Fertigation: interaction of water and nutrient management in almonds – monitoring water use (ET), stress & yield impacts

(Joint project with Shackel: Advanced sensing & management technologies in specialty crops: case studies of water & N in almonds under normal & resource-limited conditions.
Brown: Development of a Nutrient Budget Approach To Fertilizer Management In Almond)

Project Leaders: Blake Sanden (Kern County, UCCE), K. A. Shackel (UC Davis)

Cooperators: Patrick Brown, Bruce Lampinen, Richard C. Rosecrance, John Edstrom, Roger Duncan, Bob Beede, Franz Neiderholzer, Paramount Farming Company

Funding: California Almond Board

Introduction

Competition for fresh water in California has increased dramatically over the last 30 years. The population of California has grown by 10 million people and ag demand has dropped from 26 to 25 MAF mostly due to the adoption of micro (drip) irrigation systems (Figure 1). Farmers in the San Joaquin Valley especially have changed cropping patterns and field practices to remain profitable as water (and other) costs have soared.

Almonds have been one of the bright spots in this setting as the Almond Board has successfully expanded markets around the world and our understanding of almond irrigation and production practice has at the same time greatly improved yields (Figure 2).

Improved varieties, planting, pruning and pollination practices have all contributed to this increase, but some of the most significant yield increases have been realized through the use of micro-irrigation, fertigation and improved under-standing of the water use (ET) potential of these trees. In an era when regulators are stressing water conservation it is essential to scientifically document this high ET requirement that is not supported by almond research done 15 years ago (Figure 4).

Objectives

- Determine actual almond ET under truly non-stressed conditions using 3 different methods.
- Determine if differential fertilizer regimens, micro irrigation system type (drip vs. microsprinkler) and yield result in differential rootzone soil moisture, tree stress (SWP) and tree ET.

