Almond Water Production Function

Project No.: **14-HORT17-Shackel**

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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.

Interpretive Summary:

The 2014 season was the second year of imposing a range of water applications to determine a WPF at three locations in the state (Kern, Merced, and Tehama counties). Reducing irrigation has caused a clear increase in tree water stress (lower SWP) and in most cases a reduction in yield and/or canopy light interception (%PAR) across all sites, but there also appear to be site-specific effects on yield that are independent of the influence of SWP or %PAR. The overall change in yield with %PAR is consistent with the relationship proposed by Lampinen (50 kernel pounds per %PAR), but with a different overall level of yield for each site. The reason for this difference is not yet clear, but substantially different applied irrigation amounts (26” in Merced and 43” in Kern) were also associated with the same moderate level of tree water stress (-17 bars SWP), indicating that some of the site effects may still be attributable to differences in water availability and/or factors not yet considered, such as root health, other environmental factors (e.g., temperature) or specific developmental processes/periods (e.g., springtime tree water status and nut development). At the Kern and to some extent the Tehama site there is evidence that increased irrigation has led to increases in canopy size (%PAR) over time, and hence more time may be needed to see clear yield effects. Detailed remotely sensed measurements of canopy temperature and conductance were conducted at the Kern site, and these also indicated that a measureable canopy response to stress can be detected prior to detecting a yield response.

Materials and Methods:

A randomized complete block experiment was set up in commercial almond orchards in three counties (Tehama, Merced, and Kern). At each site, 4 to 5 irrigation treatments, with target levels ranging from 70% - 110% ETc, in 3 to 6 blocks (**Table 1**) were established by modifying the existing irrigation system. Applied irrigation amounts were measured approximately weekly in at least half of the experimental plots using water meters, and periodic measurements of soil water to 9' were made with a neutron probe throughout the season in order to estimate soil water use in each plot. For plots without water meter or neutron probe data, the treatment averages were used as estimates. Periodic (at least weekly) measurements of midday stem water potential (SWP) were made on individual monitoring trees in each plot. Mid-season canopy cover (% PAR Interception) was measured using the light bar technique developed by Bruce Lampinen, and plot yields as well as individual tree yields for SWP monitored tress were obtained. At the Kern site, additional treatments were imposed as well as more detailed measurements made of ET and canopy imaging. These results will be presented at the end of this report.

Table 1. Numbers of blocks and target levels of irrigation treatments at each location of the study.

Location	# of blocks	Treatment targets (% ET)
Kern	6	70, 80, 90, 100, 110
Merced	3	70, 80, 90, 100, 110
Tehama	6	74, 86, 100, 116

Results and Discussion:

This is the second year of applying different amounts of water, approximating 70 – 110 % ET, in a randomized complete block design at three orchard sites across the state. One important irrigation decision is when to begin irrigation in the spring, and when comparing applied water to tree water demand (ETc), as calculated based on orchard specific bloom dates and real time reference ET, [ETo]), each was unique in this respect, with the Tehama site closely matching ETc in the spring, the Merced site 'falling behind' ETc in the spring, and the Kern site 'getting ahead' of ETc in the spring (**Figure 1**, left panel, compare dashed line to treatment lines). Despite these early season differences, irrigation treatments at all sites applied significantly different amounts of water seasonally (**Table 2**), but there were important differences between sites in the quantity of soil water used by the trees, with the Merced site generally showing the highest use of soil water and the Tehama site showing the least (**Table 2**). There was a parallel trend in the overall soil water content at these sites, with the Merced site showing the highest average soil water content and the Tehama site the lowest (**Figure 1** right panel). Presumably, these differences in average soil water content and the use of stored soil water reflected site difference in soil texture and water holding capacity. However, it was surprising to note that none of the sites showed a statistically significant difference in the use of soil water due to irrigation treatments (**Table 2**), as it would be expected that significantly less irrigation would result in significantly more use of soil water. At the Tehama site there was no discernible pattern of decreased irrigation leading to increased soil water use. At the Merced site the pattern was somewhat the opposite of that expected, with a higher water use in the higher irrigation treatments (**Table 2**). At the Kern site the trend of soil water use was consistent with the expectation of decreased irrigation giving increased soil water use, but the net effect of this 'compensation' was that there was no statistical separation in the total water use between the treatments (expressed as % of ET, **Table 2**), although the ranking of the treatments at this site was as expected, with the lowest level of applied water showing the lowest water use and the highest applied water the highest use. The Tehama and Merced sites also showed the expected ranking, but with statistical separation between at least some of the treatment means (**Table 2**). Soil water use is likely underestimated for the Tehama County experiment since the current methodology limits the estimate for the period of March 1 through September 1, 2014. These estimates of soil water use are preliminary. The methodology for measuring and reporting soil-water will be improved in future seasons. It is challenging to apply a consistent methodology for measuring and reporting soil water contributions across all three almond production regions, particularly the northern Sacramento Valley growing region when rainfall is higher and may contribute significantly during the spring growing season.

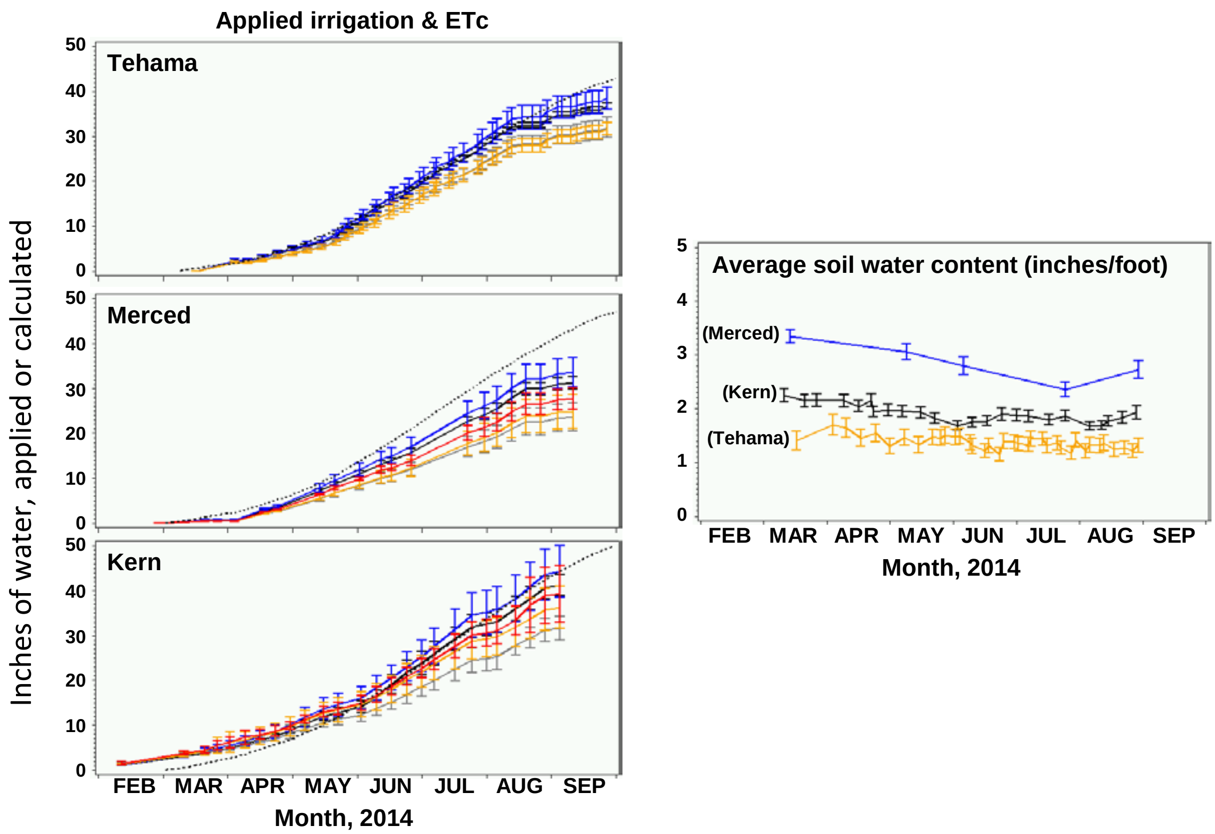

Figure 1. Seasonal pattern of cumulative applied irrigation amounts (left panel) and average soil water content (1' – 9' depth, right panel) at each of the three WPF sites. For reference, the dashed lines in each graph of the left panel are the calculated ETc for almond using the most accurate estimates available for local, real time reference ET (spatial CIMIS ETo) and almond crop coefficients (Kc). In essentially all cases, the cumulative applied irrigation ranked in treatment order, from the lowest (70% ET) to the highest (110% ET) irrigation treatment level. Soil water content is averaged over all treatments, only to illustrate the overall seasonal pattern and differences between sites.

