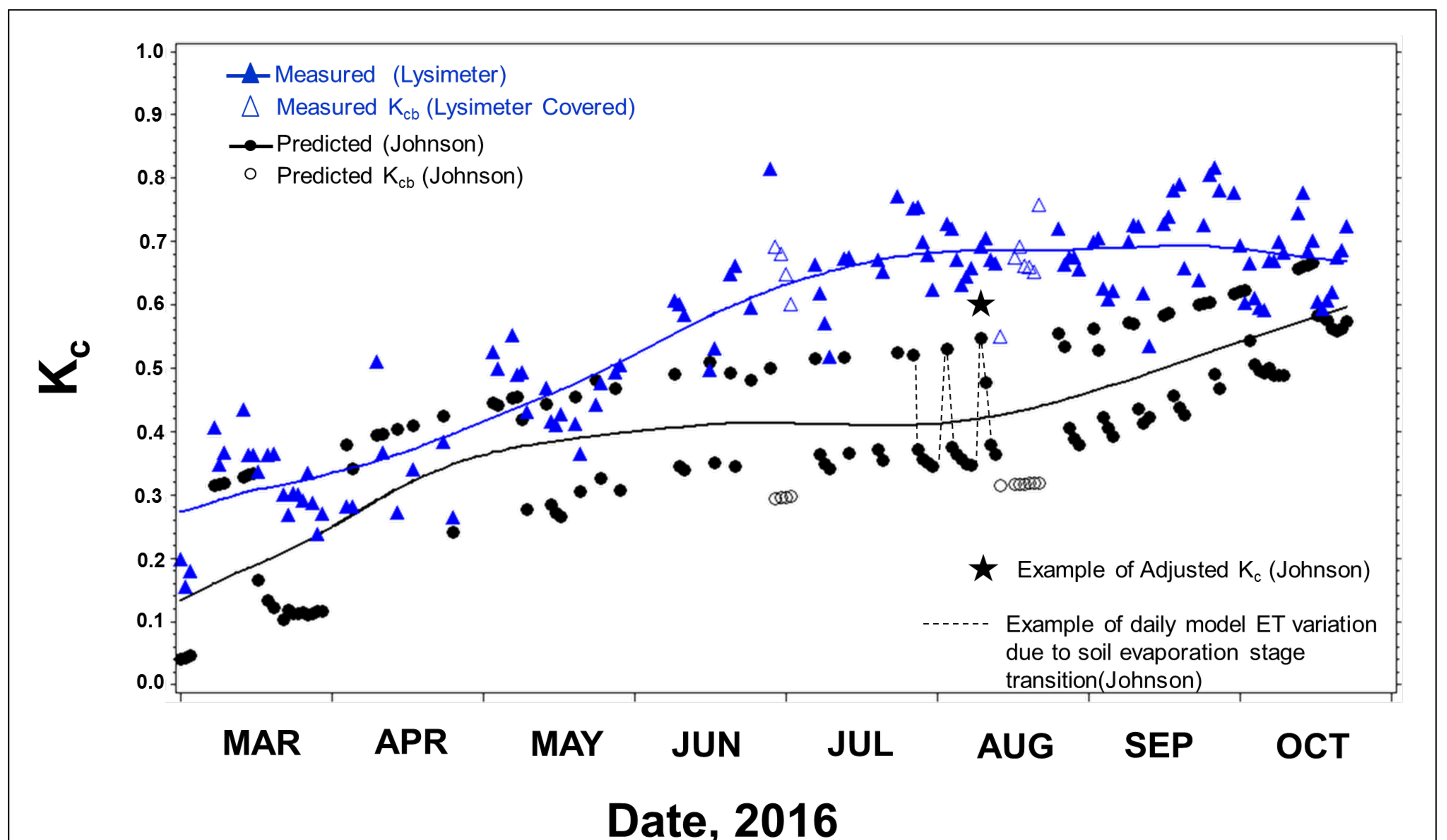

Figure 4. Measured Kc **(blue)** compares to that predicted by the Johnson model **(black)** in 2016 (year 2).

