Almond ET/Yield Production Function

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Problem and its Significance:

Water is a critical resource for Californian agriculture and much of California suffers from periodic shortages and persistent threats of reduced allocations. Water is also the primary means of delivery of nitrogen and the primary driver for nitrogen loss. One of the major challenges faced by irrigated agriculture is to optimize the use of water with respect to production (i.e., more "crop per drop"). It is well known in almonds and most other crops that production increases with increasing water availability up to a point, but for almonds a relation between water availability and crop production, the "Water Production Function" (WPF), has not been established. It has long been assumed that production will be maximized by applying water to match orchard evapotranspiration (ETc), but we do not know the shape of this relation, and the shape of the relation is an important basis for determining the optimum irrigation approach. It is imperative that the almond industry have the best available information on the relation of almond tree yield to different levels of irrigation in mature orchards.

Objective:

- Develop a water production function (WPF) for almonds grown in California that will relate potential yield to water applied, accounting for the site-specific effects of orchard cover, soils, varieties, and physiological level of stress experienced by the tree.

Results and Discussion:

The 2013 season was the first year of imposing a range of water applications to determine a WPF at three locations in the state (Kern, Merced, and Tehama counties). At all sites the imposed irrigation levels (from about 70 to 110 % ETc) gave highly significant differences in tree water stress (SWP, **Table 1 and Figure 1**). Based on previous studies we did not expect to see a substantial reduction in yield, PAR, or yield/PAR, and only one site showed a statistically significant reduction in yield for the lowest irrigation level (70% ET, **Table 1**). Carryover effects will start in 2014. The overall relation between yield and PAR was similar to that found in other almond orchards and reported by B. Lampinen (**Figure 2**), but there appear to be significant differences between sites, with the Merced site somewhat above the line and the Tehama site below (**Figure 2**).

Across all sites, there were clear tree-to-tree differences in yield, and these differences were mainly due to differences in nut load, with a similar relation between load and yield across all sites (**Figure 3**).

Table 1. Orchard yields, % light interception, yield per % light, and average tree SWP (May through harvest) for the different sites and irrigation treatments in 2013.

Site	Treatment (%ET)	Yield (Lbs/ac)	PAR (%)	Yield/PAR	SWP (bars)
Tehama	116	2275	66.5	34	-10.5 a
	110	2174	64.9	33	-12.4 b
	86	2404	64.4	37	-13.1 bc
	74	2268	65.7	35	-13.7 c
Merced	110	3137	56.2	56	-15.1 a
	100	3301	49.6	67	-14.9 a
	90	2744	47.9	57	-17.0 a
	80	2711	52.2	52	-15.8 a
	70	2933	48.9	60	-21.2 b
Kern	110	3336 a	67.5	49	-14.7 a
	100	3316 a	68.3	49	-15.9 ab
	90	3454 a	70.5	49	-16.9 b
	80	3140 ab	69.3	45	-17.2 b
	70	2839 b	69.3	41	-18.8 c