Table 2. Treatment mean values and statistical comparison (means followed by different letters are significantly different at P<0.05) for applied water, soil water depletion and water balance estimates of % full ET for each location **for the period March 1 – September 1, 2014**. Negative values for soil water depletion indicate soil recharge over this period (i.e., excess of irrigation over tree water use). All means are shown in rank order.

Location & ET (inch)	Applied water (inch)		Soil water depletion (inch)		% of ET for March 1 – September 1, 2014	
	Treatment	Mean	Treatment	Mean	Treatment	Mean
Tehama 36.8”	116	35.5a	74	1.5	116	96a
	100	33.8ab	100	1.4	100	96a
	86	29.5bc	86	1.2	74	84b
	74	29.1c	116	-0.2	86	82b
Merced 40.7”	110	32.1a	100	5.9	110	93a
	100	29.9ab	110	5.8	100	88ab
	90	26.6bc	90	5.8	90	79bc
	80	23.8c	70	5.5	80	71c
	70	22.6c	80	5.0	70	69c
Kern 43.2”	110	42.4a	90	4.4	110	102
	100	39.5ab	70	3.8	90	97
	90	37.3ab	80	2.5	100	96
	80	34.6bc	100	2.0	80	86
	70	29.8c	110	1.6	70	78

Early season SWP values were close to the baseline value at all sites, but despite the ‘late start’ of irrigation at the Merced site, trees at the Merced site remained closer to the baseline through May than trees at the other two sites (**Figure 2**), which was also the case in 2013. At all sites there was also a general trend of increasing stress from spring to midsummer, even at the highest level of irrigation, but this was also the case in 2013. At all sites, the ranking of SWP was in essentially the same order as the ranking of the treatments and irrigation amounts throughout the season (**Figure 2**), and the seasonal average SWP values showed statistical separation at all sites (**Table 3,** column “SWP”). Despite these differences, there were no statistically significant differences in kernel yield at any site, although for the Kern and Merced sites, there was a clear trend for higher yields with higher applied water (**Table 3**). Since the ranking of yields was consistent with the ranking of the irrigation amounts, the lack of significance was presumably due to sampling variability, and this should be resolved with further years of testing. Irrigation had a statistically significant effect on kernel weight at the Kern site, but not in a way that was consistent with the irrigation treatments, with both the 100% and 70% showing the highest kernel weight (**Table 3**). At the Merced site, kernel weight ranked in exact treatment order and at the Tehama site the highest and lowest kernel weights were from the highest and lowest irrigation treatments, respectively. Hence, as with the yields, the lack of a significant treatment effect on kernel weight was due to variability and should be resolved with further years of testing. At the Kern and Merced sites, PAR was reduced as irrigation decreased, although the overall reduction from the highest to the lowest values was only 9% and 6% respectively, at those sites. The Tehama site did not show a clear trend, but also showed a smaller range from highest to lowest PAR (4%).

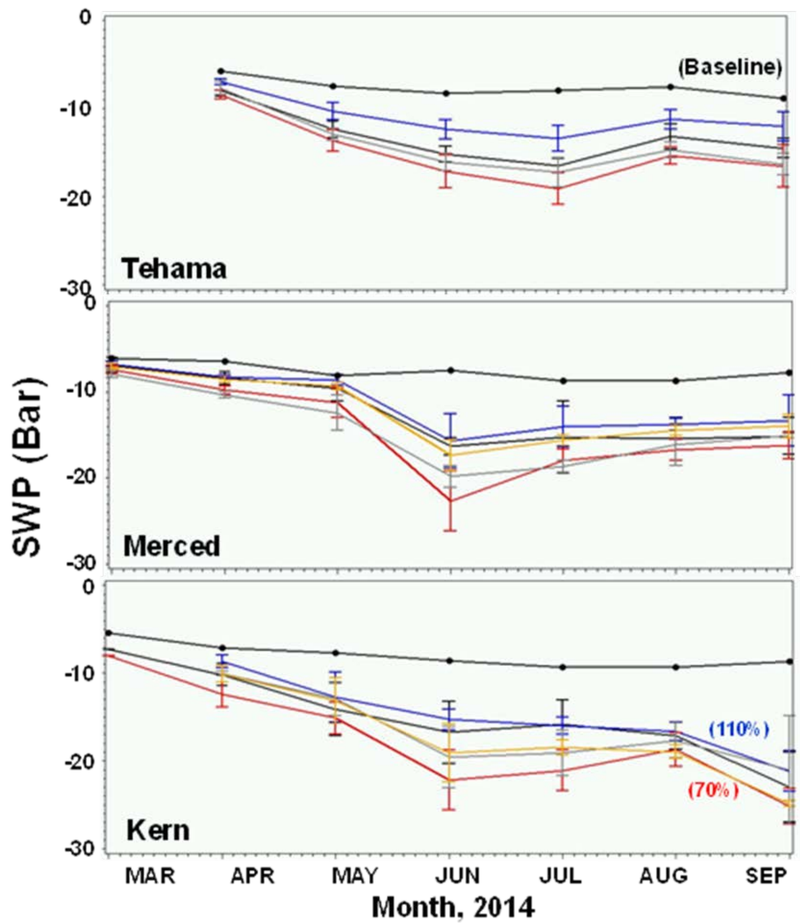

Figure 2. Seasonal pattern of monthly average stem water potential (SWP) for each treatment at each location, with the highest and lowest irrigation treatments indicated for Kern (other sites were also consistent with the irrigation treatments). Also shown for reference is the fully irrigated (non-stressed) baseline SWP (black line and solid dots).

Table 3. Kernel yield, Kernel weight, PAR (% light interception), and average midsummer SWP (June-August) for the different sites and irrigation treatments (% ET) in 2014. All means are ranked in numerical order (means which appear to be identical are due to rounding), but means followed by the same letter are not significantly different. An absence of letters indicates that there was no significant treatment effect.

Site	Kernel Yield (#/ac)		Kernel weight (g)		PAR (%)		SWP (bar)	
	Treatment	Mean	Treatment	Mean	Treatment	Mean	Treatment	Mean
Tehama	74	2340	116	1.35	116	71	116	-12a
	100	2315	86	1.29	86	68	100	-15b
	116	2260	100	1.27	74	68	86	-16b
	86	2260	74	1.24	100	67	74	-17b
Merced	110	2910	110	1.04	110	68	110	-14a
	100	2900	100	1.00	100	68	100	-15ab
	80	2640	90	1.00	90	64	90	-16ab
	90	2540	80	0.97	70	63	80	-18bc
	70	2420	70	0.90	80	62	70	-19c
Kern	90	1960	100	1.17a	110	73a	110	-16a
	110	1890	70	1.15ab	100	70a	100	-17a
	100	1870	110	1.08ab	90	69a	80	-19ab
	80	1840	80	1.08ab	80	68ab	90	-19ab
	70	1610	90	1.01b	70	64b	70	-21b

In summary, when almond production data are analyzed based only on irrigation treatments (e.g., **Tables 2** and **3**) there are general trends showing, as expected, reductions in production due to reduced irrigation. This is the case in most measures of orchard productivity, but there are notable exceptions (e.g., the highest yield was from the 90% ET treatment in Kern and the 74% ET treatment in Tehama). This analysis also indicates that after 2 years of differential irrigation, in most cases the irrigation treatments are not statistically different, and it is important to note that these analyses already adjust for block-to-block variation in productivity. The primary goal of this project is to develop a water production function for almonds, and it must be recognized that the **shape** of the relation between water and yield is important. For instance, whether production (yield, quality, or anything related to economic productivity) either levels off or continues to increase with increasing water availability. Yield and other measures of economic productivity can be measured relatively easily, but soil conditions such as water holding capacity and the level of winter recharge, as well as environmental evaporative demand, will vary between orchards, and these will affect the net level of 'available water' to the tree. Hence, another important factor which must be evaluated in this analysis is how to measure water availability. It is common to express applied water and applied water plus soil moisture depletion as a percent of full ET to adjust for both soil and environmental conditions, but another useful plant-based measure which may be more closely related to production is SWP. All of these measures of available water may be useful, and so the following analysis will include consideration of these alternative measures, and their relation to yield and/or orchard properties that are closely related to yield, such as the percent of intercepted sunlight (PAR).

