University of California Cooperative Extension

KERN SOIL & WATER

Kern County • 1031 S. Mt. Vernon Avenue • Bakersfield, CA 93307 • 661-868-6218

Mid-season Irrigation Checkup for a Drought Year

July 2008

It's official – the Governor declared official drought status for California Wednesday, June 4. Ironically, the new ag reporter for the Bakersfield Californian called me Monday, June 2 to ask me what I thought about the reduction in the Friant Federal water allocation. In Tuesday's paper she quoted, "We've been skating just above the levels of official drought," said Blake Sanden, a farm adviser for UC Cooperative Extension Kern County." The next day came the announcement. I should have bought a lottery ticket!

Well, for all of you scrambling to find enough water for irrigation it feels more like you're holding the losing ticket by now. Due to judicial pronouncements and below average rainfall/snowpack over three years, the Federal project water allocation has been cut to 40% (even less if you're in Westlands Water District), and State water supplies from the California Aqueduct have been slashed to 35%. Snowpack and reservoir storage across the state as of the beginning of June was 50 to 69% of normal. In many areas of Kern County, groundwater pumping levels have dropped 20 to 50 feet; meaning your old dependable 1200 gpm well might only be yielding 1000 gpm.

A large grower in NW Kern told me it was costing him about $300/ac-ft to get the extra water he needed to irrigate his trees. Another grower in the same area is not paying quite as much but their supply is limited to 4 ac-ft/ac even though many of their almond blocks have marginally high chloride levels at the three foot depth in the rootzone and they have no extra water for leaching. Some burn and defoliation will be impossible to avoid. The coffee shop talk says some growers in on the Westside paid as much as $700/ac-ft to buy water off of fallowed ground to make up the deficit.

Okay, we know it's bad, now what can we do about it? Following is a list of practices and resources to help you get the most out of every drop of water. The following topics are too extensive to explain in one newsletter, so they are only introduced here as a general category (with a couple exceptions) with links to other newsletters or tables posted on our Kern Cooperative Extension Website http://cekern.ucdavis.edu (and a few others) so you can get more info on the topic of your choice.

NORMAL YEAR CROP WATER USE, EVAPOTRANSPIRATION (ET) and CIMIS

From May through August we are blessed with very predictable weather in the San Joaquin Valley, where the "reference crop potential evapotranspiration" (basically unstressed pasture grass water use, ETo) varies no more than 5% from one year to the next. This makes it possible to estimate average crop ET for a given week based on the "normal year" ETo multiplied by a crop coefficient (Kc) for that stage of crop development. Table 1 shows average ET estimates for a variety of Kern crops. The specific Kc values used in this table, Average SSJV ET and Crop Coefficients can be found at:

http://cekern.ucdavis.edu/files/53222.xls

These are a combination of published values and my personal observation from Kern County trials. Additional references are also listed. More detailed Excel tables can be downloaded for the below crops:

- Almonds: Almond ET- Age-Week-Month http://cekern.ucdavis.edu/files/53223.xls
- Citrus: Citrus ET by age http://cekern.ucdavis.edu/files/53224.xls
- Forage: Forage ET http://cekern.ucdavis.edu/files/53225.xls
- Grapes: Grape ET http://cekern.ucdavis.edu/files/53226.xls
  Estimating vineyard crop coefficients http://cekern.ucdavis.edu/files/53263.doc
- Pistachios : Pistachio ET by Age http://cekern.ucdavis.edu/files/53227.xls

Table 1: CIMIS "Normal Year" Crop ET for the southern San Joaquin Valley. (ETo - Jones, 1999)

