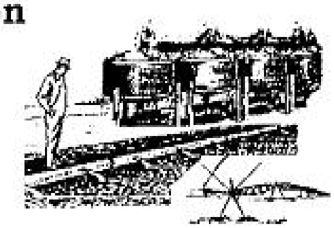
University of California Cooperative Extension

KERN SOIL AND WATER

MARCH 2012



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

KERN ALMOND MEETING & IRRIGATION WORKSHOP -- March 28, 2012
UCCE Conference Room, 1031 S. Mt. Vernon Ave, Bakersfield 93301
(Just south of the Ag Commissioner's Office)

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

8:30 -9:00 SIGN-IN/WELCOME

ALMOND PRODUCTION UPDATE – MORNING SESSION

9:00-9:20 FERTILITY: What does it take to make 4,000 + lb/ac? New tissue sampling guidelines and fertilizer rates – Sebastian Saa Silva (or Patrick Brown), UC Davis Pomology

9:20-9:50 WATER DEMAND & FERTIGATION OPTIONS – Blake Sanden, Kern UCCE

9:50-10:10 ALMOND VARIETY UPDATE – Mario Viveros, Kern UCCE

10:10-10:30 INTERACTION OF DISEASE, CANOPY SIZE & YIELD – Bruce Lampenin, Statewide UCCE Almond Specialist

10:30-11 BREAK (refreshments / talk with exhibitors)

11:00-11:20 DISEASE/FUNGICIDE MANAGEMENT – Bruce Lampenin or Mario Viveros

11:20-11:55 PLANT STRESS & DROUGHT MANAGEMENT – Ken Shackel, Pomology UC Davis

LUNCH – sponsored by service providers listed below

IRRIGATION MANAGEMENT AND ASSISTANCE – ALL CROPS

12:45-1:00 BALANCING EFFICIENCY & SALINITY CONTROL in the FIELD – Blake Sanden

1:00-1:15 OPTIMAL IRRIGATION of CRIMSON TABLE GRAPES USING PLASTIC – Dale Handley, Irrigation Consultant

1:15-1:30 IRRIGATION SYSTEM UNIFORMITY – Brian Hockett (North-West Kern Mobile Irrigation Lab)

1:30-1:50 NRCS EQIP COST SHARE FOR MICRO SYSTEMS – James Booth, Kern NRCS

1:50-2:10 PUMP IMPROVEMENT REBATE PROGRAM – CIT CSU Fresno, Pete Canessa

2:10-3:30 **WHAT'S IN THE TOOLBOX?** 5-10 minute presentations by sponsoring service providers: SIMPLOT: aerial imagery, HARMON: sulfur burner/water treatment, *SOIL MOISTURE SENSORS/MONITORING* – IRROMETER: tensiometers & Watermark, PURESENSE: capacitance probes/web-based data, GRUNDFOS PUMPS: precision injection & energy saving pumps, DELLAVALLE: weekly neutron probe, DALE HANDLEY IRRIGATION CONSULTANTS: Grape ET under plastic, HELENA CHEMICAL & PERRY BRUCE, field mapping with VERIS, TORO IRRIGATION, micro-irrigation of trees, vines and row crops

Service providers on-site to answer questions about their technology as it relates to your operation.

(RSVP to cekern@ucdavis.edu by 3/26 for a lunch head count)

ALMOND IRRIGATION UPDATE

How much?! How often?! Those two questions are probably the most common questions asked not just in ag, but for all of humanity: "Dad, how much allowance do I get? How often do I have to take out the trash?" How much fertilizer and water does it take to make 5,000 lb/ac almond kernel yield?

Increasing almond yield: Figure 1 illustrates changes in almond acreage and yield in Kern County since 1980. The inset box identifies major changes in agronomic practice. The average yield for 2002-12 increased over 700 lb/ac compared to the previous 14 years. The large swings in the last 5 years are related to weather and juvenile orchard acreage counted as "bearing acres". The Kern County average for 2010 was 2,620 lb/ac. One of Paramount Farming's Kern County Westside divisions averaged 4,000 lb/ac for all Nonpareils for the 2011 harvest. The significant factors driving this change are really centered around maximizing almond canopy capture of sunlight to achieve maximum spur density and productivity, namely; high density plantings, "long pruning", improved varieties, more timely and sufficient supply of nutrients, and, most significantly, a better understanding of truly non-stressed almond water use (evapotranspiration, ET). This newsletter will focus mostly on this last factor, but will also discuss some results on fertigation options and fertilizer type. This data has been derived from statewide and Kern County field trials from 2008 through 2011.