At each site there was significant block-to-block variation in the amount of water applied, even for the same irrigation treatment (data not shown). However, this variation was useful in establishing a range of conditions both between and within sites. There was a clear positive correlation of applied water to both PAR and SWP (**Figure 3**). For PAR, all sites were similarly distributed around one fit line, but for SWP, there were clear differences, with Merced showing generally higher SWP for the same level of irrigation compared to Kern, and Tehama being intermediate (**Figure 3**). For instance, an SWP of about -17 bars (moderate stress) was associated with about 43" of irrigation in Kern but only about 26" in Merced and 30" in Tehama. Presumably, this can be attributed to greater soil moisture reserves in Merced and Tehama compared to Kern, but it also raises the possibility that the almond water production function may not be the same for different almond growing regions/soils. A parallel difference between the three sites can also be seen in the relation of yield to all measures of applied water (**Figure 4 B-D**), with Merced having the highest, Kern the lowest, and Tehama intermediate yield at the same level of applied water. The slopes of linear

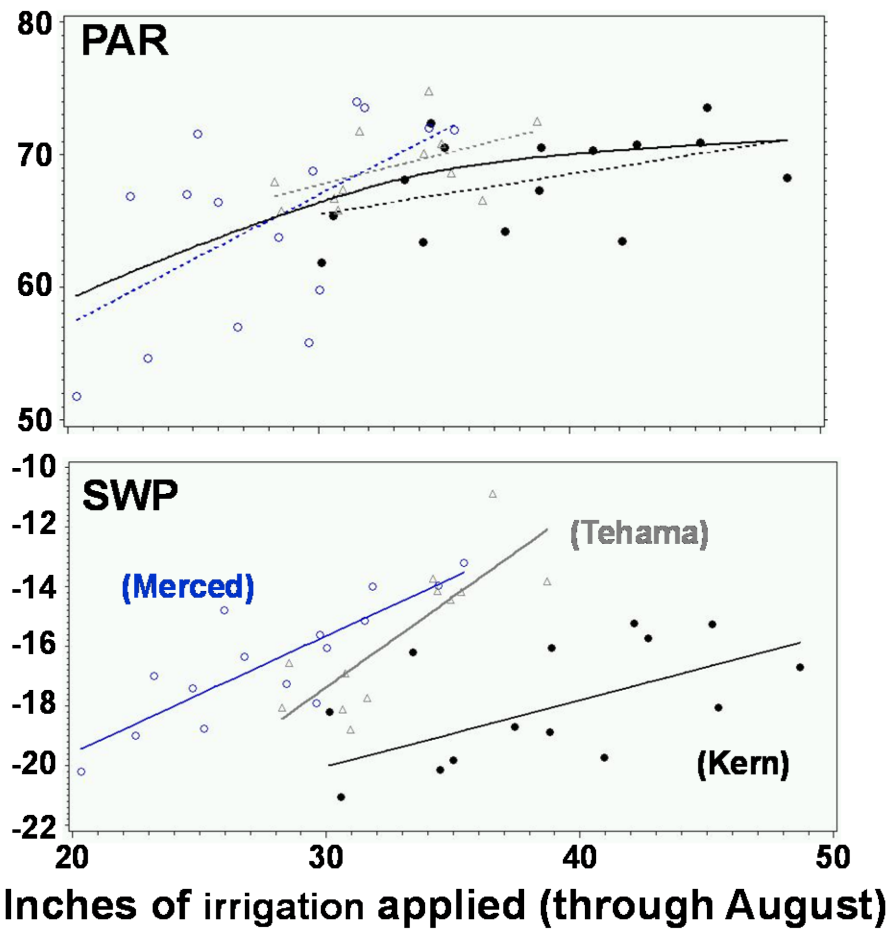

Figure 3. Influence of applied water amounts on midsummer canopy light interception (PAR) and midsummer (June – August) stem water potential (SWP). Linear regressions are shown for each individual site, but in the case of PAR only the Merced site was statistically significant, and a solid spline fit to all sites is also shown. In the case of SWP, all sites showed significant (Kern) to very highly significant (Merced) r-square values (0.32 to 0.71).

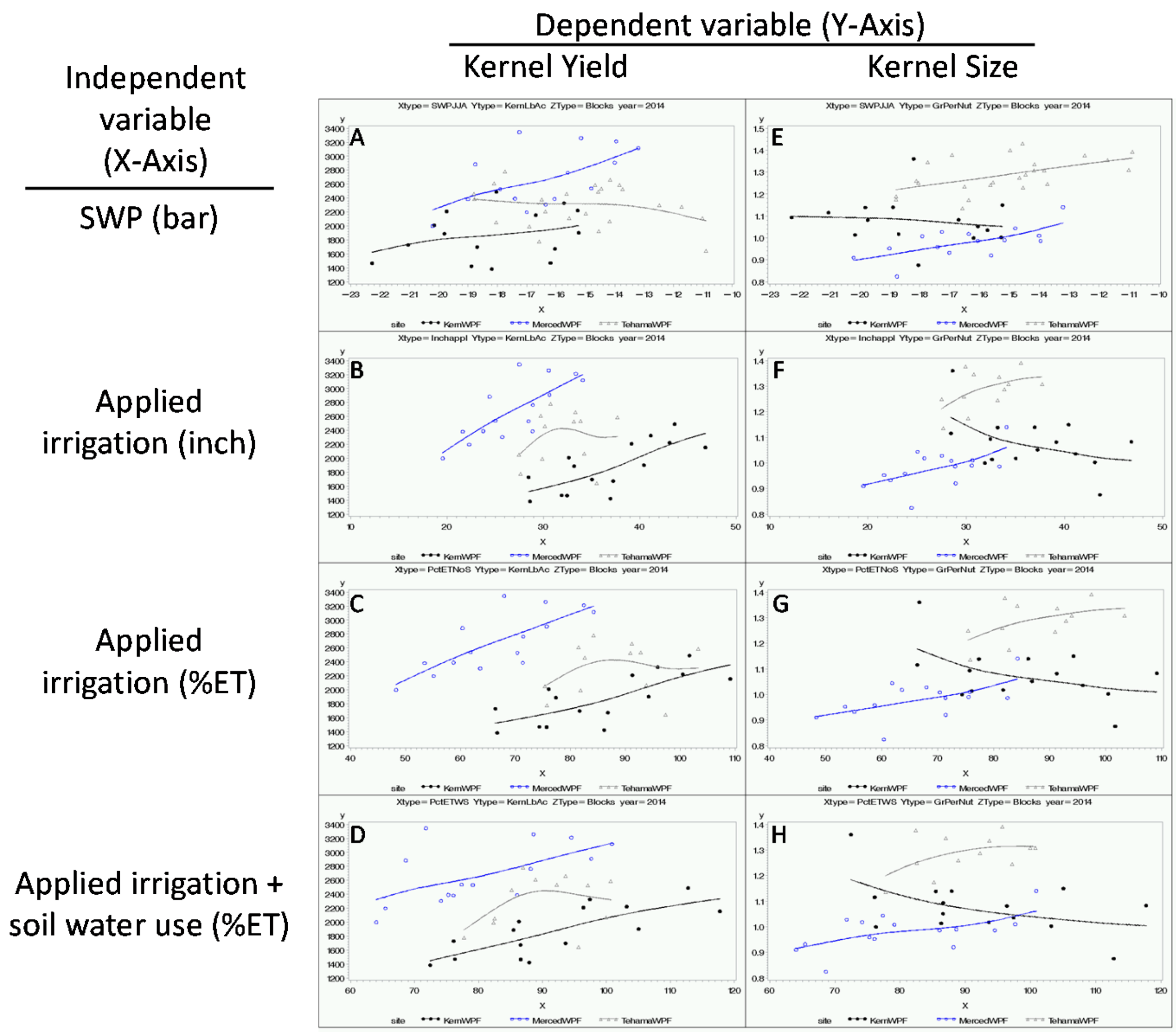

Figure 4. Comparison of alternative methods to express a WPF (water production function) in almonds for 2014. Production is expressed as kernel yield (left side graphs, Y scale is 1,200 to 3,400 pounds per acre) or kernel size (right side graphs, Y scale 0.8 to 1.5 grams per kernel) as a dependent (Y-axis) variable, and the corresponding values of SWP (bars), applied irrigation from March 1 – September 1 (X scale is 10 – 50 inches), or applied water expressed as a % of ET either not including (X scale is 40 – 110%) or including (X scale is 60 – 120%) the contribution of soil water to ET, as the independent (X-axis) variable. Each point shown represents an individual replicate from Tehama (triangles), Merced (circles), or Kern (filled dots), with smoothed splines to illustrate the trend of the data.

regressions to these data (not shown) were the most consistent between sites when the sum of the applied water and the use of soil moisture was expressed as a percent of calculated ETc (**Figure 4D**). For this measure of applied water, a 10% increase in applied water gave an increase of about 200 kernel pounds per acre yield in Kern and Merced, with no clear increase in Tehama. The only site where irrigation amounts substantially exceeded 100% ETc in some blocks was the Kern site, and for these points there was no indication of a 'leveling off' of yield at high levels of applied water when the data was fitted with a smoothed curve (**Figure 4D**). This is an important result which will need to be confirmed with further years of data. An increase in kernel yield was also associated with increases in SWP at Kern and Merced, but not Tehama (**Figure 4A**). It was anticipated that yield would be more closely related to SWP than to applied water across all sites, and at an intermediate level of SWP (e.g., **Figure 4A**, -17 bar SWP) there was much less of a difference in yield between Kern and Merced (about 500 pounds/acre) than there was at an intermediate level of %ET (e.g., **Figure 4D**, 85% ET, about 1,000 pounds/acre), indicating that SWP was a more consistent indicator of water availability than %ET. However, site-to-site differences in response to of yield to SWP remained (**Figure 4A**), indicating that there may be factors other than irrigation and plant water status that are limiting yields at these sites. Kernel size generally had a positive relation to all measures of water availability at the Merced and Tehama sites, but not at Kern (**Figure 4E-H**). It is expected that kernel size may be reduced at higher yields, and the highest yielding site (Merced) did have the lowest kernel weight, but Tehama, which had intermediate yields, had the highest kernel weight, so the reason(s) for site-to-site differences in kernel size are not clear.