Week Ending	Normal Year Grass *ETo	Afalfa (non-dormant)	[1]Almond (micro sprinklr)	[2]Almond (active cover flood)	Black-eyes (full season)	[3]Carrots (2/1 plant)	[3]Carrots (9/1 plant)	Citrus	Corn (silage)	Cotton	Grapes (late, gable trellis)	Pist-achios	Potato (2/1 plant)	Small Grains	[3]Tomato (3/10 plant)
1/6	0.21	0.20	0.09	0.21			0.24	0.16						0.01	
1/13	0.28	0.26	0.11	0.28			0.29	0.21						0.10	
1/20	0.30	0.28	0.12	0.30			0.30	0.22						0.13	
1/27	0.36	0.34	0.14	0.36			0.32	0.27						0.18	
2/3	0.42	0.40	0.17	0.42		0.84	0.38	0.31						0.26	
2/10	0.47	0.45	0.19	0.47		0.94		0.35					0.20	0.34	
2/17	0.54	0.51	0.22	0.54		0.05		0.40					0.20	0.44	
2/24	0.61	0.58	0.24	0.61		0.08		0.44					0.25	0.56	
3/3	0.69	0.66	0.29	0.71		0.09		0.50					0.35	0.64	
3/10	0.79	0.75	0.48	0.81		0.14		0.56	0.09		0.10		0.44	0.82	1.18
3/17	0.87	0.83	0.56	0.91		0.23		0.61	0.14		0.11		0.52	0.96	0.87
3/24	0.98	0.93	0.65	1.03		0.35		0.69	0.20		0.13	0.07	0.75	1.08	0.20
3/31	1.09	1.04	0.78	1.18		0.60		0.76	0.25		0.18	0.11	1.07	1.27	0.28
4/7	1.19	1.13	0.88	1.29		0.98		0.84	0.36		0.27	0.24	1.33	1.40	0.36
4/14	1.32	1.25	0.99	1.44		1.31		0.92	0.55	0.13	0.53	0.39	1.50	1.49	0.46
4/21	1.41	1.34	1.14	1.57		1.50		0.98	1.13	0.16	0.70	0.56	1.64	1.58	0.63
4/28	1.49	1.41	1.24	1.66		1.58		1.04	1.56	0.19	0.86	0.74	1.81	1.66	0.74
5/5	1.59	1.51	1.37	1.84	0.15	1.70		1.11	1.83	0.26	1.11	0.95	1.97	1.75	1.03
5/12	1.66	1.58	1.50	1.93	0.23	1.84		1.16	1.96	0.34	1.33	1.16	1.91	1.72	1.33
5/19	1.73	1.65	1.63	2.05	0.49	1.95		1.21	2.05	0.44	1.56	1.56	1.89	1.64	1.73
5/26	1.78	1.69	1.72	2.13	0.76	2.01		1.23	2.11	0.54	1.69	1.78	1.60	1.45	1.96
6/2	1.85	1.75	1.80	2.20	1.06	1.94		1.25	2.18	0.77	1.85	2.03	1.51	1.22	2.03
6/9	1.88	1.79	1.86	2.27	1.62	1.98		1.25	2.22	1.09	1.97	2.16	1.08	0.95	2.07
6/16	1.91	1.81	1.94	2.30	2.03	1.94		1.24	2.22	1.43	2.10	2.23	0.84	0.76	2.10
6/23	1.93	1.83	2.03	2.33	2.18	1.89		1.25	2.24	1.73	2.12	2.25			2.12
6/30	1.94	1.84	2.06	2.34	2.21	1.73		1.26	2.21	2.01	2.23	2.31			2.13
7/7	1.94	1.84	2.09	2.34	2.23	1.75		1.26	2.17	2.31	2.23	2.31			2.02
7/14	1.93	1.83	2.07	2.35	2.24			1.25	2.12	2.33	2.22	2.29			1.93
7/21	1.89	1.80	2.03	2.30	2.21			1.23	2.04	2.29	2.17	2.25			1.70
7/28	1.86	1.76	1.99	2.04	2.18			1.21	1.67	2.25	2.04	2.21			1.11
8/4	1.80	1.71	1.93	1.62	2.16			1.17		2.18	1.98	2.14			
8/11	1.75	1.67	1.89	1.23	2.11			1.14		2.12	1.93	2.09			
8/18	1.69	1.61	1.82	1.02	2.05			1.10		2.05	1.78	2.01			
8/25	1.62	1.54	1.74	1.54	1.87			1.05		1.96	1.70	1.82			
9/1	1.55	1.47	1.66	1.55	1.71		3.10	1.06		1.80	1.63	1.74			
9/8	1.47	1.39	1.55	1.61	1.56		2.94	1.07		1.58	1.54	1.47			
9/15	1.40	1.33	1.45	1.54	1.35		0.21	1.09		1.34	1.40	1.33			
9/22	1.31	1.24	1.33	1.48	1.00		0.39	0.85		1.07	1.31	1.26			
9/29	1.19	1.13	1.16	1.34	0.53		0.60	0.79		0.83	1.19	1.05			
10/6	1.10	1.05	1.04	1.20			0.77	0.76		0.63	1.05	0.95			
10/13	1.00	0.95	0.88	1.09			0.90	0.70		0.46	0.90	0.80			
10/20	0.90	0.85	0.79	0.95			0.90	0.63			0.63	0.67			
10/27	0.77	0.74	0.64	0.82			0.81	0.54			0.39	0.55			
11/3	0.67	0.64	0.53	0.70			0.74	0.47			0.34	0.47			
11/10	0.57	0.54	0.41	0.60			0.66	0.40			0.29	0.26			
11/17	0.48	0.46	0.33	0.49			0.55	0.34			0.24	0.19			
11/24	0.40	0.38	0.24	0.40			0.46	0.28				0.12			
12/1	0.34	0.32	0.17	0.34			0.39	0.24							
12/8	0.29	0.28	0.12	0.29			0.35	0.20							
12/15	0.26	0.25	0.10	0.26			0.31	0.18						0.07	
12/22	0.23	0.22	0.09	0.23			0.27	0.16						0.07	
12/29	0.21	0.20	0.09	0.19			0.24	0.16						0.07	
Total	**57.90**	**55.00**	**52.34**	**62.65**	**33.93**	**27.42**	**16.09**	**39.54**	**31.27**	**34.29**	**45.78**	**46.53**	**20.85**	**22.63**	**27.99**