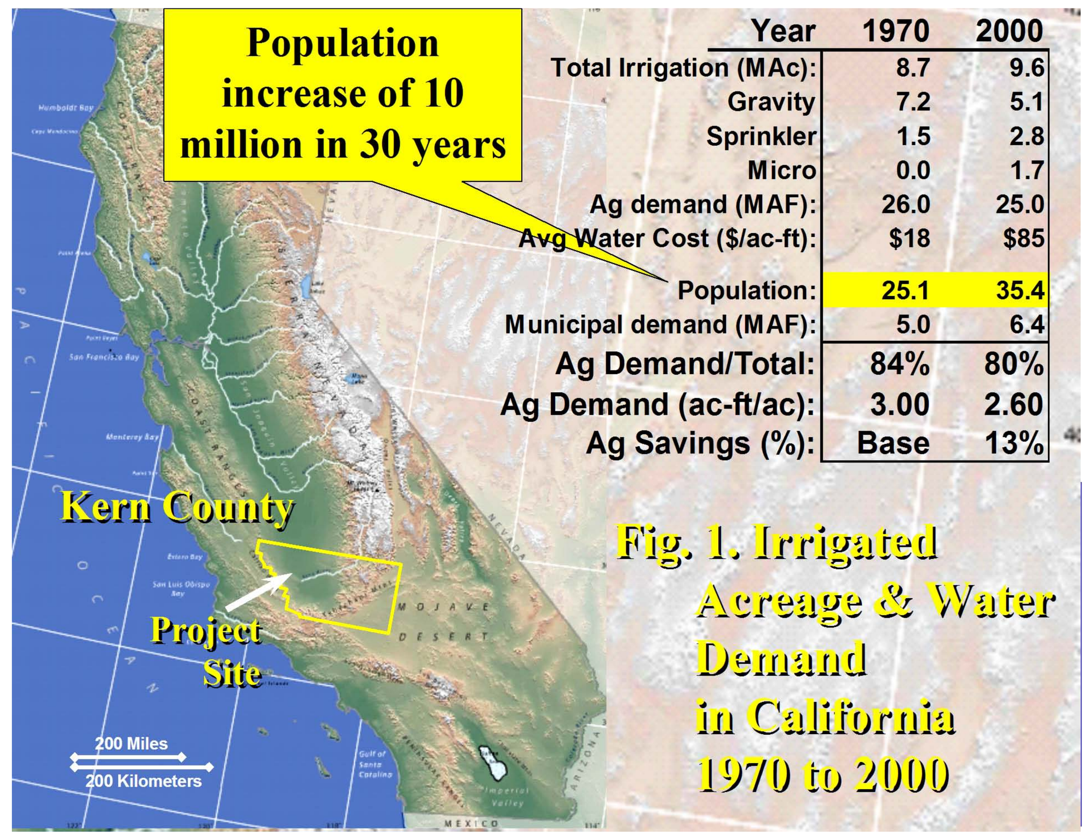

Fig. 1. Irrigated Acreage & Water Demand in California 1970 to 2000

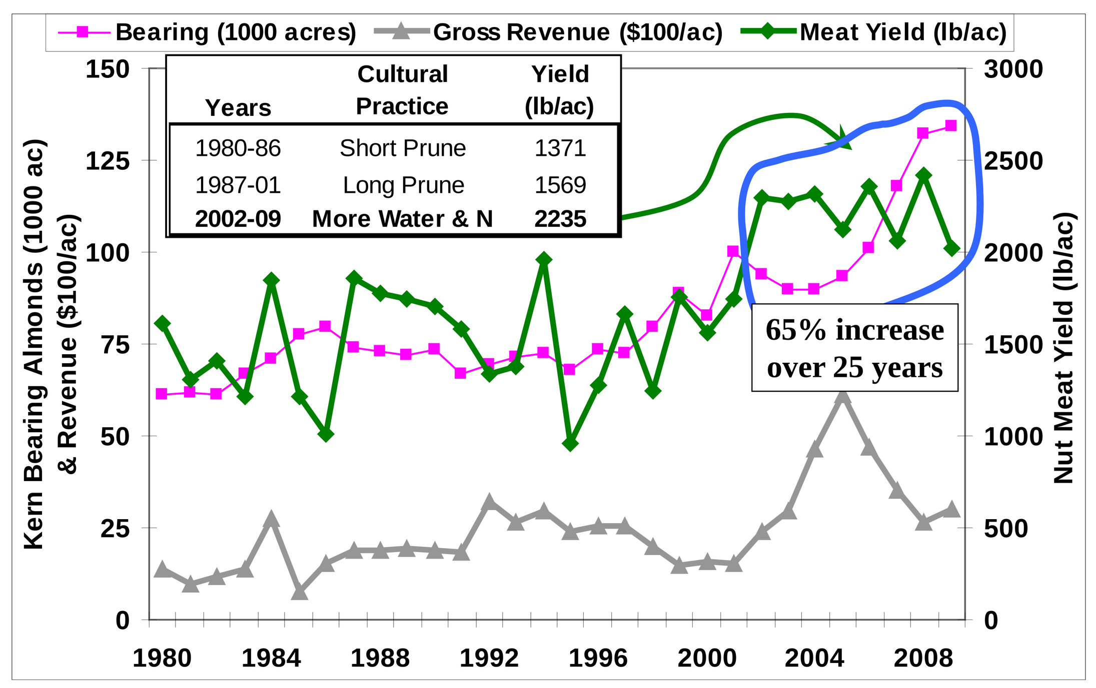

Fig 2. Changes in almond acreage and yield, 1980-2009.