It has been established that canopy cover (%PAR) is a strong determinate of maximum possible yield in almond, but the development of canopy cover is a relatively long term process and the range in %PAR across sites was relatively small (about 60% to 70%, **Table 3**). There was a trend for a small but consistent reduction in %PAR with a reduction in irrigation for all sites and measures of applied water (**Figure 5B-D**); although when water availability was expressed as SWP, Merced exhibited a stronger response than Kern or Tehama (**Figure 1A**). This may indicate that the trees at the Merced site had a more pronounced defoliation response to deficit irrigation than trees at Kern or Tehama, but this will need to be confirmed with more frequent measures of %PAR. The most appropriate basis for comparing orchard yields should be yield per unit PAR, but since there were only small differences in %PAR between sites (**Table 3**), essentially the same patterns in yield per unit PAR (**Figure 5E-H**) were found as were found for yield (**Figure 4A-D**), with Merced and Kern having the highest and lowest yields, respectively, and a more-or-less linear increase in yield for increases in water availability, and Tehama showing some evidence of a decreased yield with higher water availability (**Figure 5E-H**). Average yield per unit PAR ranged from 25 to 40 pounds per acre per %PAR at these sites, which is below the value of 50 pounds per acre per %PAR which has been found to be the practical upper limit for almond orchards, and hence factors other than water availability appear to be limiting yields at all of these sites. This is an important point to keep in mind when evaluating a 'water production function,' and that is that it may be necessary to express orchard production as a relative value (i.e., relative to the maximum possible in each orchard as 100%), rather than as kernel pounds per acre.

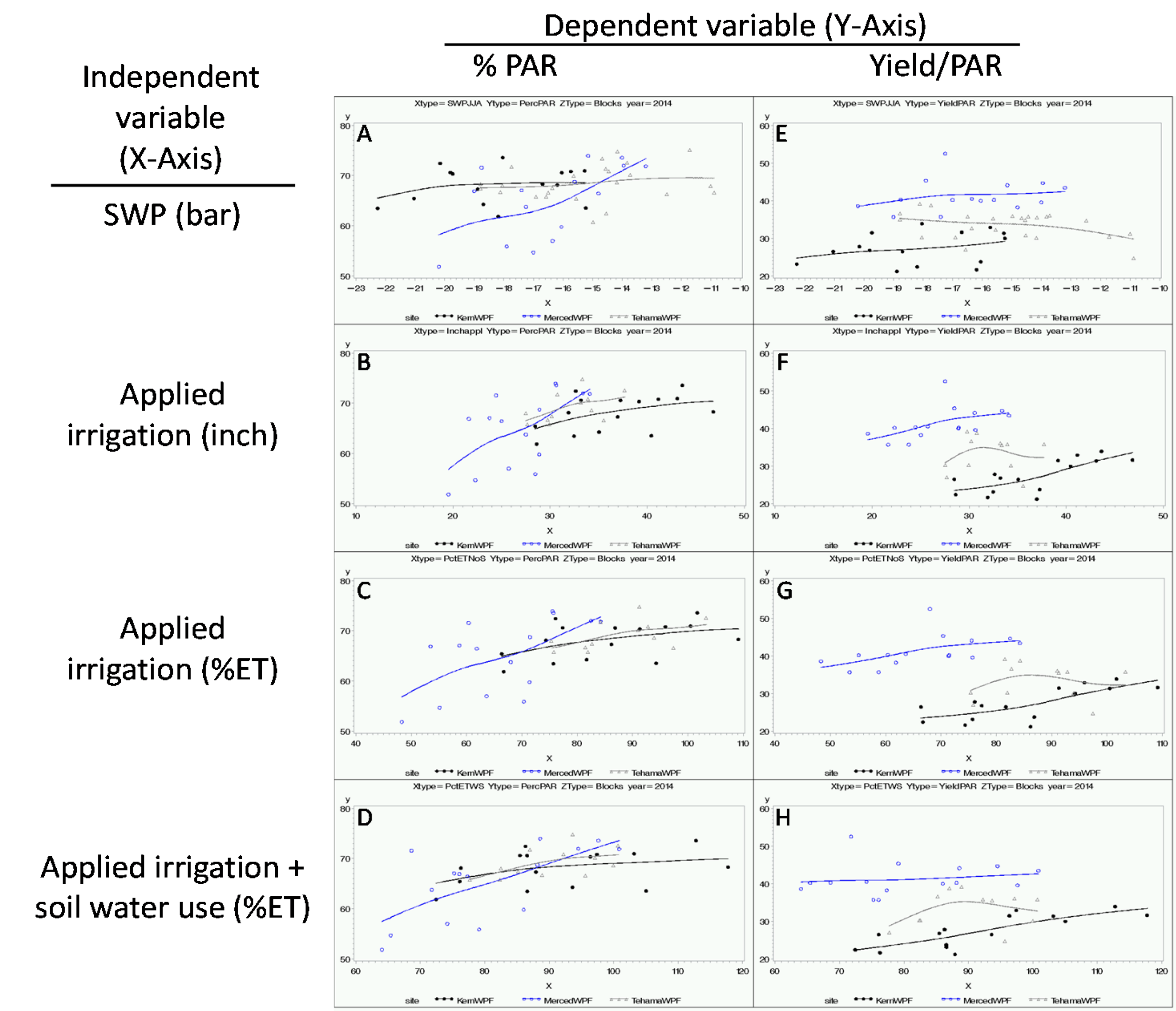

Figure 5. Comparison of alternative methods to express a WPF (water production function) in almonds for 2014. Production is expressed as yield/PAR (right side graphs, Y scale is 20 to 60 pounds per %) or PAR (left side graphs, Y scale is 50 to 80%) as a dependent (Y-axis) variable, and the corresponding values of SWP (bars), applied irrigation from March 1 – September 1 (X scale is 10 – 50 inches), or applied water expressed as a % of ET either not including (X scale is 40 – 110%) or including (X scale is 60 – 120%) the contribution of soil water to ET, as the independent (X-axis) variable. Each point shown represents an individual replicate from Tehama (triangles), Merced (circles), or Kern (filled dots), with smoothed splines to illustrate the trend of the data.

The influence of irrigation on yields at each site can also be evaluated by comparing the pattern in yield and other measures of productivity over time, and **Figures 6-8** show these patterns from 2012, prior to any imposed treatments, through 2014. For these graphs, an irrigation treatment effect which develops over time will be expressed as lines moving progressively farther apart over time, but the only case which shows this pattern clearly is the %PAR intercepted at the Kern site (**Figure 7**). As expected, at this site we see a progressive decrease over time with the lowest irrigation level (70%) and a progressive increase over time with the highest irrigation level (110%). This indicates that the trees at the Kern site have had a canopy growth response to irrigation (**Figure 7**), but not yet a clear yield response (**Figure 6**). Trees at the Merced and Tehama sites have not yet exhibited a response in either category, and there has been no clear response to irrigation at any site in yield per unit PAR (**Figure 8**).