*****Using most recent Potential ET numbers for the southern SJV from Jones, et. al., 1999. California Irrigation Management Information System.

[1] MInimal winter weeds present.

[2] Winter and summer grasses actively growing and receiving irrigation water. If chemical mowing/killing used mid season, switch to Microsprinkler schedule IF THE PROFILE IS FULL AT TIME OF TREATMENT.

[3] High evaporative losses occur during germination due to shallow planted seed and frequent sprinkling.

The data given in these tables is my best estimate for the southern San Joaquin Valley. You can update these tables with the current year's ETo by accessing the CIMIS website and following these steps:

Website Address: http://www.cimis.water.ca.gov/

Non-Members – last 7 days only:

1. Select Data tab on header
2. Sample Daily or Monthly report
3. Select County
3. Submit – gives last 7 days for all stations in county

Signing up for membership is free, can be done on the website and allows many more options for data access.

KERN COUNTY CIMIS STATIONS	
5	Shafter/USDA
54	Blackwell's Corner
125	Arvin-Edison
138	Famoso
146	Belridge
172	Lost Hills NW

There are many other publications available with suggested crop water use tables (browse UC irrigation publications: http://anrcatalog.ucdavis.edu/Search/irrigation.aspx and our current UC Drought Management Website: http://ucmanagedrought.ucdavis.edu/almonds.cfm); not all of them agree. My numbers for almonds are higher than nearly any other reference, but are the result of 7 years of various trials and observations in more than 40 almond blocks across Kern County and they also reflect a higher estimate of San Joaquin Valley ETo than the one we used 10 years ago. Remember, these tables are just guidelines to get you started. Depending on salinity impacts, crop load, the overall vigor of your field and irrigation uniformity your actual crop water requirement (ET + non-uniformity + leaching) may be less or as much as 10 to 20% greater than the table values. Checking field soil moisture (next section) and actual crop stress will tell you whether you are on target or not.

FLOOD SYSTEM MANAGEMENT – know your soil water holding capacity, use higher flows and tailwater return for better uniformity and efficiency

Flood systems usually offer the greatest possibilities and biggest challenges for "saving" water. It is much more important to know the mechanics and interaction of soil water holding capacity, infiltration, run times, tail water management/return and field distribution uniformity for flood systems than micro systems. A well designed fanjet system puts out a 92% uniform application rate on the sandy part of the field as on the clay loam area, and it doesn't matter if there is a "low belly" in the middle of the run. With a flood system you may get anything from as little as 0.6 inch depth of water infiltrated in a Wasco sandy loam irrigated with snow-melt water that has "sealed over" by mid-season to as much as 7 inches on a Milham sandy loam irrigated with well or Aqueduct water. A Buttonwillow cracking clay may take in 5 to 8 inches in a 24 hour set, then seal up when the cracks close and not take a drop more. Of course the path of greatest water use efficiency is the cross road of timing the irrigation to just infiltrate the depth of water the plant has used since the last irrigation and before experiencing undesirable stress. Coming back too soon with too much water will push water and fertilizer out the bottom of the rootzone (deep percolation) and possibly cause waterlogging and increased disease potential. Tailwater losses can also increase.