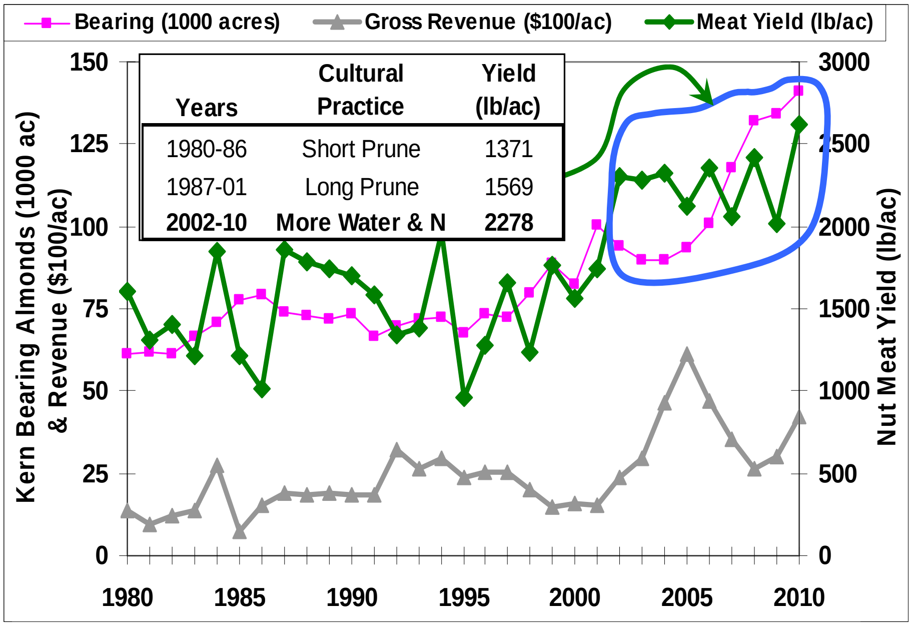


Fig. 1. Changes in bearing almond acreage, yield and gross revenue in Kern County from 1980-2010. (Source: Kern County Ag Commissioner) Comparison of 4 years of mature

Estimating Crop Water Use (ET) Using Crop Coefficients (Kc)

One of the most common approaches to estimating production irrigation demand is still to assume a "normal year" irrigation schedule, usually based on experience and what your neighbors do, that might call for an irrigation every 4 to 14 days depending on the irrigation system and age of the orchard. A much more accurate preliminary estimate of crop ET (not just irrigation events) can be made by using published crop coefficients (Kc) and local estimates of potential evapotranspiration, ETo. Seminal international extension manuals promoting this method in production agriculture go back to the 1970's (Crop Water Requirements, Doorenbos and Pruitt, 1977 and Yield Response to Water, Doorenbos and Kassam, 1979).

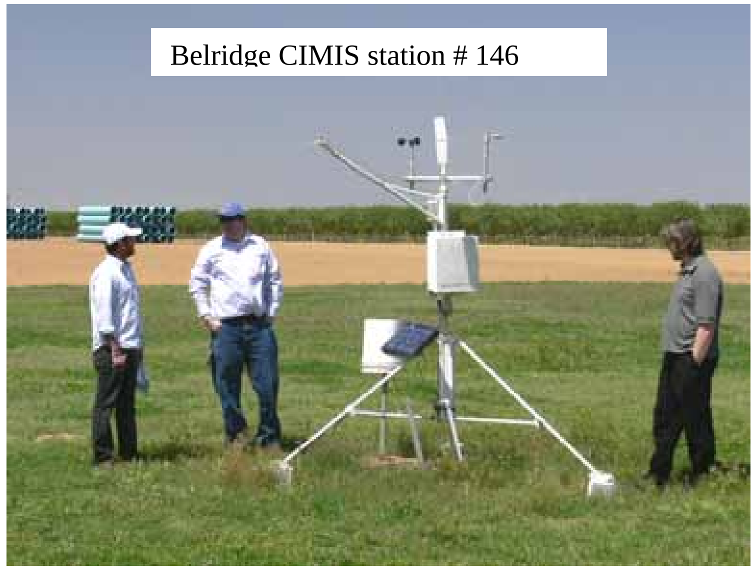
The general theory is that the Kc value represents the ratio of actual **non-stressed** crop water use compared to "reference crop" water use (like a well watered pasture) for that climate for a given stage of the crop growth. The initial theory also assumed that these seasonal Kc values, particularly for permanent crops, are constant regardless of where the crop is grown – hard-wired into the genetics of the species and any increase or decrease in the actual crop ET was climatically driven (i.e. it's hotter and drier in Bakersfield than in Stockton). The most accurate Kc values are developed from crops planted in large weighing lysimeters (basically huge tanks capable of a large enough rootzone soil volume for the crop being studied) where irrigation and subsequent water extraction by the crop is actually weighed. This has been done with peaches at the Kearney Ag Center but never with a large tree like almonds. Other field and meteorological energy balance techniques have also been developed to estimate ET in actual field settings. The first California specific extension publications listing our major commodities started coming out in the 1980's (Pruitt, 1987 and Snyder, 1989.) The calculation for crop ET is shown below:

$$\mathbf{ET_{crop} = ET_o * K_c * E_f}$$

ET_o = **reference crop** (tall grass) ET

K_c = **crop coefficient** for a given stage of growth as a ratio of grass water use. May be 0 to 1.3, standard values are good starting point.