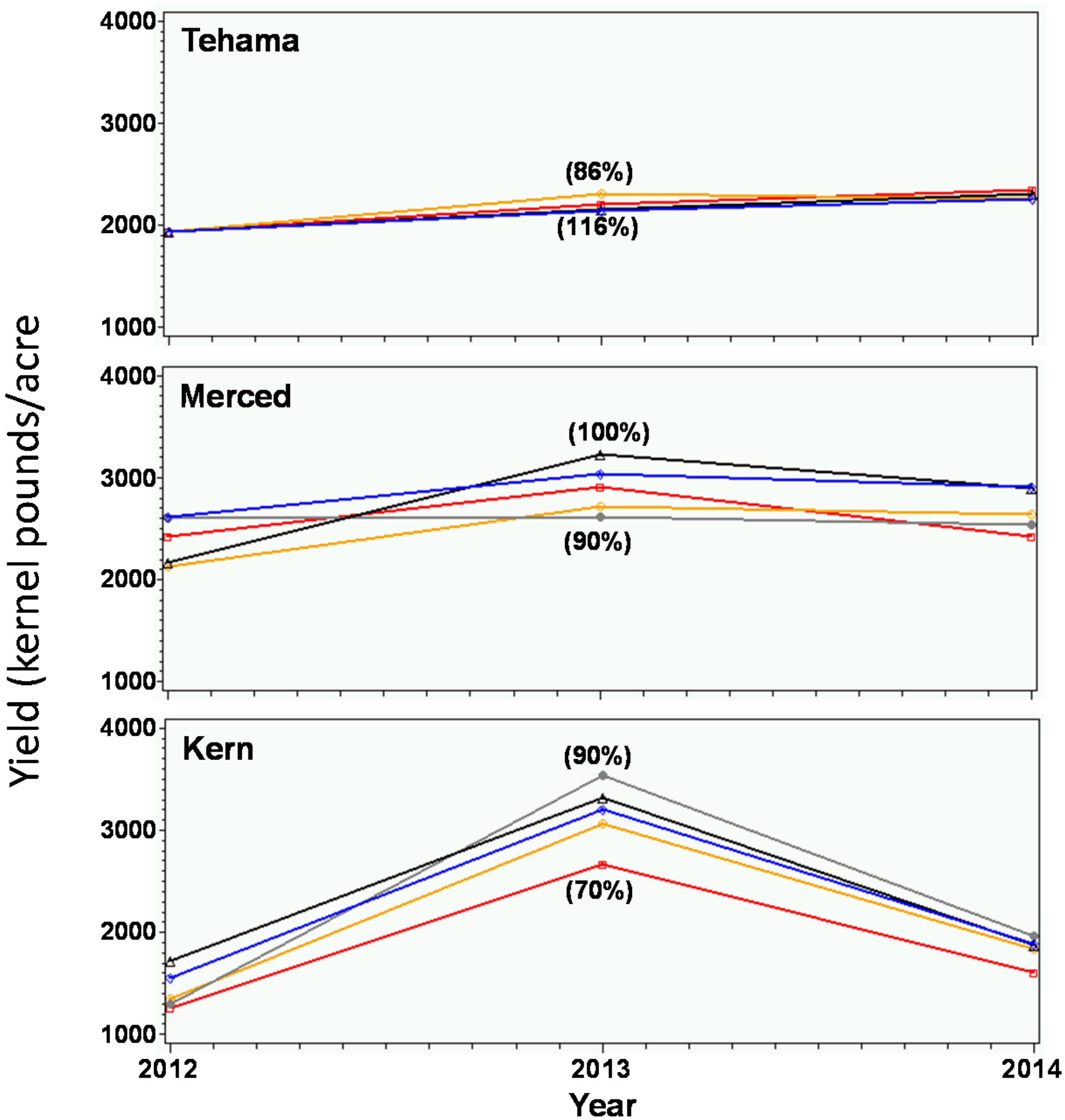

Figure 6. Treatment average yields over time from pre-treatment (2012) through the first two years of the WPF study at each site. Treatments with the highest and lowest values in 2013 are indicated.

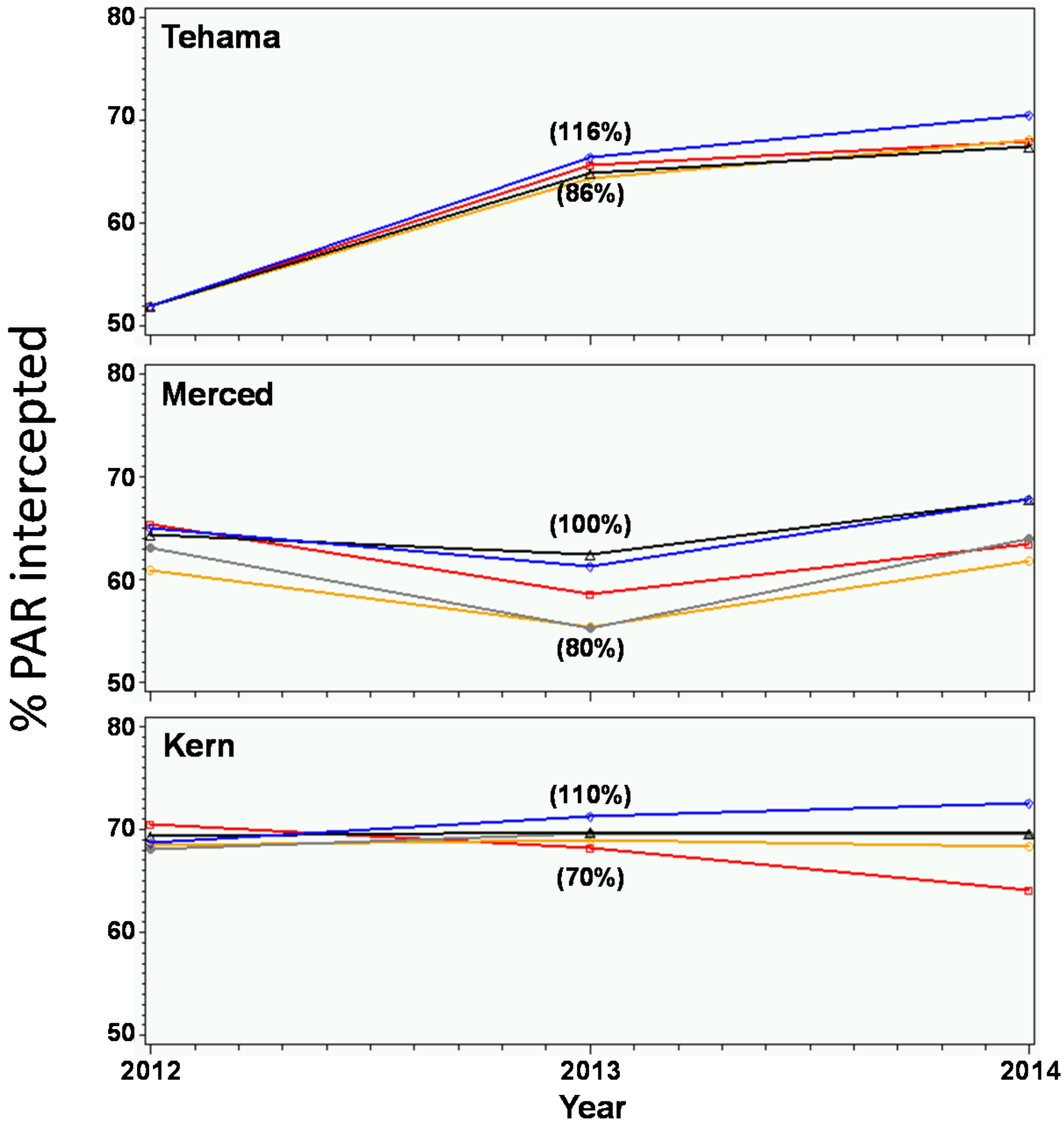

Figure 7. Treatment average % PAR intercepted over time from pre-treatment (2012) through the first two years of the WPF study at each site. Treatments with the highest and lowest values in 2013 are indicated.