So the first step is to know your dirt, okay soil. The available water holding capacity (AWHC) may be as little as 0.75 inches of water/foot in a coarse loamy sand to 2.5 inches/foot in a fine textured silt/clay loam to clay, which means your reserve moisture available to say a corn or alfalfa crop over a 5 foot rootzone an range from 4 to 12 inches total. For an annual crop like corn you also need to consider the increasing rooting depth as the crop grows. The forgiving aspect of flood irrigation is that most of our ag soils from a fine sandy loam to a clay loam will give up 4.5 to 6 inches of water before crop stress ocurrs (about a 50% depletion), assuming a six foot rootzone. Table 2 shows typical irrigation intervals for different soil textures over the season, which somewhat confirm the old standard of irrigate 3 weeks apart early season and every 2 weeks midseason and that will get you close to what you need.

Well, if you're irrigating with $200 water (or even $100 water) then "close" is no cigar. Over irrigating by 6 inches/acre costs you $100, or underirrigating by 6 inches could lose you a ton of alfalfa or 3 to 5 tons of silage. The only way you'll know is by checking soil moisture by hand or with various sensors or contract irrigation scheduling services. By using a flowmeter for the field and hand checking to 4 feet (head and tail) before and after the irrigation you will have a better idea of the depth of water the field not only "takes", but actually "stores". If your calculation of stored water is significantly less than what the flow meter measured then you're losing a lot of water out the tail ditch or to deep percolation.

For a handy guide on UNDERSTANDING ESSENTIAL SOIL TEXTURE/MOISTURE STORAGE & DISTRIBUTION UNIFORMITY FOR EFFICIENT FLOOD IRRIGATION download:

Table 2. Calculated irrigation interval (days of moisture reserve) by month, soil texture and rooting depth.

110 day silage corn plant 4/14		Roots1.5' Apr	Roots 3 ft May	Roots 4.5' Jun	Roots 6 ft Jul	Aug
Soil Texture	**Avg Daily ET**	**0.06**	**0.15**	**0.26**	**0.3**	**0.26**
Available Soil Moisture to 6 feet @ 50% depletion	(in)	Days of Moisture Reserve for Average Daily ET by Month and Root Delopment				
Sand	**2.1**	9	7	6	7	8
Loamy Sand	**3.3**	14	11	10	11	13
Sandy Loam	**4.2**	18	14	12	14	16
Loam	**5.4**	23	18	16	18	21
Silt Loam	**5.4**	23	18	16	18	21
Sandy Clay Loam	**3.9**	16	13	11	13	15
Sandy Clay	**4.8**	20	16	14	16	18
Clay Loam	**5.1**	21	17	15	17	20
Silty Clay Loam	**5.7**	24	19	16	19	22
Silty Clay	**7.2**	30	24	21	24	28
Clay	**6.6**	28	22	19	22	25

- **Flood irrigation soil moisture and scheduling** **http://cekern.ucdavis.edu/files/53297.doc**

The Center for Irrigation Technology has an on-line water balance scheduling spreadsheet and webiste that might also be helpful: **http://www.wateright.org**.

TAILWATER RETURN & ENERGY EFFICIENCY – improve irrigation uniformity and save water

For most ag soils, the "on time" water needs to be applied to the tail end of the field should be at least 25 to 35% of the total on time that the head end received to get a reasonable "distribution uniformity" (DU) of infiltrated water of 70 to 80%. Except for coarse sandy soils, about 60 to 80% of the maximum infiltration over 24 hours occurs in the first 3 to 6 hours. This is why we can produce fairly uniform yields in cotton with a ¼ mile run, 24 hour set, 16 to 18 hours to get out and 6 to 8 hours to run on the tail. The resulting tailwater may be about 15% of the total applied. Whether borders in hay, wheat, almonds, grapes or furrows in cotton, corn and beans the faster you run the water (avoiding heavy erosion) for a given set time, the better uniformity you'll have AND the more tailwater you'll generate.

