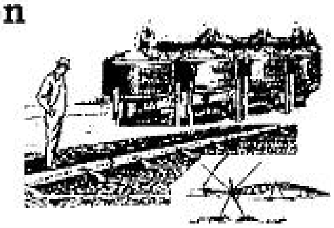
University of California Cooperative Extension

KERN SOIL AND WATER



Kern County • 1031 S. Mt. Vernon Ave • Bakersfield CA 93307 • Telephone: (661) 868-6218

Kern Almond Field Meeting – July 14, 2009

MANAGING MID-SEASON ALMOND IRRIGATION, HULL ROT & REGULATED DEFICIT IRRIGATION

Paramount Farming Co. Belridge Ranch 3360B (½ mile north of office)

Co-sponsored by North-West Kern RCD Mobile Irrigation Lab

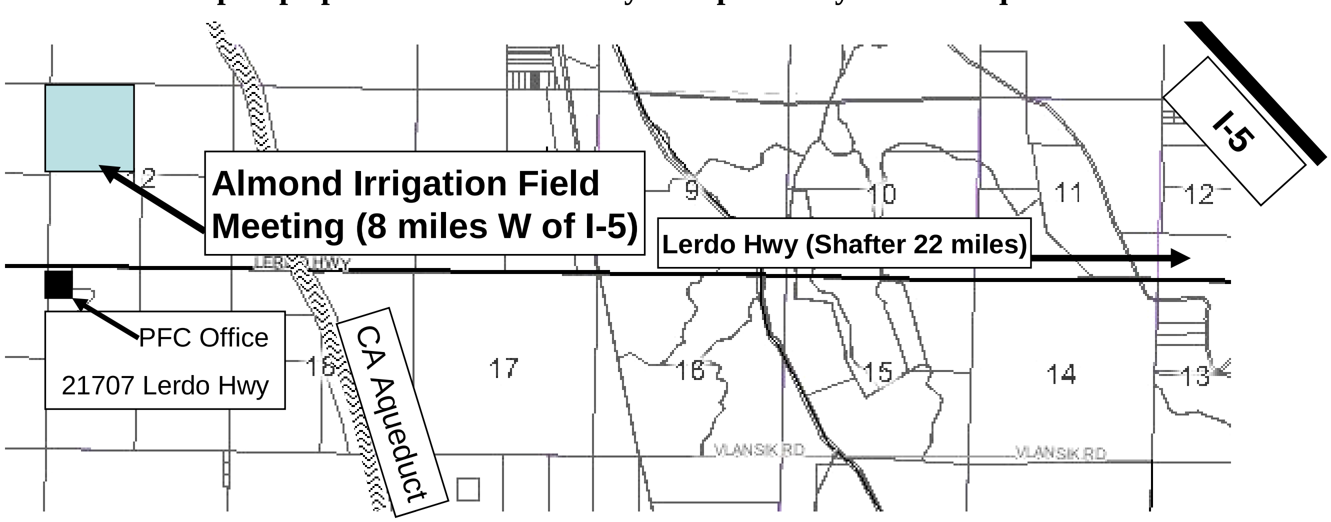
Join Mario Viveros, retired (but still very active) Kern County UC Almond Advisor and Blake Sanden, Kern County UC Irrigation/Soils Advisor and some of the best almond managers in the business for a heated (it is July!) field discussion on almond water use, yield and disease management.

<u>ALMOND WATER USE AND DISEASE MANAGEMENT:</u> 9:00 to 10:30 AM

- Almond ET update: new crop coefficients & using CIMIS to schedule irrigations
- Irrigation systems/uniformity/scheduling and soil texture: constraints & potential disease problems
- Soil moisture monitoring demonstrations for efficiency, optimal yield and minimizing disease:
    - Soil probe/Auger, Neutron probe, Tensiometers, Electrical resistance blocks (Watermark), Capacitance probes (PureSense)