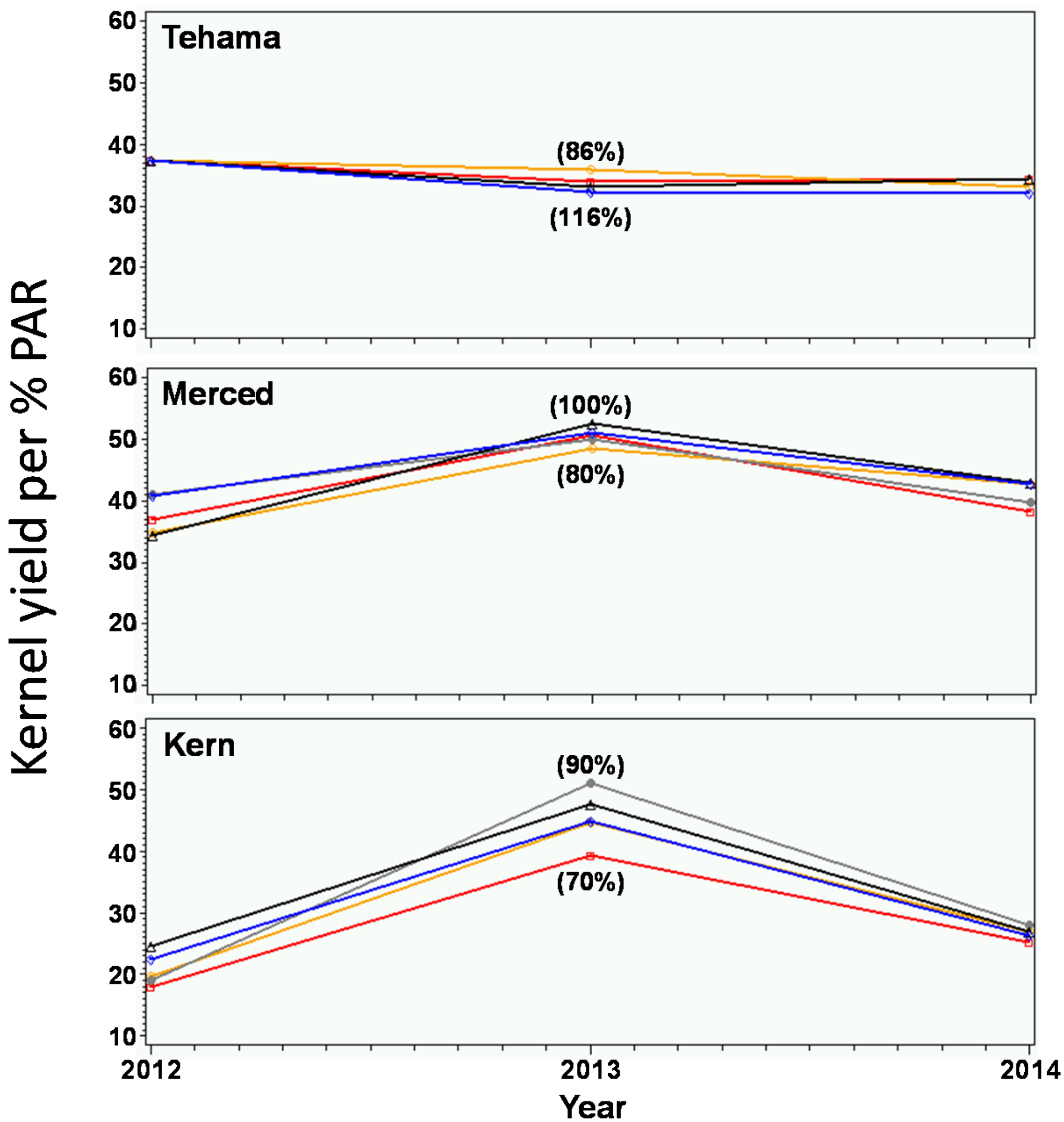

Figure 8. Treatment average yield per % PAR over time from pre-treatment (2012) through the first two years of the WPF study at each site. Treatments with the highest and lowest values in 2013 are indicated.

Kern Materials and Methods Using CERES Imagery for Conductance/Water Stress Measurement

The Kern County trial is the largest and most complex of the three statewide project sites. With the cooperation of Paramount Farming Company (now Wonderful), Jain Irrigation, Galcon Controllers, CERES Imaging, Phytech International, Smartfield, Inc., Rainbird and Hortau we have been able to install a double-line drip system powered with a variable frequency drive booster that has independent remote valve control of plots that are 6 rows wide by 15 or 16 tree long (**Figure 10**). Thus, differential irrigation amounts are achieved using a uniform flowrate, but varied duration to achieve as close as possible to a 70, 80, 90, Hull Split RDI, 100 and 110% ET application of water.

Objectives:

1) Quantify **kernel yield in lbs/inch actual ET** (applied water + soil moisture depletion – leaching) under non-limiting fertility levels by varying depths of applied irrigation. (Primary objective common to all 3 sites.)

Kern Specific Objectives:

1) Quantify the interaction of hull-split Regulated Deficit Irrigation on the yield function with a simplified 50% ET irrigation application from mid-June to Nonpareil harvest irrigation cutoff – about 6 weeks.
2) Assess the yield benefit of “pulsed” (6 hours on, 6 hours off for 4 cycles over 48 hours) vs. continuous (24 hour set) irrigation.
3) Assess the grower friendliness, benefits and accuracy of in-situ data collection using web-based monitoring of trunk diameter (Phytech dendrometers), infrared sensed canopy temperature (Smartfield), and soil water content (Rainbird Climate Minder capacitance probes, Hortau tensiometers).
4) Assess the accuracy and relationship to kernel yield of remotely sensed aerial imagery used to calculate crop water stress (Conductance measurement, **Figure 10**) and tree biomass/vigor (NDVI, normalized differential vegetative index) using images supplied by CERES Imaging.
5) Assess the feasibility, final water use, and yield of high frequency “on-demand” plant stress and soil moisture triggers for irrigation scheduling (Unavailability of extra water due to drought canceled these treatments.)

The following discussion and figures will focus on plot size, applied water, final Kernel yields (the actual Water Production Function) and whole orchard water stress – which was only possible to measure using CERES Conductance imagery (objective 5). This metric is calculated using canopy temperature, vapor pressure deficit, and a proprietary algorithm to estimate stomatal conductance as the flow of water vapor from the leaf. **Figure 9** shows the correlation of the average CERES conductance measurements for 6 flyovers from 6/3 to 9/30/2014 with seasonal applied water for 50 metered plots across the trial. You will notice that there is considerable variability of total applied water that does a good job of covering the 70 to 110% range but is not perfectly clumped into our 5 exact percentage treatment groups. This is from leaks (gophers), occasional controller/program errors, and flow meter variability.

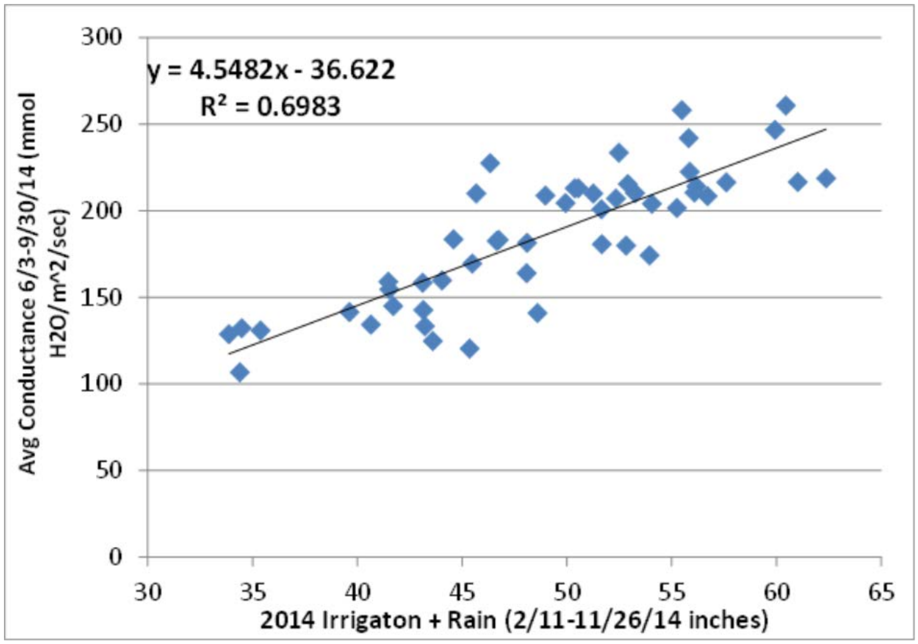

Figure 9. Average CERES conductance water stress as a function of applied water for 2014.