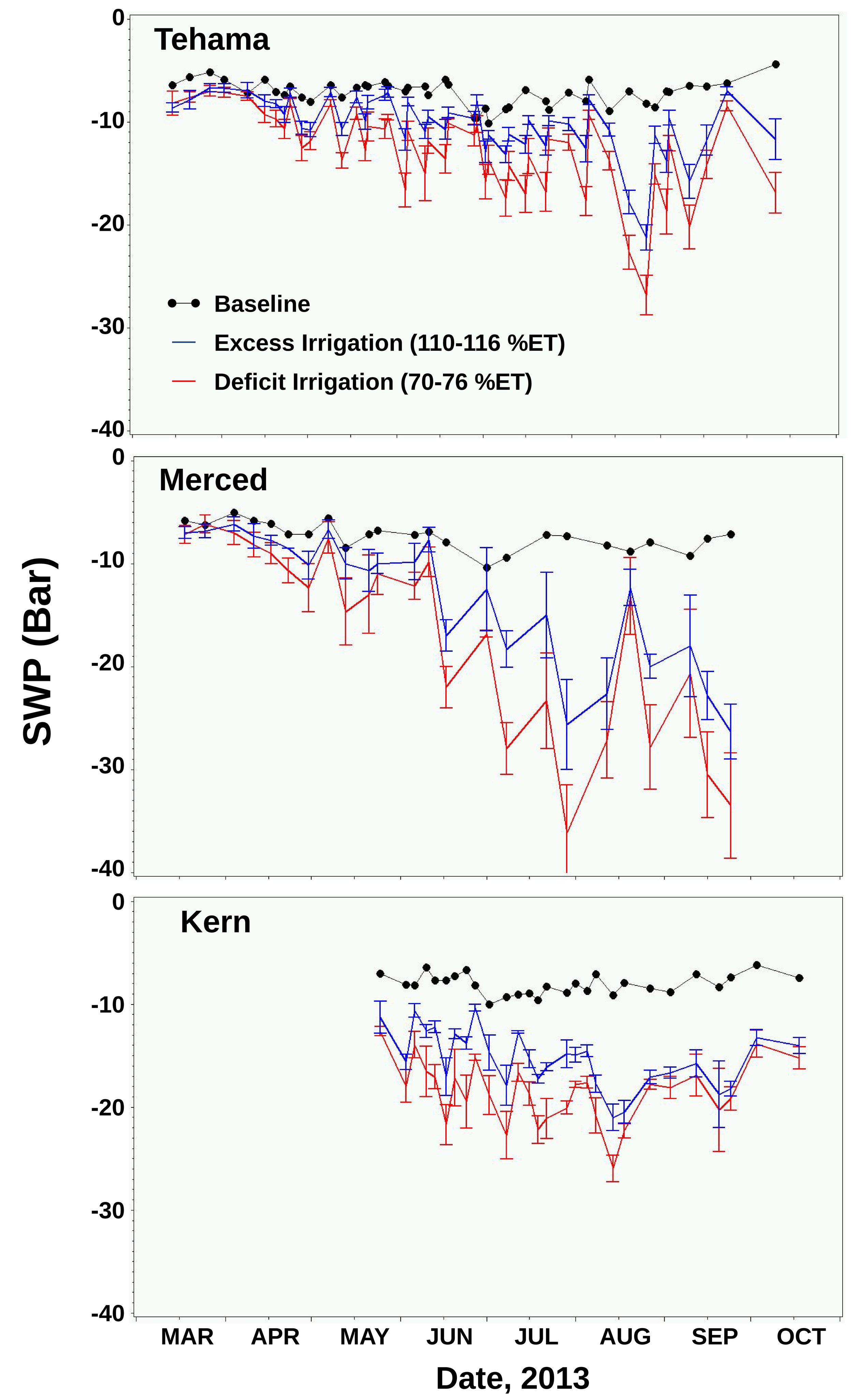

Figure 1. Seasonal pattern of stem water potential (SWP) for the driest and wettest treatments at each study site. Also shown for reference is the fully irrigated (non stressed) baseline SWP.