E_f = an "**environmental factor**" that can account for immature permanent crops and/or impact of salinity. May be 0.1 to 1.1, determined by site.



Kc values may be listed by crop stage of development, or more conveniently as a weekly or bi-weekly average. This last format is most convenient for growers as they can simply multiply the Kc by the local real-time ETo (available on-line from the California Irrigation Management Information Service, CIMIS, http://www.cimis.water.ca.gov/cimis/data.jsp) to get an estimated crop water use for that week. Of course there can be some differences in the spring for an early or late start to the season.. For example: many almond blocks I checked around March 10 had the equivalent leafout of about March 20-25 for a normal year, which is like a Kc of 0.67 instead of 0.61. Not a real big deal unless you were already short on your winter refill of the profile and you're late starting up in the spring. To avoid falling behind and getting early depletion of the lower profile growers with micro systems should begin normal irrigation schedules by March 20th this year.

The right Kc values? Of course the condition that we have the right Kc for 100% ET assumes that the crop was at full vigor and canopy size and not stressed when ET was measured and the Kc calculated for that period. Unfortunately, many of the early Kc estimates for permanent crops were made in flood irrigated orchards and vineyards where this was not the case. This is most likely the case with the original Kc values for deciduous crops (including almonds) published by Pruitt (1987) and Snyder (1989). The peak Kc value for almonds was assumed to be 0.95 for orchards with no cover crop and a micro-irrigation system. For a 57.9 inch CIMIS "normal year" southern San Joaquin Valley ETo (Jones, 1999) the old yearly calculated almond ET with no cover crop equaled 42.3 inches. This number was assumed to be the 100% non-stressed ET for numerous almond trials conducted from the late 1980's to early 2000's, even though there was often signs of stress in these "100% ET" treatments.

Production and extension field observations: At the same time a number growers, managers, consultants and some extension personnel in California and Australia were paying close attention to the trees and rootzone soil moisture reserves. Improved technology such as inexpensive loggers, capacitance/TDR probes, electrical resistance blocks and recording tensiometers for the first time gave us a 24 hour a day picture of water movement in the soil. This information, often showing declining soil moisture reserves, coupled with an improved understanding of tree stem water potential (SWP, the measurement you get with a pressure chamber, often called a pressure "bomb") stress thresholds convinced much of the almond industry that the old Kc/ET estimates were too low and limiting yield.

After nearly 15 years of personal production experience and irrigation monitoring/scheduling extension demonstrations in more than 50 almond orchards (Sanden, 2006) I upset a number of my UC extension colleagues by publishing my own set of almond Kc values for you growers here in the southern San Joaquin Valley starting in 2002, which peaked out at 1.08, for a yearly ET of 52.3 inches, a 23.6% increase over the old ET estimate. These values have been put out in several of my newsletters and workshops over the last decade. (Table 1 at the end of this newsletter.)

Do the Sanden Kc values represent 100% non-stressed almond ET? Some progressive growers attained 4,000 lb/ac kernel yields in the early 2000's and most of the industry has responded with improved monitoring and increased precision and often quantity of fertigation and irrigation. Twenty years ago a yield of 2,500 lb/ac kernels was exceptional and you were considered to have a direct pipeline to the Almighty. This figure now barely pays the bills and 5,000 lb/ac is the new target. Unfortunately, we also see significant increases in disease in these well-watered and fertilized orchards. Increased hull-rot, some times phytopthora and syndromes such as "lower-limb dieback" have become increasing problems and threaten to shorten the life of the orchard. However, an average yield of 3,300 lb/ac from say 6th leaf through 18th leaf = 13*3,300 = 44,200 lb/ac, while 2,400 lb/ac from 6th through 22nd leaf = 17*2,400 = 40,800 lb/ac with an additional 4 years of cultural costs.

Scientific Validation of a New Set of Almond Crop Coefficients

Field observation is one thing, but scientific validation is another. Starting in 2008, a statewide collaborative effort lead by Rick Snyder to validate new almond crop coefficients provided for the installation of sophisticated meteorological instruments to measure ET in four almond orchards from the southern San Joaquin Valley in Kern County to Butte County in the northern Central Valley. The results for four years in Kern County are reported here. Figure 2 shows the weekly ET measured using the Eddy Covariance heat flux technique in a Westside almond orchard from 2008-2011. Cumulative ET for each seasonal measurement period ranged from 49.1 to 61.5 inches.