<u>REGULATED DEFICIT IRRIGATION (RDI) FOR CONTROL OF HULL ROT:</u> 10:30 to 12:00

- What causes Hull Rot? How bad is "bad"? Yield impacts? (FYI -- we don't have all the answers!)
- Controlling the disease with stress using the pressure "bomb": Stem Water Potential (SWP)
- What is Regulated Deficit Irrigation and when to do it.
    - 6" of water @ $300/ac-ft = $150, is it worth it?
- Using soil moisture monitoring and irrigation scheduling to initiate RDI and maintain the right level of stress, cautions on potential problems with excess stress during and after harvest
- **Practice using the pressure bomb: we will have two pressure bombs with gas tanks and at least 1 "hand pump" pressure chamber for you to practice your technique**



Managing Mid-Season Almond Irrigation, Hull Rot & Regulated Deficit Irrigation

July 2009

Almond ET Update

More than 30 years ago the CA Department of Water Resources mounted the first major project to develop crop water use (evapotranspiration, ET) measurements for the major crops in the San Joaquin Valley. The science of crop biometeorology was just beginning to come into it's prime, but most energy/weather-based calculations were developed for flat, full cover field crops like hay and pasture and researchers were hesitant to apply them to irregular crop surfaces like trees and vines. So DWR, with the help of their regional staff and UC Cooperative Extension, placed more than 100 Class A evaporation pans around the valley and installed hundreds of neutron probe access tubes in orchards, vineyards and other crops; attempting to quantify the ET of these crops and develop seasonal "crop coefficients". These coefficients, designated as Kc, are a ratio of crop ET compared to the "potential ETo" of a well watered pasture for a given region. The idea is these Kc values should hold constant for a given crop at a specific stage of develeopment. You then estimate the actual crop water use for any area by multiplying the crop Kc by the local grass ETo. At the time of these early studies, the ETo was estimated from 4 foot diameter evaporation pans. The current ETo for most regions of California is now available on the internet by using the California Irrigation Management Information System (http://www.cimis.water.ca.gov/).

Table 1.Comparison of almond crop coefficients (Kc) and "normal year" (Avg) crop ET for older values from the 1980's to current field measurements in the southern San Joaquin Valley.

Date	Older Publis hed Kc	Sanden SSJV Kc	2008 & 9 Measd Kc	Avg Year Grass *ETo	Older Avg SSJV ET	Sanden Avg SSJV ET	Measd Avg SSJV ET
1/15		0.40		0.54		0.22	
2/1		0.40	0.45	0.70		0.28	0.32
2/15		0.40	0.54	0.98		0.39	0.53
3/1	*0*	0.41	0.69	1.26		0.52	0.87
3/15	*0*	0.63	0.68	1.64		1.03	1.11
4/1	0.54	0.69	0.73	2.08	1.12	1.44	1.52
4/15	0.60	0.75	0.91	2.55	1.53	1.90	2.32
5/1	0.66	0.82	0.98	3.10	2.05	2.55	3.03
5/15	0.73	0.88	1.00	3.50	2.56	3.09	3.51
6/1	0.79	0.95	1.03	3.81	3.01	3.62	3.92
6/15	0.84	1.03	1.09	4.03	3.39	4.17	4.39
7/1	0.86	1.07	1.11	4.25	3.66	4.55	4.72
7/15	0.93	1.08	1.14	4.35	4.05	4.68	4.97
8/1	0.94	1.07	1.15	4.33	4.07	4.65	4.98
8/15	0.94	1.08	1.18	4.11	3.86	4.42	4.83
9/1	0.94	1.07	1.05	3.64	3.42	3.90	3.82
9/15	0.94	1.05	1.06	3.13	2.94	3.28	3.31
10/1	0.91	1.00	1.18	2.67	2.43	2.66	3.15
10/15	0.85	0.91	1.00	2.20	1.87	2.01	2.19
11/1	0.79	0.86	1.12	1.69	1.34	1.45	1.90
11/15	0.70	0.75	1.00	1.24	0.87	0.93	1.24
12/1		0.64		0.88		0.57	
12/15		0.45		0.70		0.32	
12/31		0.40		0.52		0.21	
			Total (inches)	**57.90**	**42.15**	**52.81**	**56.63**

*Using most recent CIMIS potential ETo numbers for the southern SJV. Jones, D.W., R.L. Snyder, S. Eching and H. Gomez-McPherson. 1999. California Irrigation Management Information System (CIMIS) Reference Evapotranspiration. Climate zone map, Dept. of Water Resources, Sacramento, CA.