Kern County probably has more field specific tailwater return systems than

Table 3. TAILWATER PIT COSTS & RETURNS (April 2008)
Average energy cost, kwh over season: $0.14

Crop: ALFALFA **Acreage: 80** **Crop ET (in): 52**

Item	$
2900 feet, 8 inch pipeline @ $4/ft installed	11,600
0.5 ac-ft pit (50x100x5)	1,500
Concrete pump stand/sump	3,000
7 HP turbine pump	6,000
Electrical panel	3,500
TOTAL	**$25,600**

Return flow (gpm): 700 **Pumping Head (ft): 20**

Field Distribution Uniformity	65 %	70 %	75 %	80 %	85 %
Pumping Efficiency	50 %	50 %	50 %	50 %	50 %
Required Applic (in)	80.0	74.3	69.3	65.0	61.2
Required Applic (ac-ft)	533.3	495.2	462.2	433.3	407.8
Runoff (%)	**10%**	**15%**	**20%**	**25%**	**30%**
Total Water without Return (ac-ft)	586.7	569.5	554.7	541.7	530.2
Tailwater (ac-ft)	**53.3**	**74.3**	**92.4**	**108.3**	**122.4**
Hours On for Season	414	577	717	841	950
Sump HP Reqd	7.1	7.1	7.1	7.1	7.1
Sump KWH/ac-ft	41	41	41	41	41
Total Sump KWH	2183	3040	3783	4433	5007
Total Energy Cost	$306	$426	$530	$621	$701
Reservoir Maintenance	$200	$200	$200	$200	$200
Depreciation (20 yrs)	$1,280	$1,280	$1,280	$1,280	$1,280
Annual Water Cost ($/ac-ft)	**$33**	**$26**	**$22**	**$19**	**$18**

any other county in CA due to the cost of our water, but there are still lots of fields in Kern Delta, Buena Vista and some other districts that just dump the tail water back into the district ditch and you lose it. Table 3 shows the breakdown of costs, required water applied to meet ET, tailwater generated and your final $/ac-ft for recycled tailwater for an 80 acre block of alfalfa for different field distribution uniformities. Of course these numbers are theoretical calculations and I don't know of any hay field in Kern County where somebody puts on 80 inches trying to keep the dry end of the field wet. Most fields get 50 to 60 inches, and the best yielding fields always have some runoff to avoid drowning out the ends. So … BOTTOM LINE: better field uniformity = less total applied water required = better yield = more tailwater. For a 20 year system life: if you return 100 ac-ft/year of tailwater to the field your cost is about $20/ac-ft, if it's only 60 ac-ft/yr the cost is about $30/ac-ft – a real bargain these days, especially with reduced allocations. You can get the Excel spreadsheet for Table 3 and plug in your own numbers by downloading: **Pump-TailwaterEnergy Effic Compare —**
http://cekern.ucdavis.edu/files/53301.xls

Groundwater pumping and well efficiency

With declining groundwater levels and the increased dependence on pumping it is imperative to get your well checked to make sure you are at top efficiency, and there are substantial grants available to help. The Center for Irrigation Technology Cal State Fresno administers $millions in free pump testing payments and substantial well repair/maintenance cost share in cooperation with the California Energy Commission and other power companies. To get the details go to: http://www.pumpefficiency.org/

If your power costs $0.14/kwh and you improve the pump efficiency from 50 to 65% you can save about $3000 for the water required to irrigate 80 acres of pistachios. Improving the field uniformity with the increased flow by 15% can save another $4000 dollars in reduced water requirement and pumping. This spreadsheet is part of the above Excel file.

MICRO-IRRIGATION SYSTEMS MANAGEMENT FOR MAXIMUM EFFICIENCY

Okay, your irrigation designer/dealer guaranteed you a 92% distribution uniformity (DU) for your new micro-sprinkler orchard system. This means that when you apply a 1 inch average to the field that the wettest 25% of the field with the most pressure gets an average 1.09" and the driest 25% averages 0.92". Now it's 2 to 4 years later and you haven't checked the in-field pressure on the automatic subunit regulators (They're automatic, right?!), you haven't cleaned the hose screens at the "Tee", and you only flush hoses twice a year. A pilot valve on one of the regulators has silted up and is now unresponsive and the valve runs 10 psi higher than before. The exit port on another valve is partially plugged and causes the valve to partially close and drop the pressure to these hoses by 10 psi. Now your uniformity is down to 75%. Doesn't sound too bad until you realize that the wet area now gets 1.33" and the dry area only gets an average of 0.75". The driest 10% of the field will get less than 0.7" and the wettest 10% double that amount. This is a formula for "hull rot" and phytophthora in the wet area and defoliation in the dry area. I have seen this happen.