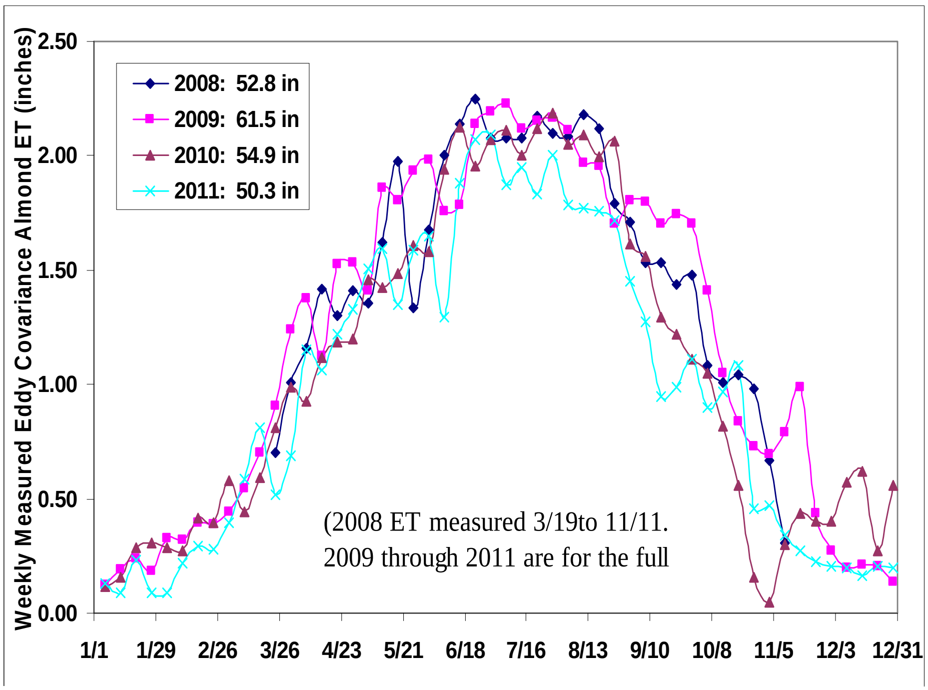


Fig. 2. Comparison of 4 years of mature almond crop ET as determined by Eddy Covariance heat flux.

To get the crop coefficients from this data we simply divide the ET by the CIMIS station ETo closest to the field (Belridge Station #146) and we come up with the weekly Kc values shown in Figure 3. A combination of neutron probe and capacitance (PureSense) soil water content readings and weekly tree stress using the pressure bomb to measure SWP (maintain at -8 to -11 bars) were used to determine irrigation schedules so as to minimize stress. Significant hull rot problems began in this orchard in 2009 and some regulated deficit irrigation (RDI) at hull split was practiced in 2010 and 2011 to try and reduce infections; hence the reduced ET for 2010 and 2011. There are also reduced N fertilizer rate treatments in this block where the lower N rate did show less disease and, of course, less yield. Despite the irrigation

deficit for both years hull rot still caused significant death in fruiting spurs in the lower canopy in the normal to high rate N treatments.

Figure 3 shows the erratic nature of measured Kc values in the spring and fall months from one year to the next. This has to do with the frequency and depth of the rain and the fact that both the orchard and CIMIS ETo are so low that even small changes in one or the other cause the Kc to jump up an down significantly. Summer "normal year" ET is much more predictable for most of California's great Central Valley and, along with higher levels of crop ET, this greatly increases the uniformity of Kc values from June to September, reaching a peak Kc of 1.15 before the stress of harvest cutoff prior to shaking reduces ET. The other sites in this statewide study found similar Kc values. The three sets of almond Kc curves (on a 15 day basis over the season), Pruitt (1987), Sanden (2006) and the combined average for the last four years of this Kern County trial, are shown in Figure 4. In this trial, the double-line drip system used as much water as micro-sprinklers (Fanjets).

So do my almonds really need 56 to 60 inches of water for maximum yield?

This is not a recom-mendation to apply 60 inches of water to almonds. Due to soil type and irrigation pressure differences in this orchard we have measured individual tree ET (using soil moisture depletion and chloride balances) that ranges from 49 to 62 inches. Figure 5 shows the individual yields from those trees and that there is no yield advantage above 50 to 52 inches of tree ET as long as the rootzone receives sufficient winter recharge and leaching of salts to start the following season with a full profile. So keep using the Table 1 ET for now.