With the vast majority of crops furrow or border strip irrigated it seemed a simple matter to use the neutron probe to measure the stored soil moisture just after the irrigation and then measure again just before the next irrigation. The difference was what went to crop ET. Of course there are problems with this technique due to soil variability, root density, irrigation frequency and the uniformity of the irrigation, which was often on a 2 week interval. These were also the days when an 1800 lb/ac almond yield was considered excellent. The result did indeed provide some measurement of the actual crop ET, but could include a significant amount of time when the crop was stressed, thus underestimating full ET. The bottom line is that the developed Kc numbers were published with the assumption that they would provide 100% unstressed ET.

Soil moisture monitoring and irrigation scheduling demonstrations in Kern County from 2001 to 2007 and my on-going interaction with some of our best almond growers convinced me that the old Kc / ET numbers were too low. So starting in 2005 I began publishing Kc numbers for May through August that were 10 to 15% higher than the old numbers. In 2008, I joined many other UC researchers in a large almond fertility/irrigation trial in western Kern County. I have measured almond ET in this trial up to 56 inches. Table 1 compares the older published values with the the newer numbers from Kern.

The older Kc values have the greatest number of citations in the scientific literature and are the ones still used in most of the UC Peer Reviewed bulletins (Nos. 21428 Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Trees and Vines. and 8212 Understanding Your Orchard's Water Requirements, for example).

Figure 1 graphically illustrates the difference between these estimates of Kc. Almost anyone who has worked with almonds over the last 20 years would say that most almonds were underirrigated in the past. Modern technology with improved knowledge and precision in micro irrigation systems and plant/soil monitoring has shown the need for more water and has resulted in improved yields. The data in Table 1 and Figure 1 show us the tremendous potential almonds have to use water and indicate that truly unstressed almonds may use as much as 56 inches of water in the SJV. 2008 Nonpareil yields for the fanjet irrigation in this most recent "non-stress ET" trial averaged 3,216 lb/ac and 3,564 lb/ac for the double-line drip, with the drip yields showing a slight, but significant yield increase as average pressure bomb readings (bagged SWP) went from -10 bars to -8 bars (less negative, less stress). Current recommendations say that a -10 bar SWP should be an insignificant stress on almonds. Hull rot is not a problem in this orchard.

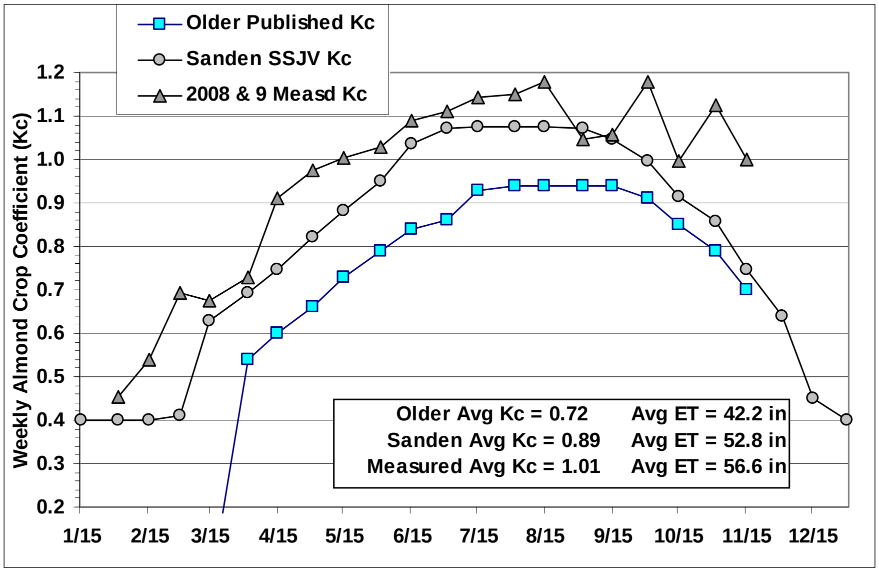


Fig.1. Comparison of various Kc values from the 1970's to present.