- In year 3 (2017) the Kc reached values that were above those expected for a fully mature almond orchard (Fig. 6).
- Kc did respond to the hull-split RDI treatment, showing a decrease to about 0.8 (Fig. 6). This drop resulted in a modest savings of 1.6" of water during this time.
- Based on the literature (Fig. 1) it is expected that immature orchard Kc will increase linearly to a maximum (mature) value once % canopy cover has reached 60%. Over the first 3 years of this study, Kc has shown close to a linear increase with % cover (Fig. 7), but has reached mature levels at about 40% cover rather than 60% cover (Fig. 7).
- Since the trees have not yet filled the space available to them (Fig. 5), it is likely that further increases in Kc will be observed.
- 2017 was the first year of harvest in this orchard, and the average ±SD Nonpareil yield was 770 ± 240 kernel pounds per acre. The yield of the lysimeter tree was 670 kernel pounds per acre, which is within the observed variability of the orchard.

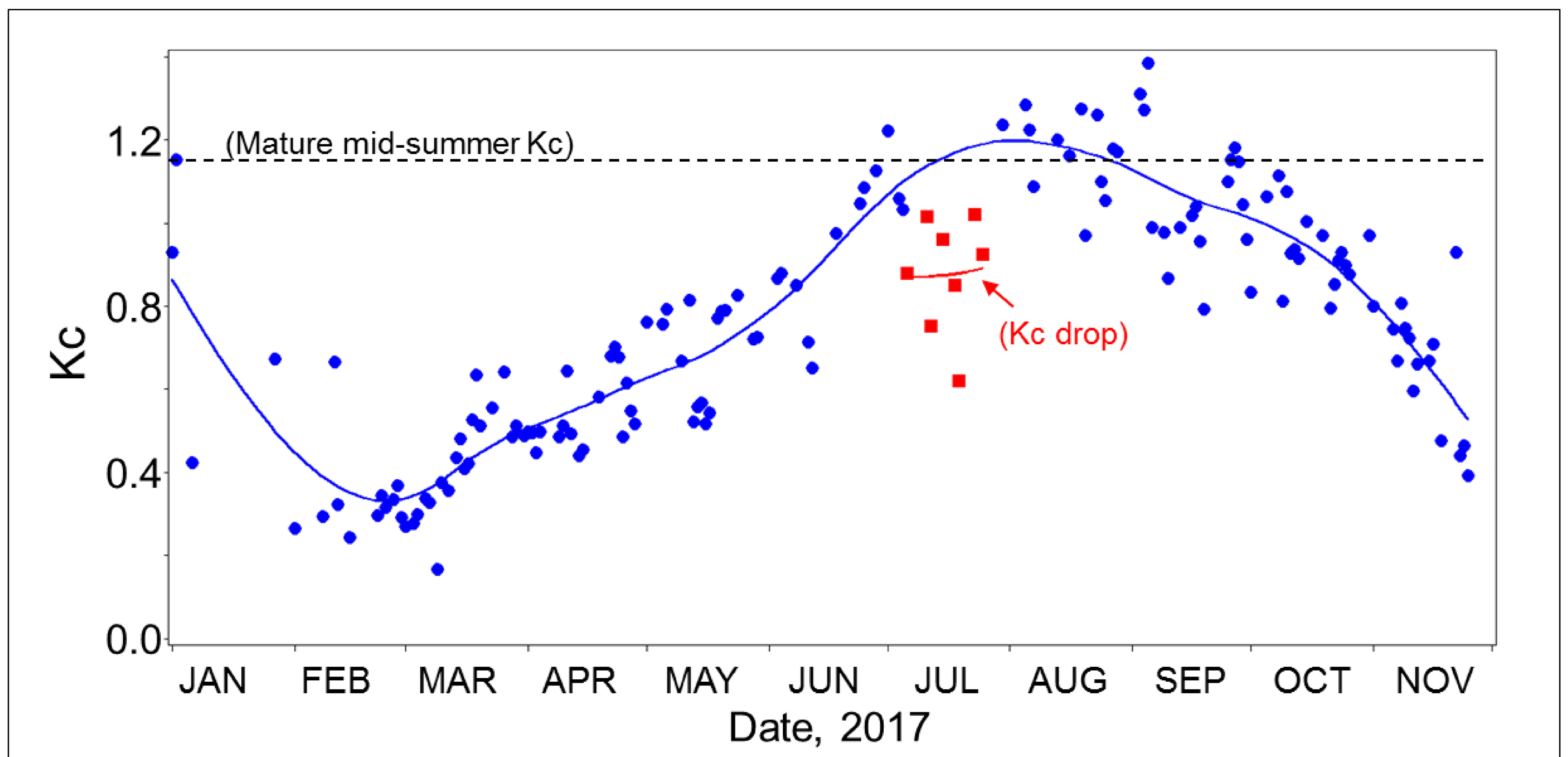

Figure 6. Lysimeter Kc in 2017 (year 3). Reductions in Kc during hull split RDI are indicated in red. Also indicated is the currently accepted maximum Kc for mature almonds (Fig. 2).