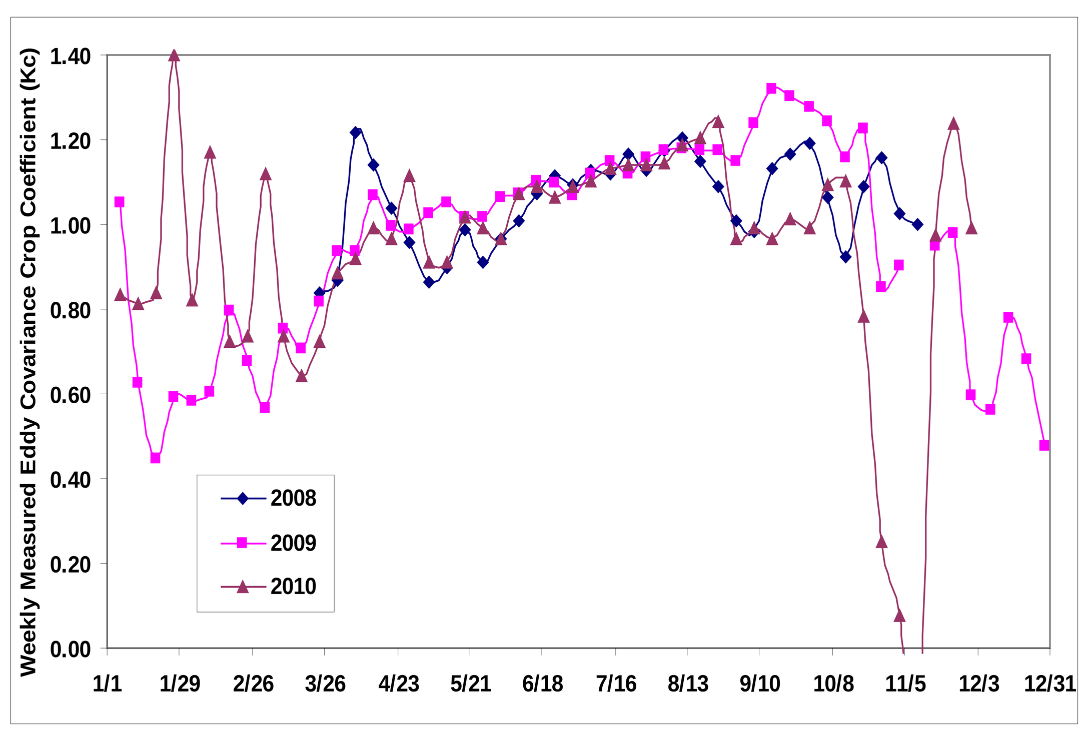

Fig. 3. Comparison of 3 years of mature almond crop coefficients (Kc) generated from EDDY COVARIANCE heat flux estimates of crop ET divided by the modified Penman ETo from the Belridge CIMIS station #146 1.5 miles due west of orchard.