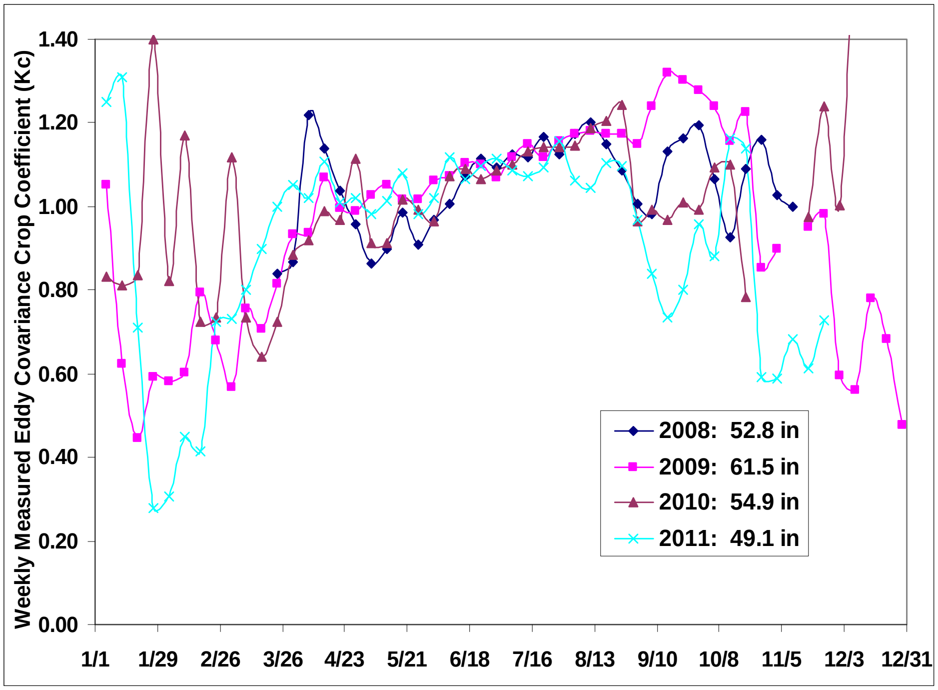


Fig. 3. Comparison of 4 years of mature almond crop coefficients (Kc) generated from Eddy Covariance heat flux estimates of crop ET divided by the modified Penman ETo from the Belridge CIMIS station #146, 1.5 miles due west of orchard.

References

Doorenbos, J. and Kassam, A. H. 1979. *Yield response to water.* FAO Irrig. and Drain. Paper No. 33, FAO, Rome, Italy. 193 pp.

Doorenbos, J. and Pruitt, W. O., 1977. Crop water requirements. *Irrigation and Drainage Paper No. 24,* (rev.) FAO, Rome, Italy. 144 p.

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.

Pruitt, W.O., Fereres, E., Kaita, K. and Snyder, R.L. 1987. Reference Evapotranspiration (ETo) for California. UC Bulletin 1922.

Sanden, B. 2006. Field management and monitoring of almond irrigation in Kern County. Proceedings 2006 California Plant and Soil Conference, "Realities of Modern Agriculture", Visalia, CA 7-8 Feb, 2006. Univ Calif, Davis. pp.49-55 http://calasa.ucdavis.edu/proceedings.htm)

Snyder, R.L., B.J. Lanini, D.A. Shaw, W.O. Pruitt. 1989. Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Trees and Vines. UC Publication 21428.