Most of Kern's irrigation districts help support the Mobile Irrigation Lab run by Brian Hockett of the NW Kern Resource Conservation District. This **FREE** service will evaluate the uniformity of your system and identify problems and possible corrections. Call Brian Hockett, 661-336-0967 ext. 138. For some tips on **Micro Irrigation Systems Tune-up** the link is: http://cekern.ucdavis.edu/files/53302.doc

SOIL TEXTURE, SUBBING and EVAPORATION LOSSES IN MICRO SYSTEMS

So you thought you didn't have to worry about the dirt when you switched to micro? Well, get the shovel and the USDA soil survey because this will determine whether you can get away with a single line drip, double-line drip or go to microsprinkler. Here are the big issues:

1. Evaporative water losses – especially when trees are small and the orchard open.
2. Water quality, clogging potential in drip from salts and fertilizers.
3. Disease pressure from water logging and humidity.
4. Sufficient wetted volume for anchoring, fertility and soil moisture storage – at least 30%.
5. Appropriate set times for the crop/soil/wetted volume complex.

DEEP PERCOLATION LOSSES: I have seen an almond orchard planted to a Cajon loamy sand near Arvin with one 14 gph fanjet/tree irrigated during the main part of the season with 48 hour sets 10 to 14 days apart. This was indeed about the right amount of water the tree needed but the coarse soil didn't have the water holding capacity to hold that much water so the grower was losing about 1" of water (in the wetted area) to deep percolation every irrigation and the trees would visibly stress the last few days before the next irrigation. The grower correctly thought that the heavier application of water with decreased frequency would reduce evaporation losses. This is true, but for this soil more frequent, shorter irrigations are necessary and the good news is that evaporation losses in a coarse sandy soil are significantly less than fine soils.

The two tables listed below are formatted so you can tack them up on your shop wall and have a quick reference on the potential "subbing" capacity of different soil textures.

- Soil Texture-Sub-Fill_Almond Micro http://cekern.ucdavis.edu/files/53303.doc
- Soil Texture-Sub-Fill_Grape Micro http://cekern.ucdavis.edu/files/53304.doc

EVAPORATION LOSSES: I have also seen the reverse side of this coin where almonds and oranges have been planted on a sandy clay loam soil and irrigated with a 6 to 7 gph low flow microsprinkler. In both cases the grower elected to run water for the reduced "off-peak" only rate, which meant sets usually ran 12 to 16 hours. For hedge row oranges with low skirts, a 3 foot rootzone and dense rooting at the surface this can work as evaporation is minimized. But in a 20 x 22 foot almond planting, especially young trees, the berms are exposed to more air and the top inch of soil can bake bone dry. It can take as much as 0.33" of water to rewet a bone dry inch of clay loam – which will again be lost to evaporation. As a rough rule of thumb, when a fine-textured soil has just been irrigated, is visibly wet on the surface and exposed to the sun and/or significant air movement, the evaporation loss for the next 1.5 days will be about 1.5 times the grass ETo. In this case, the almond system had two jets and applied 0.8"/16 hours (the whole orchard irrigated in one set). The wetted pattern was about 40% of the orchard floor so the Wetted Area = 0.8"/0.4 = 2.0". The field was irrigated every 3 to 4 days, so the evaporative loss in the wetted area was about 0.3 to 0.4" per irrigation – about 15 to 20% of the water lost to evaporation.

In a massive fertility/ET study in Belridge in 9th leaf almonds (just started this year) we have 100 acres covered with different plots – one 50 acre set is irrigated with two 10.7 gph fanjets/tree and the other 50 acre set is irrigated by double-line drip with 9 emitters/tree/hose – 18 total. The in-line drippers are rated at 1.0 gph at 15 psi. We run them around 22 psi (to get 1.2 gph – a total of 21.6 gph) to try and match the fanjet flow. Bottom line: the calculated almond ET using the Belridge CIMIS ETo x the weekly fanjet Kc values to date = 22.3". The measured fanjet ET (using applied water and neutron probe measurements to a 9 foot depth in the field) = 23.4" while the measured drip ET = 21.0". These numbers indicate an extra loss of 2.4" of evaporation from the fanjet system, or about 10.5% of the water applied to date.