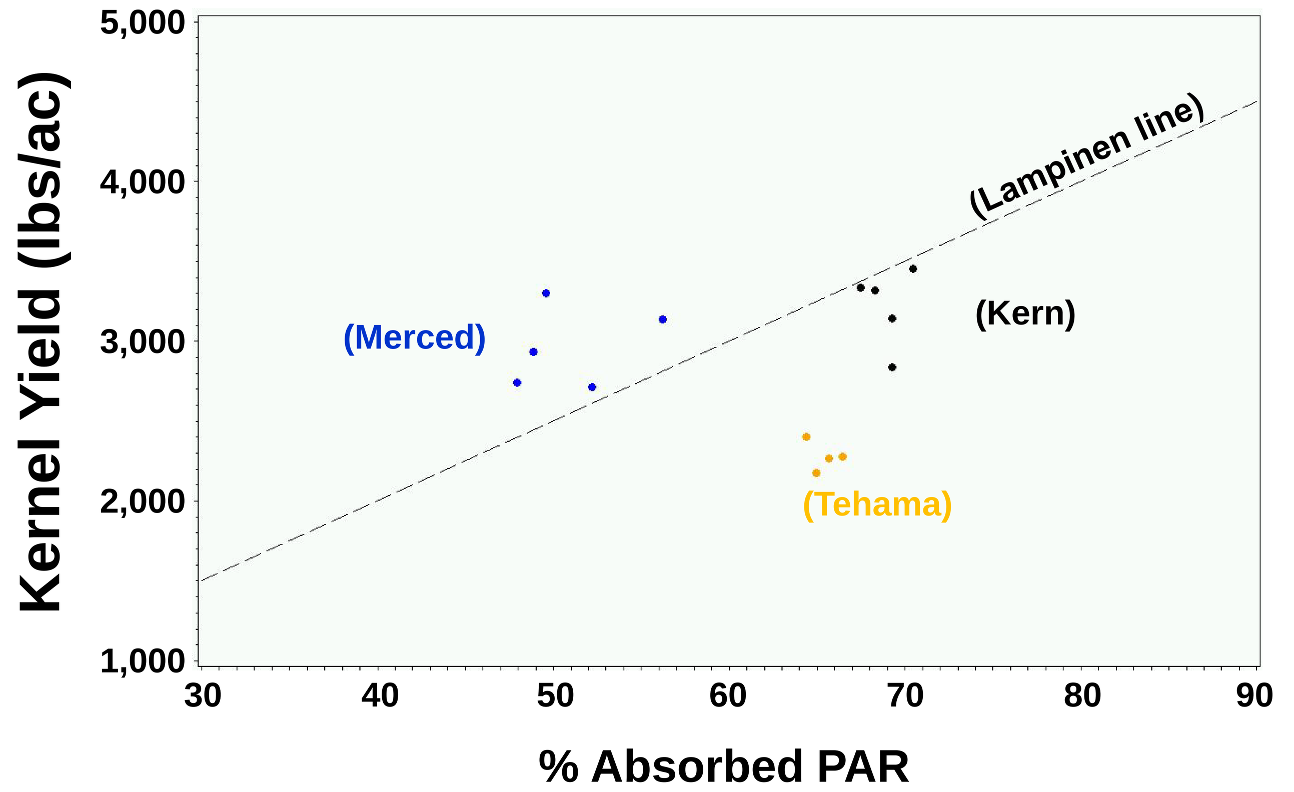

Figure 2. Relation of treatment mean yields to % PAR for each site, compared to the linear relation found by B. Lampinen (50 lbs/%).

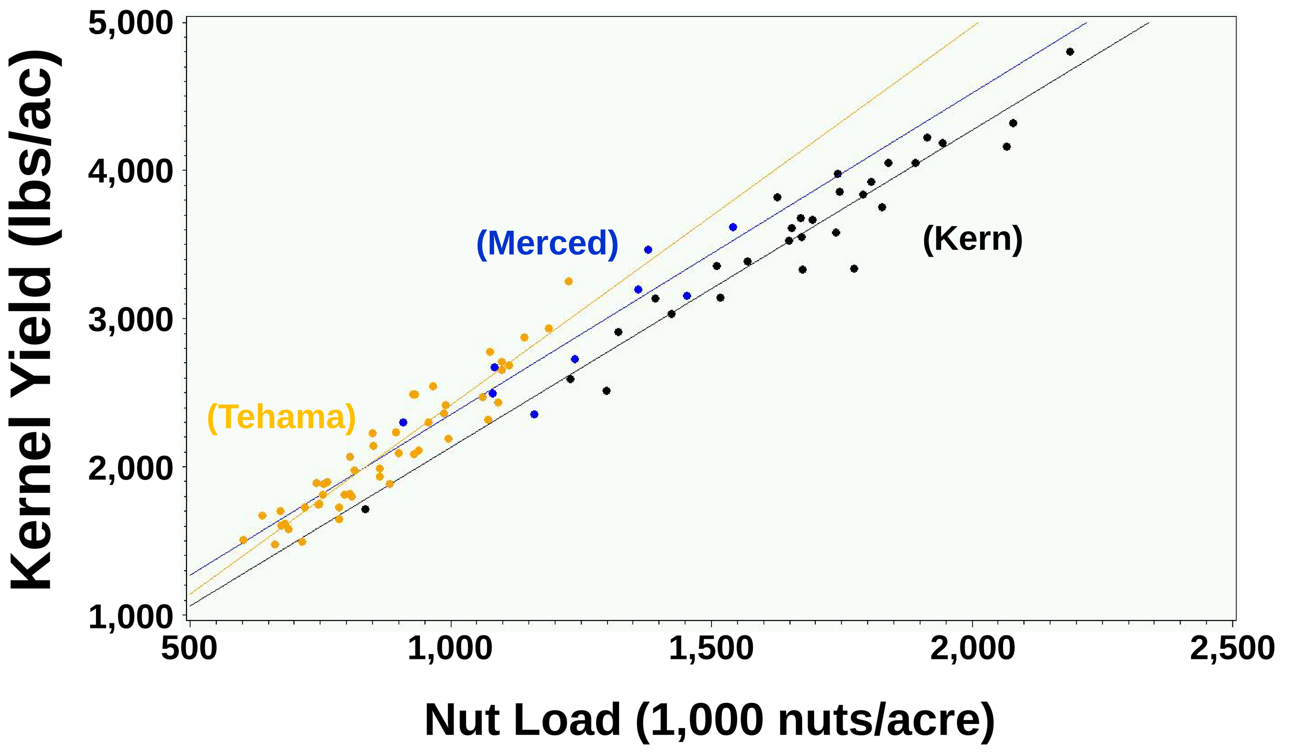

Figure 3. Relation of yield to nut load for individual trees, expressed as per acre values