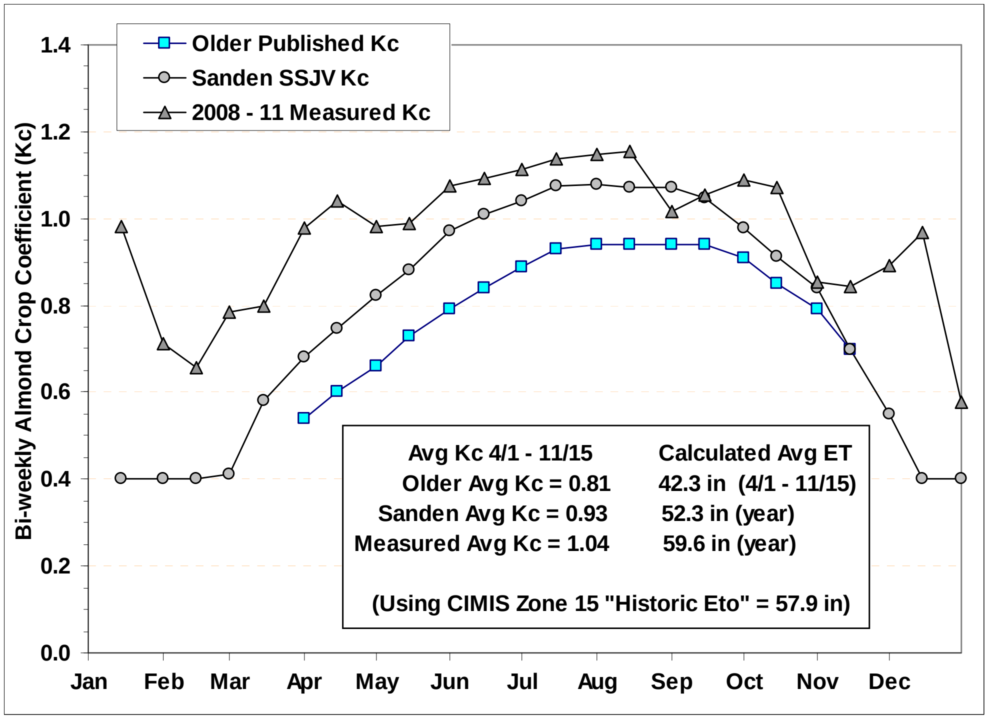


Fig. 4. Comparison of 3 Kc curves for mature almonds in the Central Valley irrigated without a cover crop.

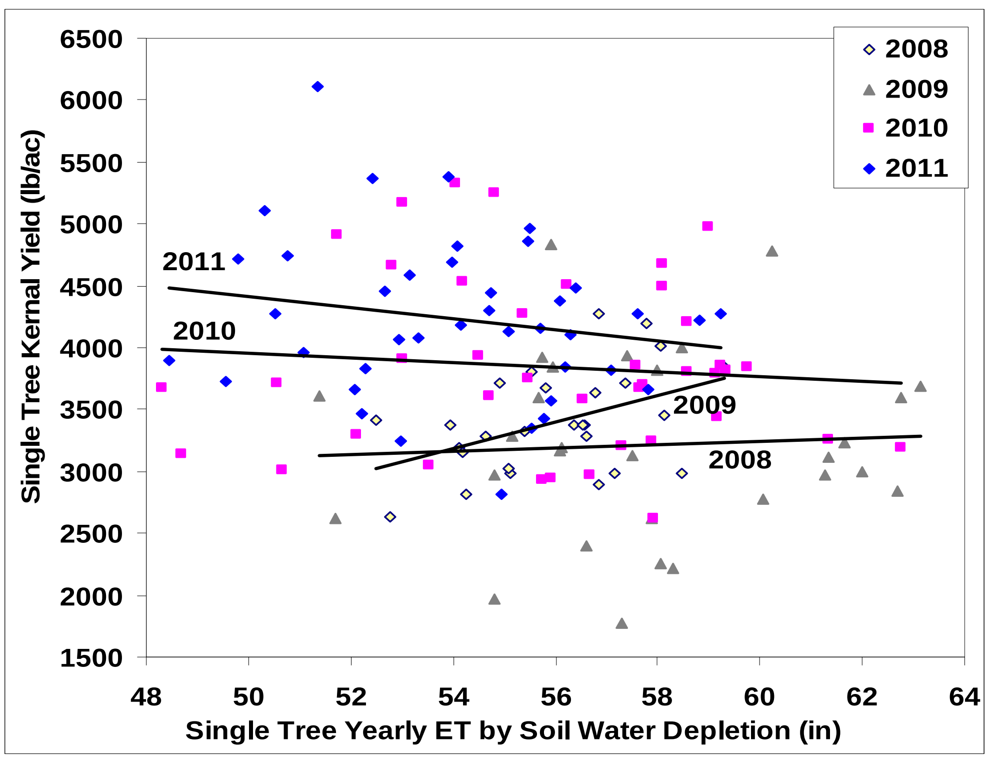


Fig. 5. Yield variation as a function of tree specific ET estimated by weekly measurements of applied water and soil water content change.

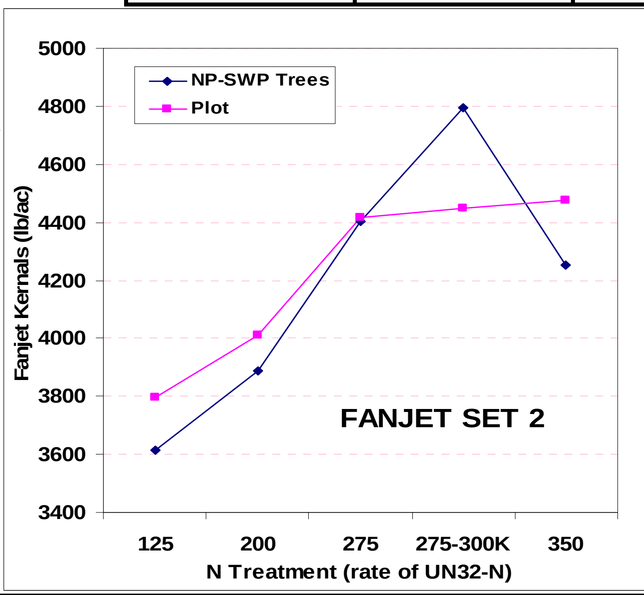
Table 1. "Normal Year" almond ET for different ages of trees irrigated with microsprinklers / drip