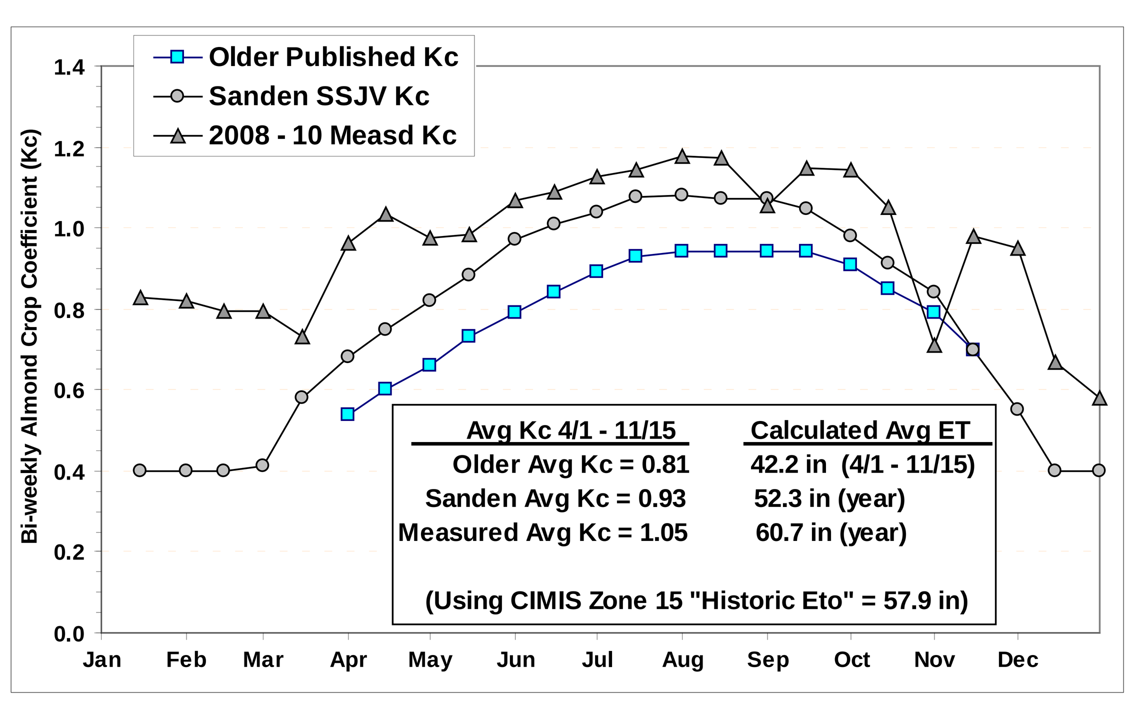

Fig. 4. Comparison of older published crop coefficients, Kc, for almonds to current practice (Sanden SSJV) and the average of actual 2008 & 2009 measured values.

Materials and Methods

Site Layout: A 9th leaf 150 acre almond orchard in NW Kern County with 3, 50 acre sets irrigated with microsprinklers (2 Fanjets @ 1.68 in/day irrigation) was selected for this trial. The eastern 2 sets are a uniform Milham Sandy Clay Loam. Past tissue tests have shown uniformly low K levels, but yields have been fairly good (2400+ lb/ac). The eastern set was converted to double-line drip applying 1.67 in/day irrigation. A total of 40 water monitoring sites (4 replications each treatment, 20 drip, 20 fanjet) have been established over 5 different fertility treatments (see Brown, et al for a fuller description).

FERTILITY TREATMENTS TO BE MONITORED WEEKLY FEBRUARY - NOVEMBER:

	N (lb/ac)	K (lb/ac)			N (lb/ac)	K (lb/ac)
1.	125	200		2.	200	200
3.	275	200	(Grower standard)			
4.	275	300		5.	350	200

(UAN32, K from base 125 lb/ac banded K2S04, balance KTS)

4 REPLICATED NEUTRON PROBE SOIL MOISTURE & SAMPLING SITES /TREATMENT
One 2 inch x 9 foot deep Class 125 PVC tube in middle of the emitter pattern, 40 sites total (20 each for microsprinkler and double-line drip)
Annual soil sampling to 9 feet @ 1 foot from neutron probe tube, Dec-Jan.

INTENSIVE SOIL WATER CONTENT MONITORING
4 additional access tubes installed at one of the high fertility sites to monitor water content change in all sectors of the wetted area.
1 site each for microsprinkler and drip systems

SOIL WATER TENSION MONITORING
1 replication of each treatment to be outfitted with Watermark blocks at the 18, 36 and 60 inch depths adjacent to the NP access tube
2 Irrometer loggers to be used to record readings @ 3 hour intervals

SOIL MONITORING FREQUENCY
All neutron probe sites and flow meters read weekly March - November

PLANT STRESS MONITORING
Weekly stem water potential (pressure chamber) May-October

METEOROLOGIC HEAT FLUX MONITORING for ET (continuous)
A sonic anemometer, net radiometer, high response air temperature thermocouples were installed above the canopy mid-March. In combination with soil heat flux plates and thermocouples installed at a 2 inch depth in 3 locations in the orchard floor these devices measure ET from the orchard by Eddy Covariance and Surface Renewal heat flux.

Results and Discussion

Bagged stem water potential (SWP) over three years was significantly greater (less stress) for the double-line drip compared to the fanjet due to less surface evaporation. SWP was less (more stress) than the moderate stress level of -12 to -14 bars for one week in July and two separate weeks during harvest in 2009. Substantial hull rot occurred. In 2010 we applied deficit irrigation from 7/13-9/28 in an attempt to reduce hull rot in both Nonpareil and Monterey. Hull rot was still significant in both fanjets and drip (average SWP -15.0 and -11.6 bars, respectively, with some stressed trees reaching -20 bars). Average stored soil moisture started the season about 80-90% of field capacity and slowly declined over the season to average 50 to 56% for the year. No water leached past 6 feet in the fanjet and 8 feet in the drip.