SOIL MOISTURE and OTHER MONITORING TECHNOLOGY

In the study mentioned above we are using the neutron probe, Watermark electrical resistance sensors, Enviroscan capacitance probes connected to a PureSense data logger with a cell phone upload to the Internet, 2 different types of weather station above the canopy heat flux methods of estimating almond ET and we will cap it off with monthly satellite estimates of ET at the end of the season. Sounds like overkill? This is only a handful of what's out there. Five years ago, Google showed about 50,000 sites for *soil moisture monitoring*, now you get 549,000.

Whether you're hand probing, tensiometers or any of the other "snapshot" techniques to estimate your water status, or you're using data loggers and get a picture of the dynamic changes of water movement in the soil (Figure 1) you are mainly checking for two things: 1) The cycling of sufficient penetration and plant root extraction of water; usually to 3 feet for most permanent crops. 2) At least occasional monitoring of the lower end of the rootzone (say about 5 feet) to make sure your aren't saturated (over irrigation) or drying out (deficit irrigation).

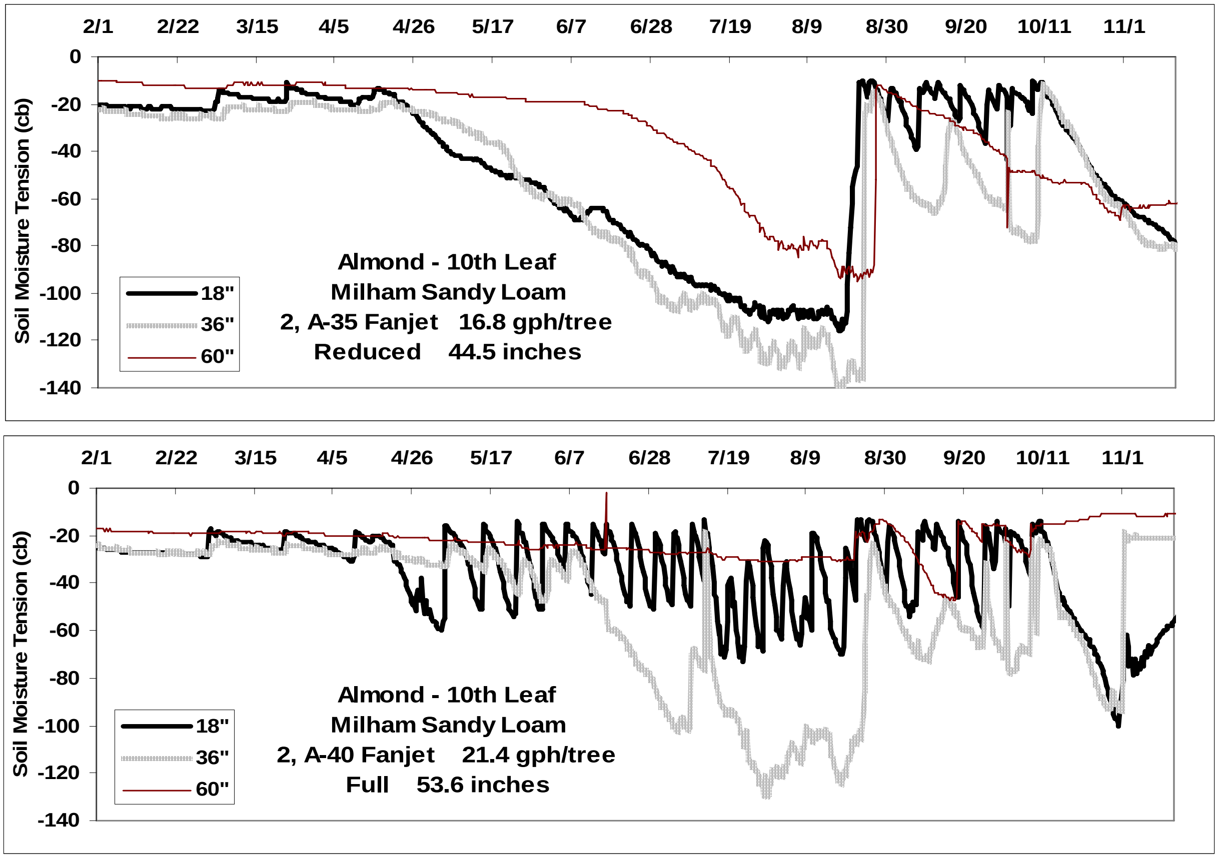

Fig. 1. Soil moisture "tension" values from Watermark blocks installed at the 18, 36 and 60 inch depths in two different Nonpareil rows (48 feet apart) and irrigated with microsprinklers with different flowrates.

The above charts show this concept perfectly. Looking at the top chart with the orange fanjets (Reduced), starting the beginning of May you can see that there is not enough applied water from these fanjets to penetrate to 18" in a 24 hour set given the high water use by the tree. The soil moisture tension (and water content) keeps dropping, along with the 5 foot depth starting in June until the field receives a 48 hour set after harvest and the weather cools off. In the bottom chart with the blue fanjets (Full irrigation) you can see the 18" depth is responsive all season but even here the 36 and 60" depths decline starting in June and don't fully recover until post-harvest. However, the decline at the 60" depth is very slight – indicating that the tree probably didn't stress and almost no water was lost to deep percolation. Readings for these charts were logged every 8 hours but hand auguring and tensiometers that you read once/week could tell you the same thing.

Continuous monitoring with loggers can be helpful in identifying pressure differentials in blocks and small losses to deep percolation that you can't see with "spot-check" methods; especially for shallower rooted veg crops or citrus. For a discussion of these benefits and a table of the different types of sensors download:

- Making sense of soil moisture sensors http://cekern.ucdavis.edu/files/53305.doc