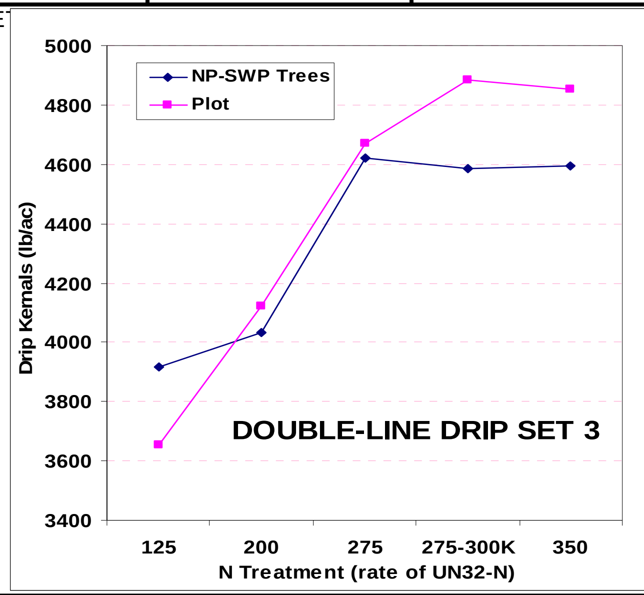
CIMIS ET Estimates Using Zone 15 Southern SJV "Historic" ETo								20X22 Spacing Gallon / day / tree
	Normal Year Grass ETo	Mature Crop Coef-ficient	Almond ET -- Minimal grass, Microsprinkler / Drip (S. San Joaquin Valley)					
Week	(in)	(Kc)	1st Leaf @ 40%	2nd Leaf @ 55%	3rd Leaf @ 75%	4th Leaf @ 90%	Mature	
1/6	0.21	0.40	0.03	0.05	0.06	0.08	**0.09**	**3**
1/13	0.28	0.40	0.03	0.06	0.08	0.10	**0.11**	**4**
1/20	0.30	0.40	0.04	0.07	0.09	0.11	**0.12**	**5**
1/27	0.36	0.40	0.04	0.08	0.11	0.13	**0.14**	**6**
2/3	0.42	0.40	0.05	0.09	0.13	0.15	**0.17**	**7**
2/10	0.47	0.40	0.06	0.10	0.14	0.17	**0.19**	**7**
2/17	0.54	0.40	0.06	0.12	0.16	0.19	**0.22**	**8**
2/24	0.61	0.40	0.07	0.13	0.18	0.22	**0.24**	**10**
3/3	0.69	0.42	0.09	0.16	0.22	0.26	**0.29**	**11**
3/10	0.79	0.61	0.14	0.27	0.36	0.43	**0.48**	**19**
3/17	0.89	0.64	0.17	0.31	0.43	0.51	**0.57**	**22**
3/24	0.98	0.67	0.20	0.36	0.49	0.59	**0.65**	**26**
3/31	1.09	0.72	0.23	0.43	0.59	0.70	**0.78**	**31**
4/7	1.19	0.74	0.26	0.48	0.66	0.79	**0.88**	**35**
4/14	1.32	0.75	0.30	0.55	0.74	0.89	**0.99**	**39**
4/21	1.41	0.81	0.34	0.63	0.85	1.03	**1.14**	**45**
4/28	1.49	0.83	0.37	0.68	0.93	1.12	**1.24**	**49**
5/5	1.59	0.86	0.41	0.75	1.03	1.23	**1.37**	**54**
5/12	1.66	0.90	0.45	0.83	1.13	1.35	**1.50**	**59**
5/19	1.73	0.94	0.49	0.89	1.22	1.46	**1.63**	**64**
5/26	1.78	0.96	0.51	0.94	1.29	1.54	**1.72**	**67**
6/2	1.85	0.98	0.54	0.99	1.35	1.62	**1.80**	**71**
6/9	1.86	0.99	0.55	1.01	1.38	1.65	**1.83**	**72**
6/16	1.90	1.02	0.58	1.06	1.45	1.74	**1.93**	**76**
6/23	1.93	1.05	0.61	1.11	1.52	1.82	**2.03**	**79**
6/30	1.93	1.06	0.62	1.13	1.54	1.85	**2.05**	**80**
7/7	1.93	1.08	0.62	1.14	1.56	1.87	**2.07**	**81**
7/14	1.93	1.08	0.62	1.14	1.56	1.87	**2.07**	**81**
7/21	1.86	1.08	0.60	1.10	1.50	1.80	**2.00**	**78**
7/28	1.86	1.07	0.60	1.10	1.50	1.79	**1.99**	**78**
8/4	1.78	1.07	0.57	1.05	1.44	1.72	**1.91**	**75**
8/11	1.75	1.08	0.57	1.04	1.42	1.70	**1.89**	**74**
8/18	1.69	1.08	0.55	1.00	1.36	1.64	**1.82**	**71**
8/25	1.62	1.07	0.52	0.96	1.30	1.57	**1.74**	**68**
9/1	1.55	1.07	0.50	0.91	1.24	1.49	**1.66**	**65**
9/8	1.47	1.06	0.47	0.85	1.17	1.40	**1.55**	**61**
9/15	1.40	1.04	0.43	0.80	1.08	1.30	**1.45**	**57**
9/22	1.31	1.02	0.40	0.73	1.00	1.19	**1.33**	**52**
9/29	1.19	0.97	0.35	0.64	0.87	1.04	**1.16**	**45**
10/6	1.10	0.95	0.31	0.57	0.78	0.94	**1.04**	**41**
10/13	1.00	0.88	0.26	0.48	0.66	0.79	**0.88**	**35**
10/20	0.90	0.88	0.24	0.43	0.59	0.71	**0.79**	**31**
10/27	0.77	0.83	0.19	0.35	0.48	0.58	**0.64**	**25**
11/3	0.67	0.78	0.16	0.29	0.39	0.47	**0.53**	**21**
11/10	0.57	0.71	0.12	0.22	0.31	0.37	**0.41**	**16**
11/17	0.48	0.68	0.10	0.18	0.25	0.30	**0.33**	**13**
11/24	0.42	0.60	0.07	0.14	0.19	0.22	**0.25**	**10**
12/1	0.36	0.50	0.05	0.10	0.13	0.16	**0.18**	**7**
12/8	0.31	0.40	0.04	0.07	0.09	0.11	**0.12**	**5**
12/15	0.29	0.40	0.03	0.06	0.09	0.10	**0.11**	**4**
12/22	0.25	0.40	0.03	0.06	0.08	0.09	**0.10**	**4**
12/29	0.21	0.40	0.03	0.05	0.06	0.08	**0.09**	**3**
Total	**57.90**		**15.68**	**28.75**	**39.20**	**47.05**	**52.27**	