No difference was seen in ET as determined by the neutron probe between the 2 irrigation systems. Measured ET by applied water and water content depletion (neutron probe method) was virtually the same (except for some pressure differences in 2010) as that estimated by meteorological energy balance (eddy covariance and surface renewal. Figure 3 and Table 1). The average measured seasonal Kc value was 1.05, with peak season values reaching as high as 1.18. N fertilizer rates were just starting to impact yield in 2009, but there is no correlation with crop load/kernal yield and tree ET above for all sites in this study (Figure 6).

Conclusions

More water probably went to actual transpiration in the Drip than the Microsprinkler – as indicated by less negative SWP. Almond ET is much greater than earlier published values and can exceed 52 inches/year, but there is no consistent yield advantage above this level (Figure 6).

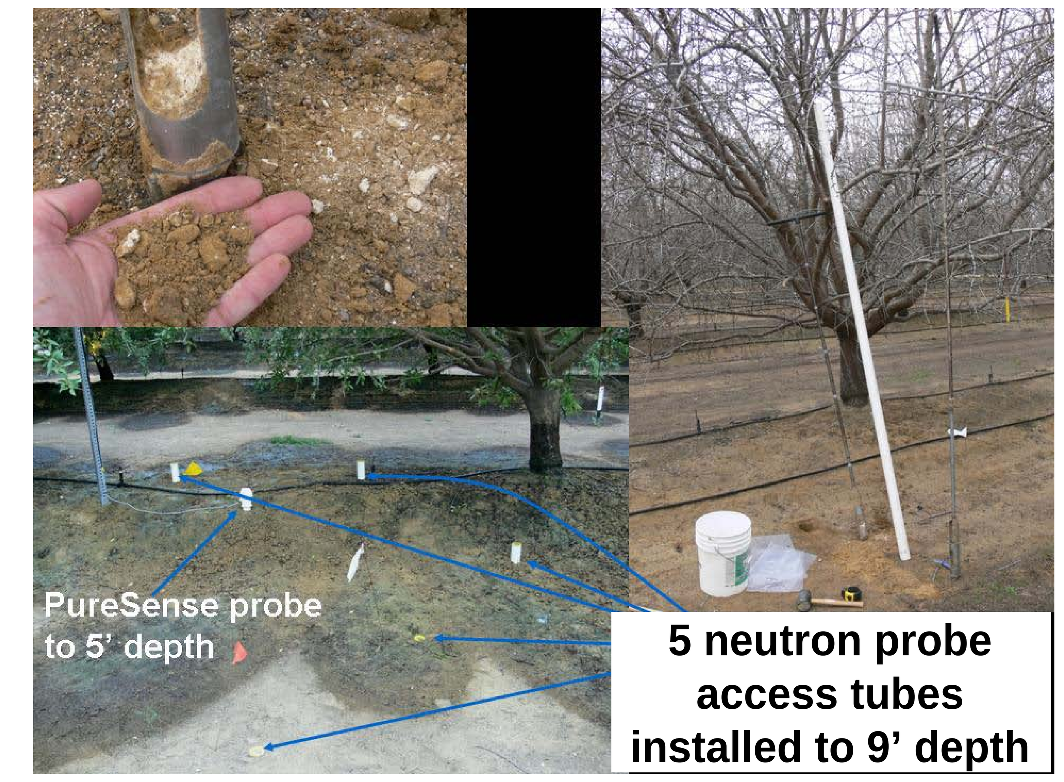

Fig 5. Layout of neutron probe tubes in intensive site.