There are not really good tables of the "right" soil moisture tension at which you should irrigate as this depends on the soil texture and the capacity of your irrigation system to recharge depleted water. But for most permanent crops, if you keep the tension (properly called "matric" potential) at the 18" depth between 20 and 60 and keep the 36" depth between 15 and 50 you will not stress the crop. Of course these numbers need to be massaged for salinity and soil texture and the sensitivity of the instrument.

Of course monitoring the plant for actual stress using devices like the pressure chamber is the final word on what the plant is actually experiencing, but without some form of soil moisture monitoring you have no idea where your "bank account" stands. Next week's ET could overdraft your reserve and place the plant (especially almonds and walnuts) into a stress mode that you may not be able to alleviate with the small amounts of water applied with most micro irrigation systems.

REGULATED DEFICIT IRRIGATION (RDI)

The concept here is to find physiologic periods of crop development where water stress won't hurt the crop and can even benefit the development of certain characteristics. Wine grapes are the most famous for this as color and flavor of the grapes can be improved for most varieties by mild to severe stress in some cases. Of course, the more the stress the less the tonnage. Reduced ET means reduced CO2 assimilation and reduced carbohydrate production. This is why deficit irrigation for annual forage crops is not even an option since you get paid on the tonnage you produce.

RDI pros: Water stress through RDI has been shown to be helpful on increasing fruit set in canning tomatoes , decreasing "puff and crease" in late navels, reducing hull rot and advancing hull split in almonds and possibly weakening shell seal in pistachio to increase split percentage.

RDI cons: Deficit irrigation has also been shown to decrease second year yields of Early Beck naval oranges in Kern County (Craig Kallsen and I achieved this dubious result last year.), decrease nut size in the current year almond crop and decrease nut load the following year. It has also been shown to decrease split % and nut size/yield in pistachios.

Bottom line: RDI is almonds for decreasing hull rot is tricky. You have to put the trees into moderate stress (-14 to -16 bars) from the end of June to Nonpareil harvest, but it's easy to go too far and have the stress continue when you're trying to set next year's crop. Pistachios have the best window (right now, actually) to cutback on ET before nut-fill in August. You can save as much as 12" of water by using only a couple inches post harvest as well. Citrus growers usually manage their trees to get around 36 to 39" of water in a normal year. So you're not going to save much here. For a full discussion and additional links download:

- Almond-Pistachio-Citrus Regulated Deficit Irrigation http://cekern.ucdavis.edu/files/53306.doc

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