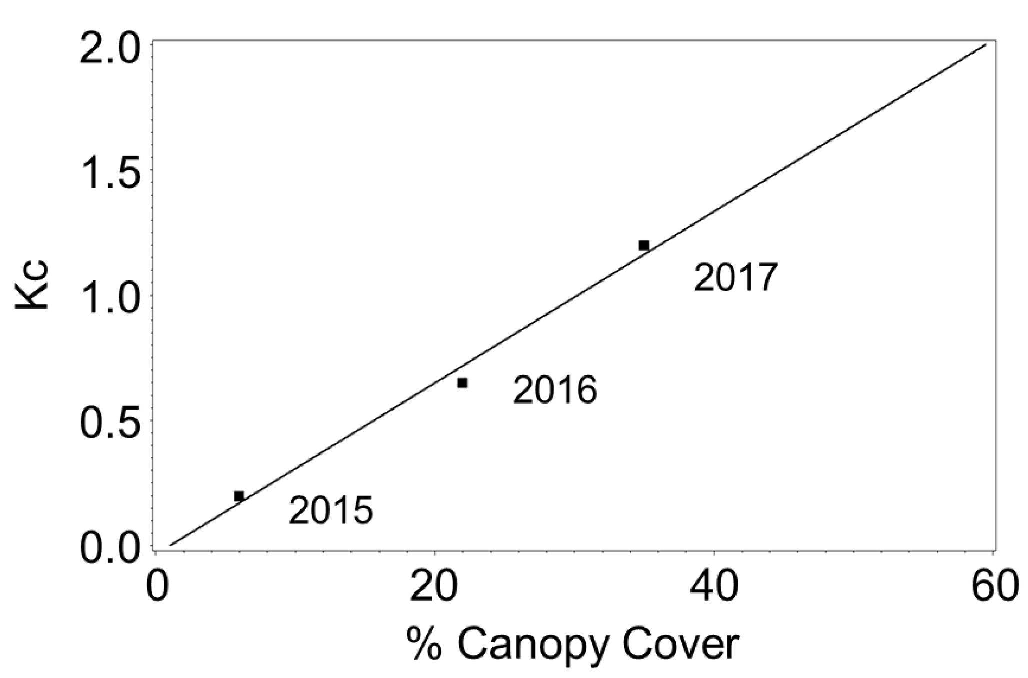

Figure 7. Relation of midsummer lysimeter Kc values to midsummer % canopy cover for the 3 years of the study.

Conclusions:

The Kc (and hence ET) of the lysimeter tree has been consistently above that expected for a young almond tree, and even though the canopy shaded area has only reached about 40% as of year 3, the Kc of the lysimeter has reached or exceed the value expected for a mature almond orchard. The high water use is consistent with the good growth and good early yield of the trees in this plot, but the high Kc may also be due to the fact that the Nonpareil trees are noticeably larger than the pollinizer trees on either side, and hence may be intercepting more sunlight and may have a higher advective energy influence on ET than they would if all trees were the same size. The difference in tree size may be economically advantageous however, given the higher value of Nonpareil compared to the pollinizers. If it is determined that the water use and hence effective Kc may be different for different varieties of almonds within the same orchard, due to tree size differences, then achieving a high water productivity in almonds may require adjusting irrigation system design and management to account for this effect.