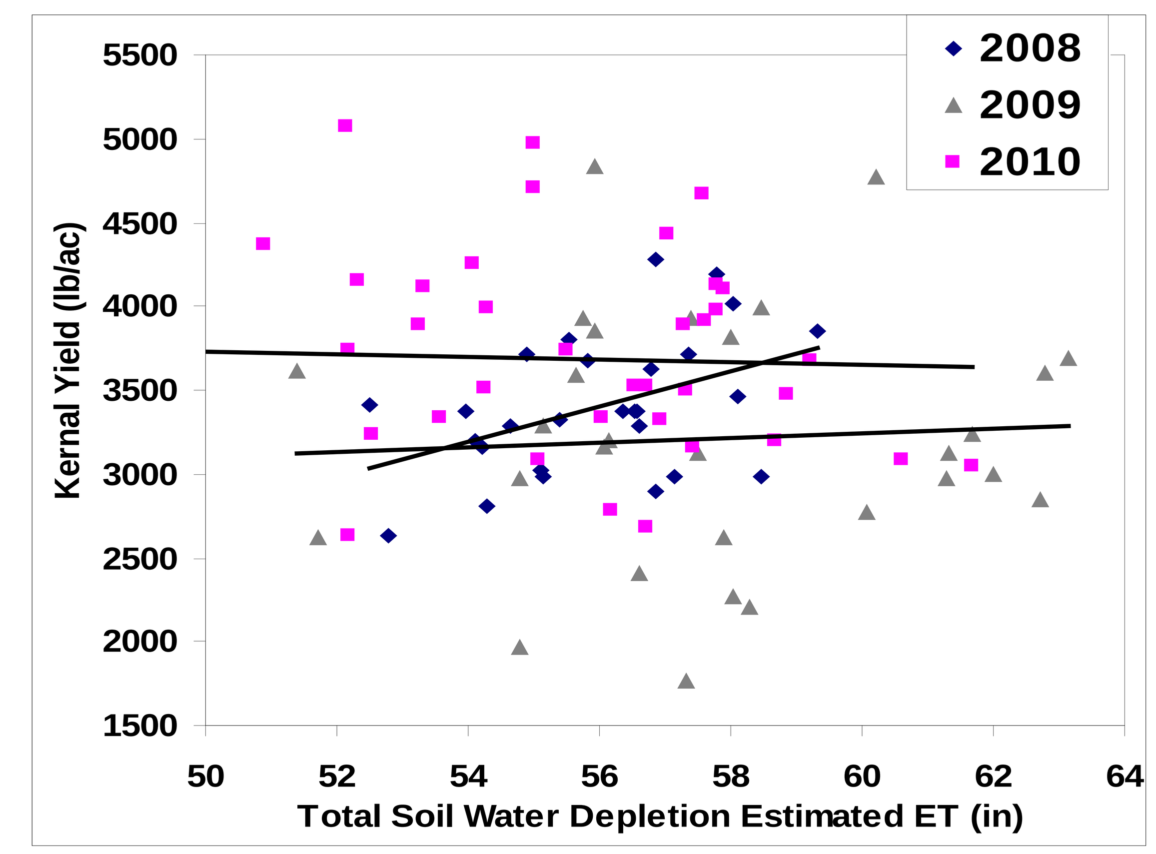

Fig 6. Yield variation as a function of tree specific ET estimated by weekly measurements of applied water and soil water content change.

Table 1. Seasonal averages and totals for SWP, soil moisture, irrigation, ET and yields for all years.

	2008		2009		2010	
	Drip	Fanjet	Drip	Fanjet	Drip	Fanjet
Avg Stem Water Potential (bars)	-8.4	-9.8	-9.1	-10.8	-9.8	-11.9
Avg Available Soil Moisture to 5 ft (%)	55%	50%	54%	56%	52%	52%
Total Irrigation (in)	57.0	56.1	58.5	58.9	51.67	49.88
Neutron Probe Calculated ET (in)	55.8	56.0	58.2	57.3	56.39	53.86
Irrigation Monitoring Tree Yields (lb/ac)	3653	3383	3262	3013	3807	3694
Whole Field Yield (lb/ac)	3637	3355	3284	3230	3573	3367