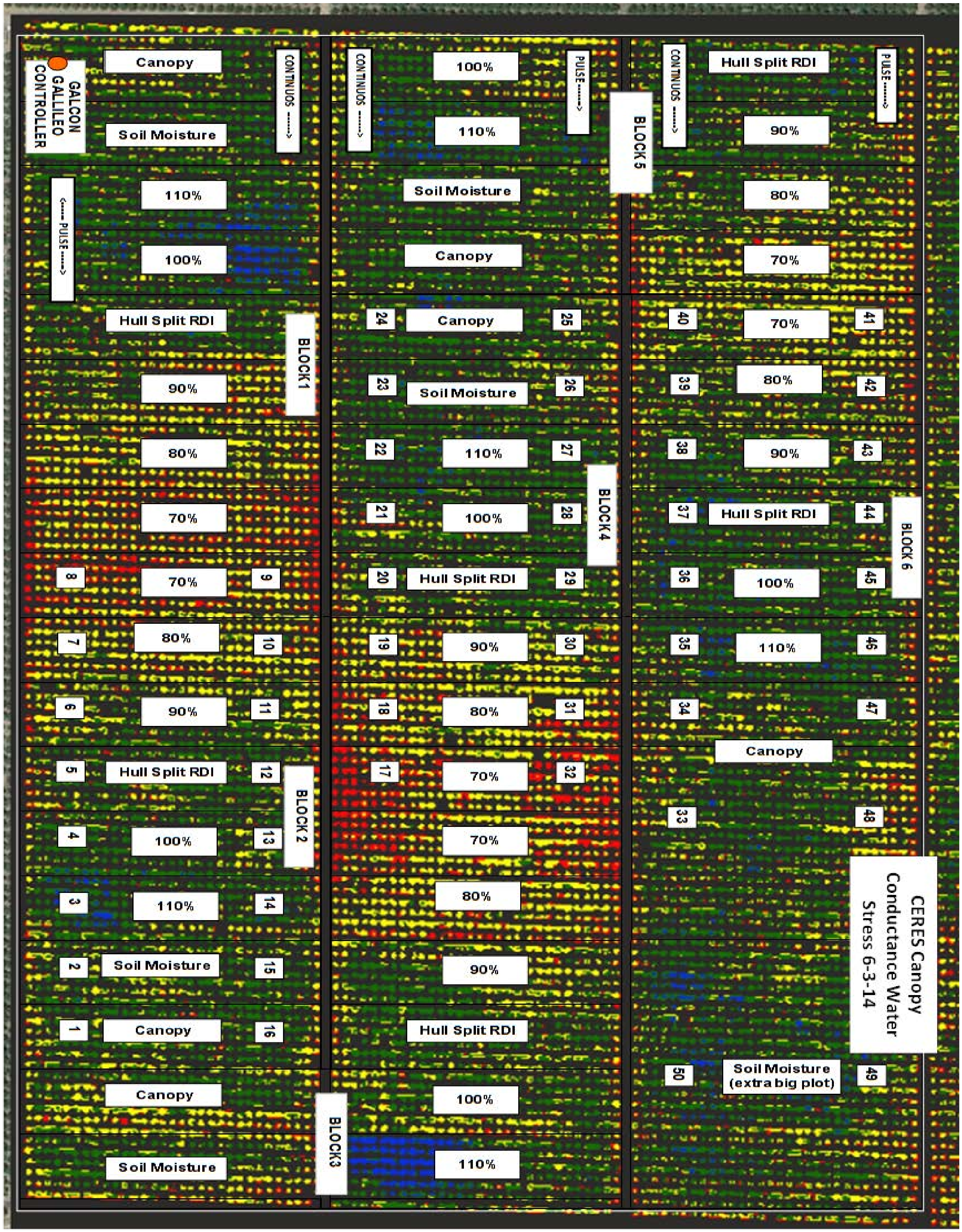

Figure. 10. Plot layout with colorized image of from CERES flyover on 6/3/14 revealing stress in deficit irrigation treatments.

A 70% correlation of a plant-based water index with total seasonal applied water is truly excellent. So do the CERES conductance measurements give us a more comprehensive way to examine stress over the whole orchard and see if we have indeed achieved the differential levels of stress designed for this trial? Absolutely! **Figure 11** below has been distilled from the 1176 data points created from 12 flyovers by CERES Imaging in 2014 from 4/24 - 9/30/2014. The below numbers represent the average per tree CONDUCTANCE (the higher the number the lower the relative leaf temperature due to a higher rate of water vapor leaving the leaf compared to low conductance trees) for all 12 replicated plots of each irrigation treatment (6 pulse and 6 continuous/normal irrigation) for the entire season. One data point equals the SUMMED CONDUCTANCE for all 15 or 16 Nonpareil yield trees per plot for a single flyover date. This analysis is extremely more rigorous than would be possible with ground observations as it tallies the water stress for EVERY TREE in EVERY PLOT for EVERY DATE (9,920 trees times 12 dates). The Canopy, Soil Moisture and 100% treatments receive the same irrigation schedule and are all effectively 100% treatments as the drought has prevented us from the water flexibility required for the "on-demand" treatments. All irrigation treatments receiving differential (%) scheduling have statistically significant different levels of water stress. There was NO significant yield effect with irrigation method (continuous vs pulse irrigation).

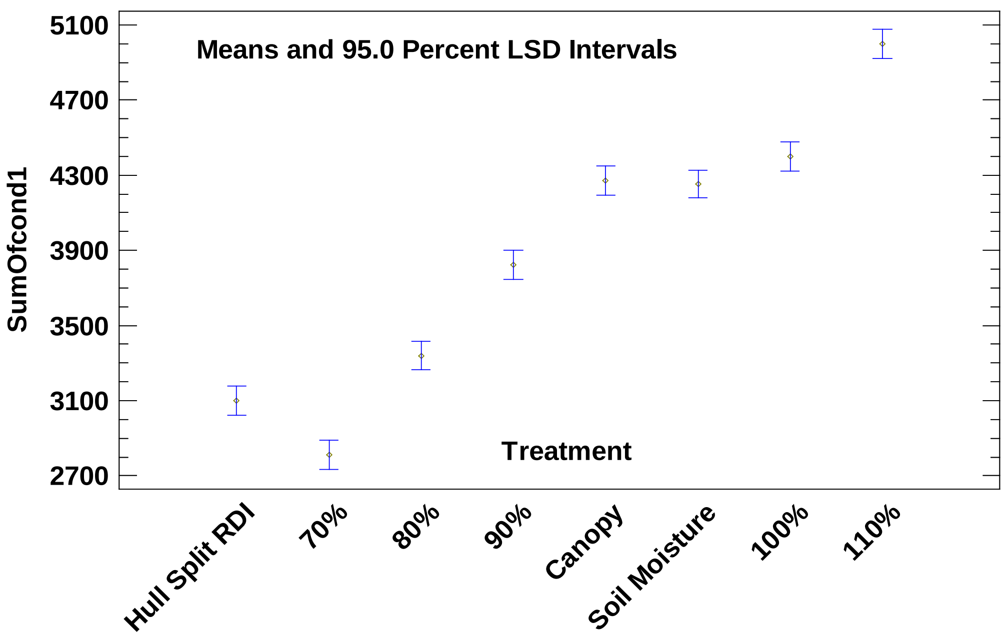

Figure 11. Summed plot Conductance with 95% confidence intervals as a function of irrigation treatment for 6/3 to 9/30/2015.

Table 4 lists the means separation for the above chart showing an average summed plot Conductance for the 70% treatment was 2810 compared to 4401 mmol $H_20/m^2/s$ for the 100% treatment – or 63.8% less than the 100%, while the 110% was 113% more than the 100%.

Table 4. Means separation table for summed plot Conductance 6/3 to 9/30/2015 (LSD 0.95)

Treatment	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
70%	144	2809.79	56.0268	X
Hull Split RDI	144	3098.67	56.0268	X
80%	144	3340.17	56.0268	X
90%	144	3824.22	56.0268	X
Soil Moisture	168	4254.18	51.8707	X
Canopy	144	4269.78	56.0268	X
100%	144	4400.69	56.0268	X
110%	144	4997.97	56.0268	X

These are startlingly accurate results given the known variability exhibited in measured flow rates shown in **Figure 9**. But the density of this data provides numbers for every tree in the orchard.

Figure 12 shows the relationship of a single CERES conductance measurement for a single tree for 3 different flyover dates compared to the more familiar measurement of plant stress using the pressure chamber to measure stem water potential (SWP). R^2 ranges from 0.41 to 0.62 for a given date. Taken as a whole, without respect to date, the R^2 is 0.12. Which of these measurements, SWP or remotely sensed "Conductance", is most accurate to explain plant water stress? We can't say at this time.

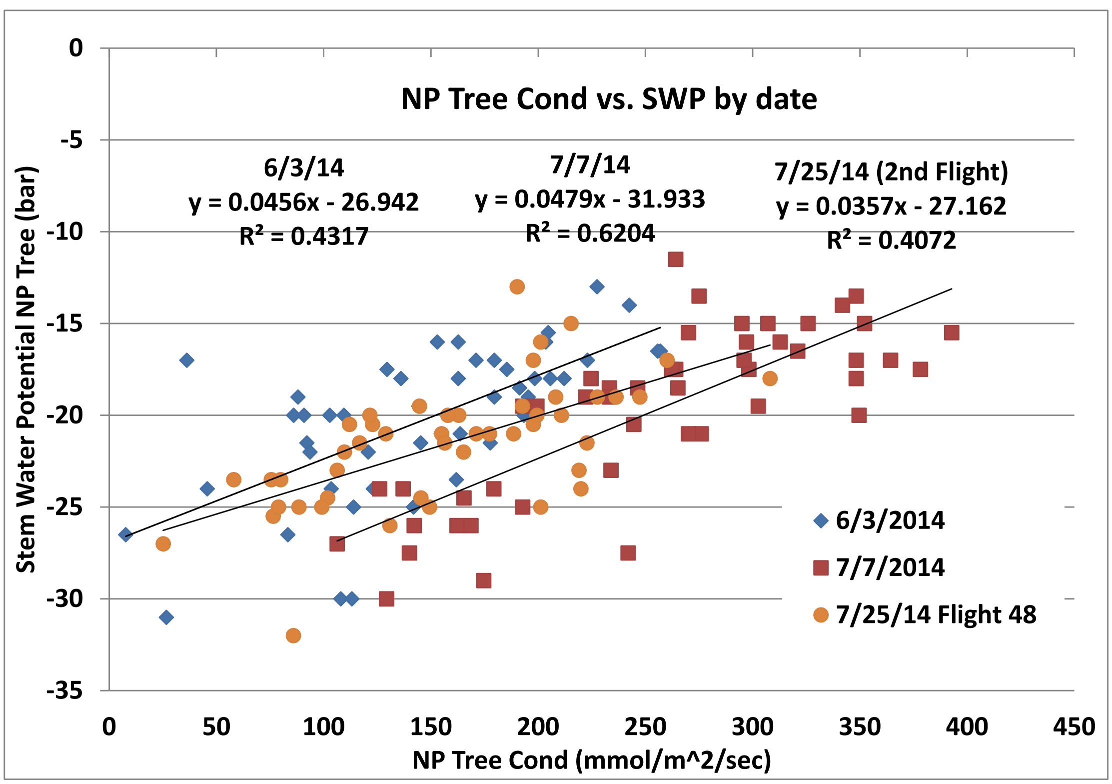

Figure 12. Individual tree Conductance compared to SWP measured the same afternoon for 3 different dates.

