ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE
January 1, 2014 - December 31, 2014

PROJECT TITLE:
Identifying opportunities for improving water use efficiency in California rice systems.

PROJECT LEADER (include address):
Bruce Linquist, UCCE Rice Specialist, Department of Plant Sciences, University of California, One Shields Ave, Davis, CA 95616
(530) 752-3450; balinquist@ucdavis.edu

PRINCIPAL UC INVESTIGATORS (include departmental affiliation):
Robert Hijmans
Assistant Professor
Environmental Science and Policy

COOPERATORS:

Randall Mutters, UCCE Farm Advisor, Butte County

Chris Greer, UCCE Farm Advisor, Sutter, Placer and Yuba Counties

Luis Espino, UCCE Farm Advisor, Colusa, Glenn and Yolo Counties

LEVEL OF 2014 FUNDING: 53,678

OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:

The specific objectives addressed in 2014 were:

1. Develop a crop development model for moderately photoperiod sensitive varieties such as M202 and M206 that predicts days to PI, 50% heading and maturity. Model will be developed using historical data, data collected in 2012 and 2013 from state wide variety trails and greenhouse studies.
2. Continue to collect data from statewide variety trails on days to PI, 50% heading and maturity in order collect data for model validation.
3. Quantitatively determine how other crop management practices (i.e. drill seeding) affect crop development so that these practices can be incorporated into the model.
4. Quantify salinity accumulation in no-spill systems. This was not an listed objective in our 2014 proposal; however, given that it was not too difficult to identify fields with no-spill management this year, we took the opportunity to conduct this research.

SUMMARY OF 2014 RESEARCH (major accomplishments), BY OBJECTIVE:

Objectives 1 and 2: Crop model development

Previous research had suggested that some varieties may be moderately photoperiod sensitive; however, an analysis of the results of a greenhouse study indicate that all varieties tested (CM101, M104, M105, M202, M205, M206, S102 and L206) were non-photoperiod sensitive except M401, which is photoperiod sensitive. Given this, crop development is expected to proceed based on the accumulation of thermal time or degree day accumulation. A thermal-time model was developed. Data from this year's statewide variety trials and historical variety trail data was successfully used for model calibration and validation. The addition of this year's data increased the accuracy of the model for all stages.

The model used was as follows:

$$DD = (Tmax + Tmin/2) - T_{base} \quad \text{(Equation 1)}$$

- *Tmin = LT if Tmin > LT*
- *Tmax = UT if Tmax > UT*

where DD is degree days, T max is the maximum daily temperature, Tmin is the minimum daily temperature, LT is the lower temperature threshold, and UT is the upper temperature threshold. Model parameters for each variety are shown in Table 1. This model accurately predicts the time to stages [PI, Heading, and R7 (physiological maturity)] as shown in Table 2 and Figure 1. We plan to develop this model into an on-line tool that will assist growers in their crop management by allowing them a good estimate of the crop progression.

Table 1. Model parameters (see equation 1) for each variety.

Variety	T_b (°C)	*LT* (°C)	*UT* (°C)	*f(S1)* (°Cd)	*f(S2)* (°Cd)	*f(S3)* (°Cd)
CM101	11.03	18.93	30.67	496	843	1063
L206	12.01	20.31	30.21	437	776	944
M104	12.00	21.20	30.33	443	747	953
M202	12.04	20.41	30.06	443	820	1025
M205	12.11	21.25	31.03	464	871	1087
M206	9.49	20.19	30.80	586	1014	1273
S102	10.50	19.77	30.98	526	876	1135
M401	11.03	18.93	30.67	496	843	1063

Table 2. Model fit for each variety and stage.

	PI			Heading			R7		
Variety	Slope	R^2	RMSE	Slope	R^2	RMSE	Slope	R^2	RMSE
CM101	1.03	0.73	2.73	1.10	0.70	3.43	1.01	0.50	3.69
L206	1.11	0.70	3.57	1.06	0.65	4.65	0.78	0.43	4.34
M104	1.18	0.44	3.63	1.00	0.33	4.69	0.38	0.07	5.70
M202	1.18	0.64	3.83	1.04	0.23	6.69	0.94	0.16	5.69
M205	1.04	0.67	3.63	1.08	0.28	6.59	0.17	0.01	6.30
M206	1.06	0.64	2.81	1.00	0.48	3.93	1.06	0.31	4.00
S102	1.00	0.67	2.82	1.17	0.71	3.29	0.86	0.46	3.65