However, these data present some problems. We know that only 42 inches of water in the SJV will cost you yield. But neither can we say that you absolutely need 56 inches of ET (a 33% increase) to obtain maximum yield. In fact, as we have generally increased water and nitrogen fertilizer applications in almonds in the last 10 years we have seen an increasing amount of Hull Rot up and down the SJV. We don't have the data to say just how much yield you lose due to hull rot infections, but we do have a number of trials over the last 15 years that show moderate stress can help reduce hull rot and apparently not reduce yield. With almond prices <$1.50/lb and water at $300 to $600/ac-ft on the westside we want to save water if we can. ***Except for one of these trials, the RDI/stress strategy focused only on the reduction of applied irrigation water and did not take into account the depletion of stored soil moisture. The most successful of these deficit irrigation trials have occurred in areas receiving 11 to 18 inches of annual rainfall. This means that accumulated salts are NOT a problem as they can be in the SJV and as much as an additional 10 inches of stored rainwater may contribute to crop ET.***

INTERACTION OF HULL ROT AND IRRIGATION: Hull rot is caused by two different fungi that can get a foot hold in almonds only when hull split starts. As soon as there is a tiny break along the suture this exposes a moist surface where the spore can germinate. The longer it takes for hulls to fully split to where the suture can then dry up, the more opportunity the fungus has to get a foot hold. The incidence of hull rot has increased in the San Joaquin Valley as we have increased irrigation and N to push up yield. Brent Holtz, Madera County UCCE Pomology Advisor, likes to call hull rot the "gout" of almonds since it is mostly seen in "well-fed, well-watered" orchards.

The first significant trial to zero in on the hull rot/irrigation interaction was done in 1990 through 1991 and built on Goldhamer's original harvest cutoff trial. The results were written up by UCCE disease specialist Beth Teviotdale (1994) from the Kearney Ag Center. Pre-harvest irrigation cutoff of only 4 and 11 days had nearly 10 times the leaf strikes and inches of dead wood as in the other treatments that were

52 to 18 days of cutoff. No yield data was given. Detailed hull rot data was taken during two years (1994-5) of the Kern County "regulated deficit irrigation" (RDI) trial by Dave Goldhamer that established the importance of post-harvest irrigation for almonds (Teviotdale, 2001). Hull rot in the 70% RDI treatment (reducing irrigation to 50% of normal from June1-July31, 100% the rest of the time) and 85% RDI treatment (50% irrigation from June1-July15 only, 100% all other times) was reduced by two to four times compared to "full" irrigation. The yield data reported in Goldhamer's study, however, shows the highest yield coming from the 100% irrigation (though not statistically different from the 85% RDI irrigation.)

In these trials the reported "**predawn" LWP** was usually -10 to -20 bars. Using unbagged leaves just prior to sunrise should give a measure of the highest water potential (least negative, least stressed) condition for that tree for the coming day. The "**midday" SWP**, however, has become the standard as it reveals the maximum amount of stress experienced by the tree during the day, and of course this is the critical time for photosynthesis and crop development. Midday SWP can be 50 to 150% greater than predawn LWP depending on many factors. UC Davis crop physiology specialist Ken Shackel has built on these earlier hull rot trials along with other SWP data and, working with UC Farm Advisors from Kern to Chico, set up grower trials from 2001 to 2004 (Shackel, 2004). They attempted to maintain a SWP of -7 to -9 (no stress) till hull split and then maintain an SWP of -14 to -18 bars during hull split for the RDI treatment. In practice, the RDI averaged an SWP of -13.6 and the grower control averaged a SWP of -11.2. Hull rot strikes were reduced by about 50% on the average for the RDI treatment. The 2004 Madera site had a 5-fold reduction in strikes and a 17% increase in yield for the RDI treatment. But in general, there were no yield differences recorded for the other sites. I assume that the water savings was 3 to 6 inches (7 to 14%).