Finally, what about the water production function and the relationship of all this stress to actual kernel yield? Even though we have shown a tight relationship with the CERES Conductance, applied water and our experimental treatments, there is only a 13% R^2 of Kernel yield as a function of average Conductance (**Figure 13**).

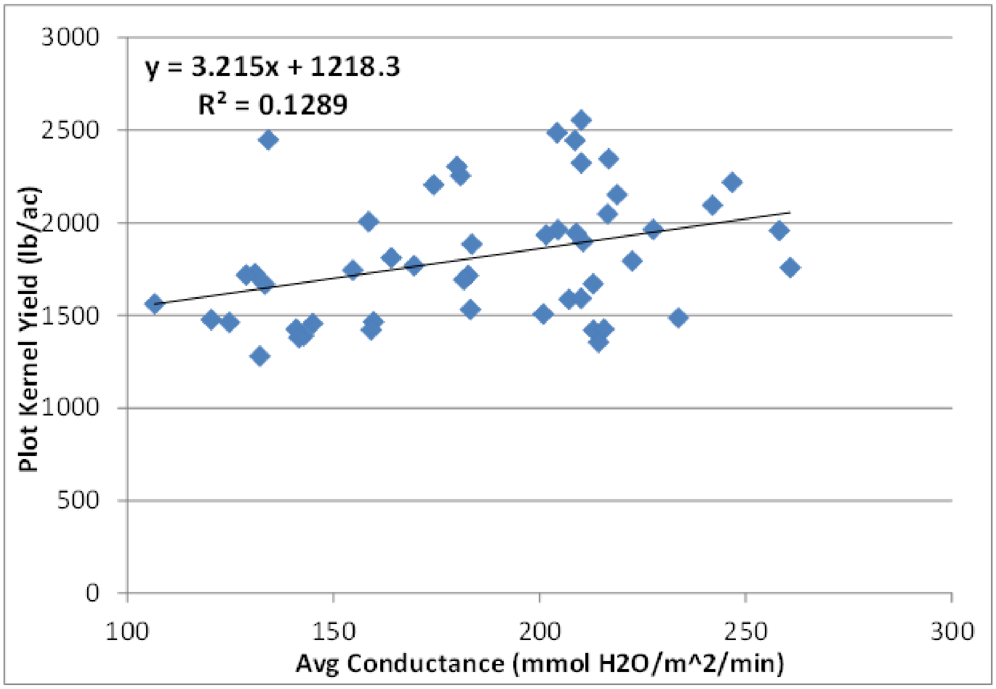

Figure 13. Nonpareil plot kernel yield as a function of average conductance for 6/3 to 9/30/2015

When plotted as a function of applied water the R^2 improves to 21.5% and 22.6 lbs kernels/inch of water (**Figure 14**), but this is only statistically significant for the difference between the 70% and the 100% treatment

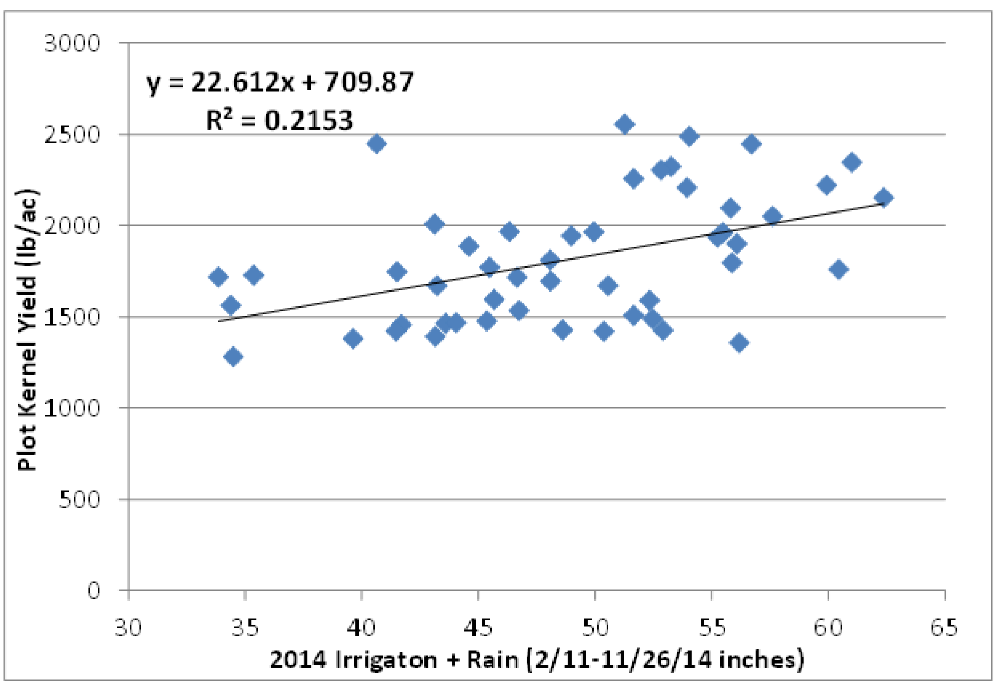

Figure 14. Nonpareil plot kernel yield as a function of whole season applied **water.**

Lastly, a very detailed calculation was done weekly at the Kern site in an attempt to estimate any leaching and appropriately account for tree wetted rooting volume and thus capture the actual tree ET over 50 monitoring sites outfitted with neutron probe access tubes to a depth of 9.5 feet. Kernel yield as a function of this calculated ET is shown in **Figure 15** – showing an even lower R^2 (15% and 19 lbs kernels/inch of water) than simply using applied water as in **Figure 14**.

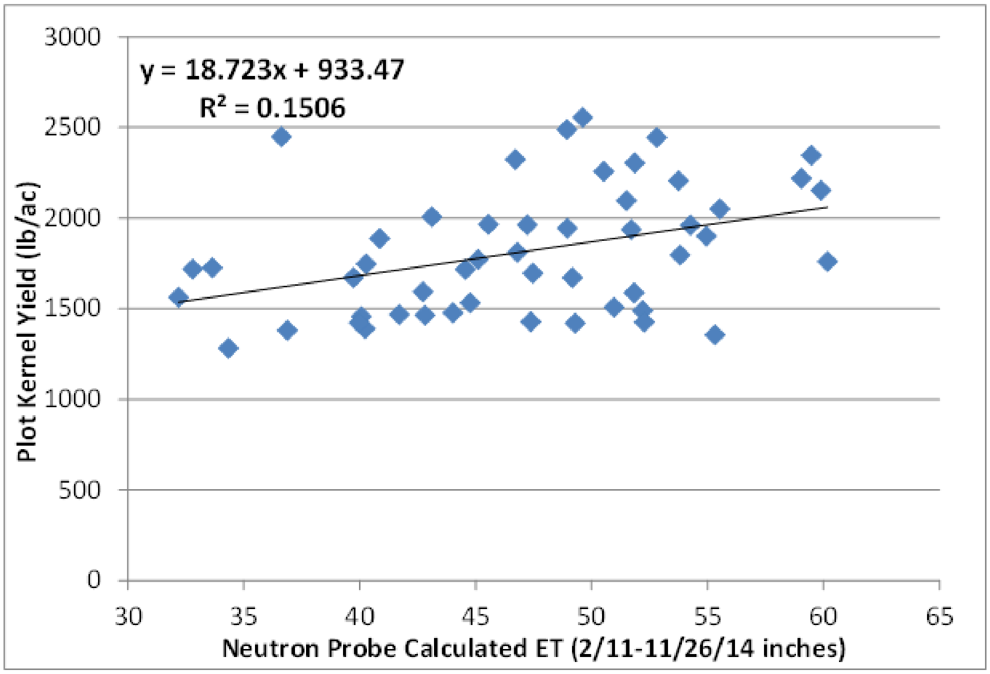

Figure 15. Nonpareil plot kernel yield as a function of neutron probe calculated ET.

<u>CONCLUSION</u>:

Mature almonds stress quickly but this doesn't always mean significant yield loss!

Research Effort Recent Publications:

(None at this time)

References Cited:

(N/A)