Even though kernel size did not have a strong influence on yield, across all sites as well as within each site there was a clear positive relation of kernel size to SWP, with more stressed trees showing a reduction in kernel size (**Figure 4**). This is a similar result as has been found in previous studies, and presumably indicates that current season stress influences kernel growth. For the Tehama and Merced sites, the strongest linear relation (highest r-square) between SWP and kernel size was for SWP during the months of April and May (data not shown), and probably indicates that the effect of stress on reducing kernel size is most important during early kernel development.

Despite the positive relation between kernel size and SWP across sites, there was an overall negative trend, although not particularly strong, between yield and SWP (**Figure 5**). Since yield is largely determined by nut load (**Figure 3**), this may indicate that some degree of water stress may have beneficial effects on the number of nuts and hence for yield. Previous research has found that severe stress will decrease return bloom as well as fruit set as a carryover effect, and hence the net effect on yield must be evaluated over more than one season.

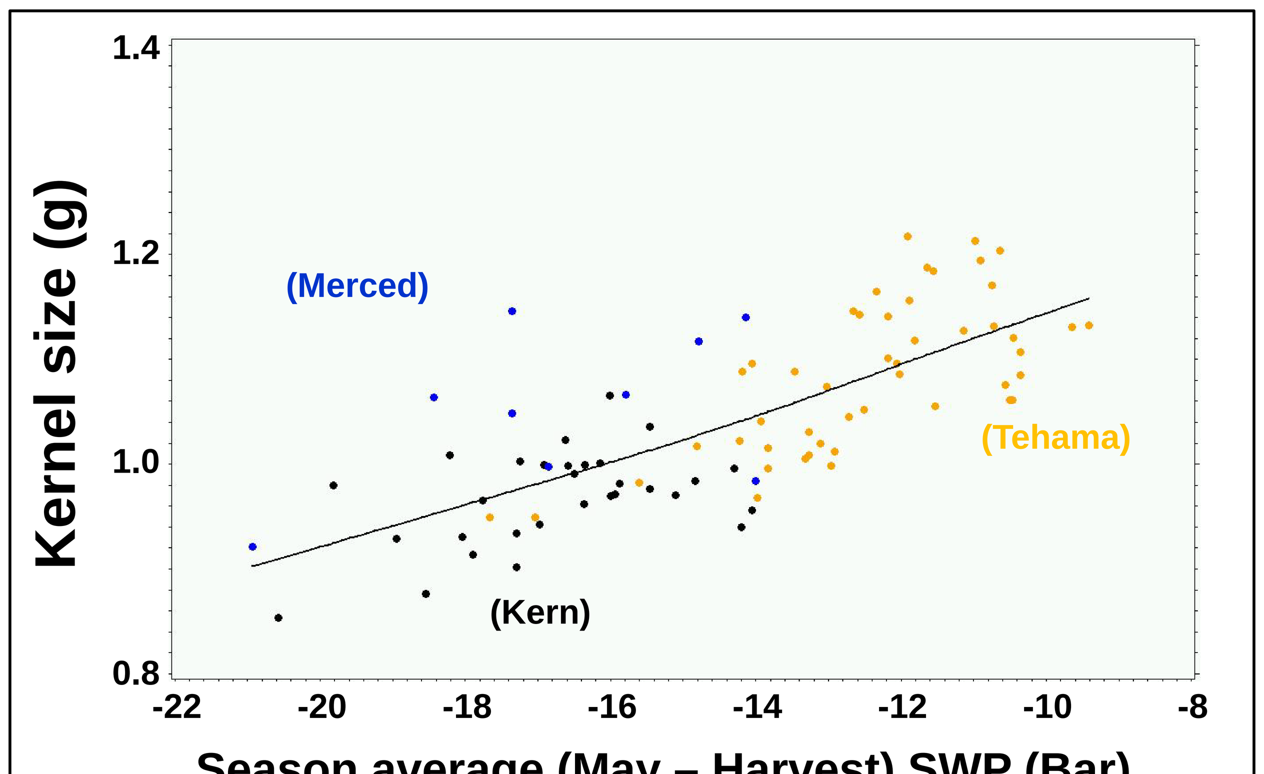

Figure 4. Relation of kernel size to SWP for all individual trees.