The most recent study by Shackel and others (2006) was a more carefully controlled experiment in Lassen County from 2004 to 2006. They successfully held the SWP at -14 to -18 bars during the RDI/hullsplit period each year, but this stress usually continued through August. In 2006, the fully irrigated trees used about 42 inches of water with the RDI using about 36, counting applied irrigation and soil moisture depletion. Yields for all treatments averaged about 2,000 lb/ac over all years, but in 2006 the RDI declined to 1,880 lb/ac with the grower control yielding 2,200 lb/ac. This difference was not statistically significant. No data on disease incidence was provided.

Does having hull rot reduce yields? Our own Kern County Almond Advisor Mario Viveros (recently retired) said last week that there has not yet been a trial designed that can truly answer that question. Most of the time the tree appears to compensate with new fruit wood higher up on the tree if water and N are adequate. However, if almond prices head south of $1.20/lb growers may decide it's more profitable to tighten the belt for a couple years to reduce inoculums in the orchard, reduce costs and help stabilize prices with restricted supply – but this can be an "iffy" game. Just ask the raisin growers!!

MEASURING TREE STRESS – LEAF & STEM WATER POTENTIAL: We all know that dry soil stresses trees. We also know that we can measure the actual water potential (stress level) of plants using a pressure chamber (often called pressure "bomb"). What we don't know is the exact relationship between soil moisture storage and midday plant water potential because this is different for every field due to soil type, irrigation system and rootstock. We also know that too much water in the rootzone inhibits oxygen uptake, can promote phytophthora and other diseases like alternaria and hull rot. Much of the work in almonds and other tree crops in the last 15 years has focused on establishing appropriate tree water potential thresholds that identify different levels of stress to help in disease prevention (hull rot) and possibly improve harvest timing and quality (hull split/shell split for almonds and pistachios).

How does it work? LEAF WATER POTENTIAL (LWP) uses bare leaves, usually in full sun, to estimate the midday stress mostly in cotton and grapes, especially wine grapes. A continual moderate stress enhances fruiting and quality in these crops. The leaf is cut off near the cane or stem and the petiole (leaf stem) placed in a rubber seal in a metal top that twists onto the chamber with the leaf side placed in the chamber. Pressure is then applied to the leaf until the xylem sap becomes visible at the cut end of the petiole. The positive pressure it takes to force out the sap is equal to the negative "suction" on the water in the leaf. The greater the "suction" (actually the more negative the internal water potential) the more difficult it is for water to move through the leaf; reducing ET and photosynthesis and eventually causing the leaf to wilt. We usually measure this potential in "bars". Essentially 1 bar is about equal to 1 atmosphere of pressure or 14.5 psi.

The preferred method for trees is to get an estimate of the water potential of the tree as a whole. The closest we can get to this is by measuring the STEM WATER POTENTIAL (SWP) by bagging or using a wet rag around interior, shaded leaves and letting them equilibrate with the water status of adjacent wood before cutting the leaf from the branch. A nice guide describing this technique has been prepared by Allan Fulton, UCCE Tehama County Irrigation Advisor, and can be found at the following link: **http://ucce.ucdavis.edu/files/filelibrary/2280/37294.pdf.** Through many different studies over the last 20 years we now have good guidelines for many tree crops as to what level of **midday (12 to 3 PM)** SWP indicates stressed or non-stressed conditions. These levels are different for different trees. For almonds: -6 to -10 bars is considered "no-stress", -10 to -12 "mild stress" and -14 to -18 "moderate/increasing stress". "Moderate stress" has been shown to reduce hull rot and cause earlier/more rapid hull split. At this point you are reducing crop ET. In a **Spur Dynamics** trial by Bruce Lampinen from 2001-07 in NW Kern County, the seasonal average SWP was -9.6 bars for the "Full Irrigation" and -12.1 bars for the "Reduced Irrigation". This produced a significant yield loss even though -12 bars is considered "mild stress". SWP in the -20 to -30 bar range will lead to wilt and defoliation. A great summary table for almonds, walnuts and prunes can be found at: **http://ucce.ucdavis.edu/files/filelibrary/2280/37303.pdf.**

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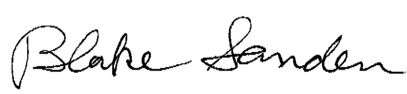

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