What about nitrogen rate impacts on ET and yield?

N rate had a highly significant impact on Nonpareil yield as shown in the below table and charts (data are for UAN32). Banded potassium sulfate @ 125 lb/ac K was applied in the winter. Additional K and the N fertilizer was injected with the irrigation water at bloom (20%), April (30%), June (30%) and post-harvest (after Monterey 20%). After 4 years, an N fertilizer rate of 125 lb/ac produced a kernel yield that was as much as 1,200 lb/ac less than the 275 lb/ac rate and 200 lb N/ac yields were decreased by 400 to 600 lb/ac. 350 lb N/ac or 300 lb K/ac compared to the standard 200 lb/ac K rate did not increase yield. New data on N-P-K export and tissue critical levels will be presented at the workshop.

2011 Treatment (N-K lb/ac)	Stem Water Potential (bars)		Soil Water Content to 9 feet		Cumulative Neutron Probe ET		SWP-NP Tree Kernel Yield (lb/ac)		Whole Plot Kernel Yield (lb/ac)	
	Drip	Fanjet	Drip	Fanjet	Drip	Fanjet	Drip	Fanjet	Drip	Fanjet
125-200	-9.3 b	-10 a	17.1 ab	15.5 a	53.8 a	54.7 a	3917 a	3659 a	3653 a	3798 a
200-200	-9.5 a	-10 a	17.5 ab	15.5 a	53.7 a	53.4 a	4034 a	3951 ab	4123 ab	4012 a
275-200	-9.3 b	-10 a	19.4 b	18.0 a	54.1 a	54.2 a	4621 b	4365 bc	4670 bc	4416 b
275-300	-9.3 b	-10 a	17.6 ab	16.1 a	54.6 a	53.7 a	4586 b	4702 c	4886 c	4447 b
350-200	-9.0 c	-10 a	15.3 a	16.5 a	55.2 a	52.8 a	4596 b	4273 bc	4854 c	4476 b
AVERAGE	-9.3	-10.4	17.4	16.3	54.3	53.8	4351	4190	4437	4230
LSD 0.05	*0.2*	*0.2*	*2.7*	*2.9*	*4.0*	*2.9*	*539*	*472*	*557*	*313*





What about "spoon-feed" high frequency fertigation compared to standard 4x/yr injection?

Come to the workshop to find out results from the first year of this trial!