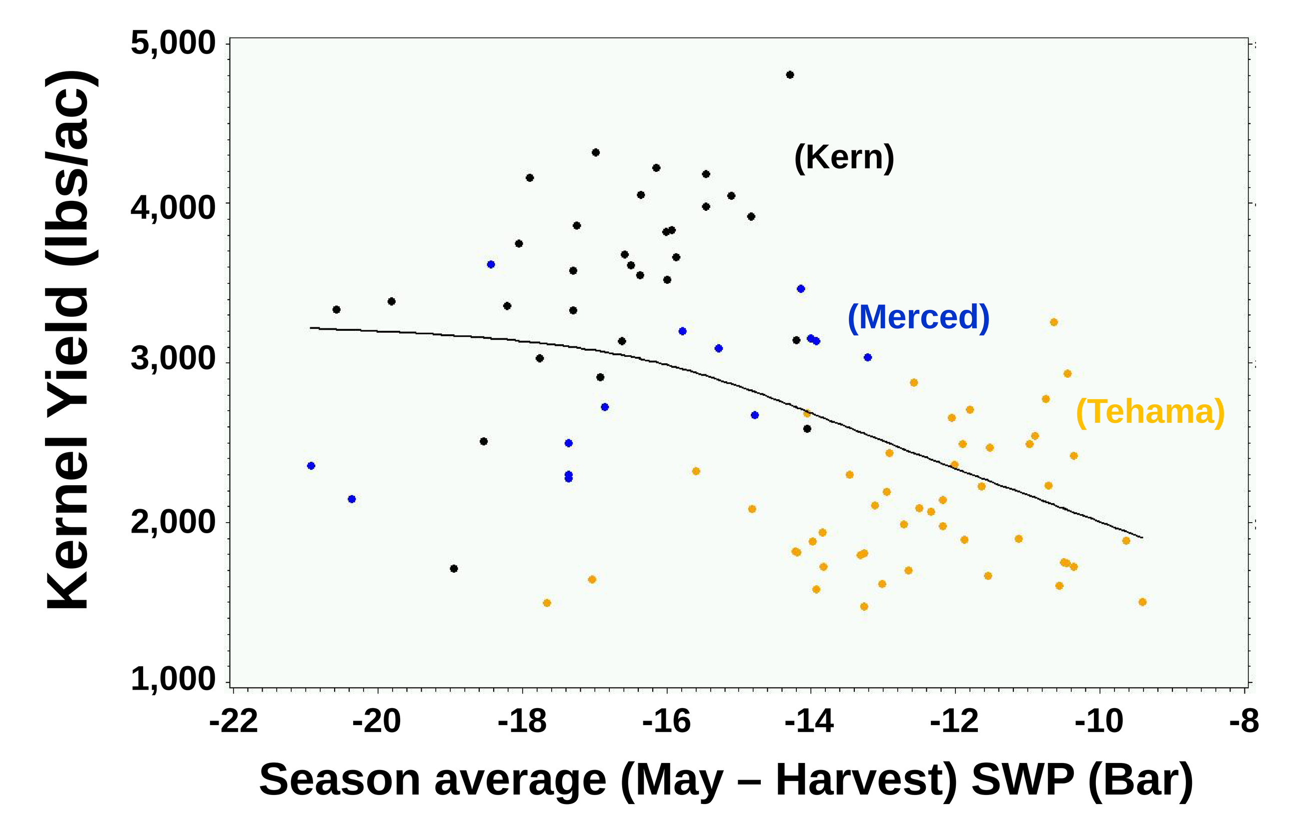

Figure 5. Relation of yield to SWP for all individual trees in the study.

Conclusions:

This is the first year that differential irrigation levels have been imposed at these sites, and since many important effects of water stress are carryover effects, only tentative conclusions can be reached. All sites showed a clear increase in stress with reduced irrigation, but even when provided with excess water (110 – 116% of calculated ETc) no site exhibited baseline values of SWP throughout the season. Interestingly, the Kern and Merced site showed generally lower SWP values than the Tehama site, but had generally higher yields, which were strongly related to a higher crop load. This may be an early indication that under some conditions water stress may have a beneficial effect on almond yields.