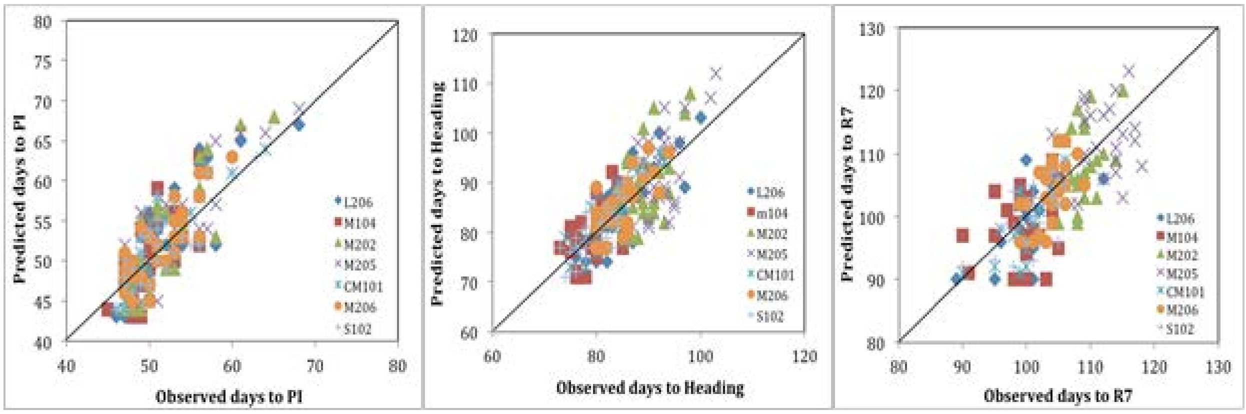
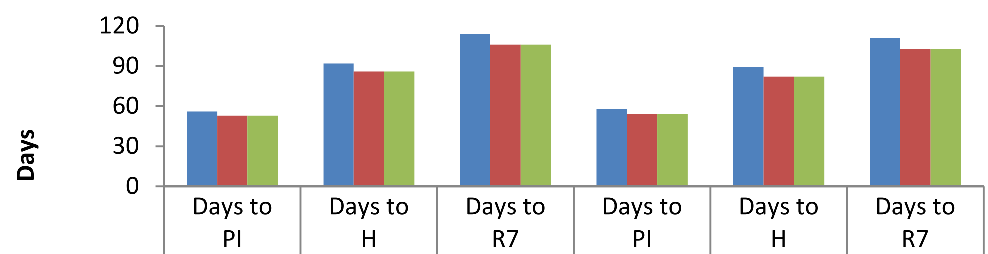


Figure 1. Model results of observed versus predicted for each variety.

Objectives 3: Water temperature and drill seeding effects on crop development

In 2013 and 2014, field trials were conducted at the Rice Experiment Station (RES) to determine the effect of water temperature and management on crop development. We made use of an experiment evaluating alternate wetting and drying (AWD) for this study. This experiment had three treatments: (1) wet-seeded continuous flood, (2) wet-seeded with intermittent wet and dry periods following canopy closure, and (3) drill seeded with intermittent wet and dry periods throughout the season. This experiment and the treatments are discussed in greater detail in the RM-4 Annual Report. We measured temperature below the soil surface (-2 cm) and at 2, 50, and 120cm above the soil surface. For each treatment, we determined the date of PI, heading, and R7 stages. The variety M-206 was grown in this study.



	2013			2014		
	Days to PI	Days to H	Days to R7	Days to PI	Days to H	Days to R7
Drill Seeded AWD	56	92	114	58	89	111
Wet Seeded	53	86	106	54	82	103
Wet Seeded AWD	53	86	106	54	82	103

Figure 2. Days to panicle initiation (PI), heading (H), and maturity (R7) in conventional wet seeded rice, wet seeded alternate wet and dry (AWD) and drill seeded AWD irrigation systems. For details of these treatments refer to the RM-4 2014 report.

Results were similar for both 2013 and 2014 studies. They show that rice development in drill seeded systems days to PI, heading and R7 were delayed by 3, 6, and 8 days, respectively. There was no difference between the water seeded conventional and water seeded AWD treatments. This suggests that water management (perhaps due to differences in air and water temperatures) plays an important role on rice development and degree day accumulation. We are analyzing the data for water temperature to quantify this effect and incorporate it into the model discussed above.

Objective 4: Salinity in no-spill systems

This research was not part of the 2014 proposal, however the drought in 2014 provided an opportunity to evaluate no-spill water management due to water restrictions. Given our interest in evaluating opportunities to reduce water use, we took the opportunity to evaluate the impact of no-spill water management on salinity build-up and yields.

Six fields were monitored for salinity during the 2014 growing season: one field each in Butte and Yuba, and two fields each in Colusa and Glenn counties. In each field, salinity was measured in the first, middle, and bottom checks. Three plots were established in each check: one close to the water inlet, one in the middle, and at the farthest point from the water inlet (Fig. 3). During the growing season, water and soil EC, water height, water and soil temperature, and plant height at PI were measured on a bi-weekly basis.

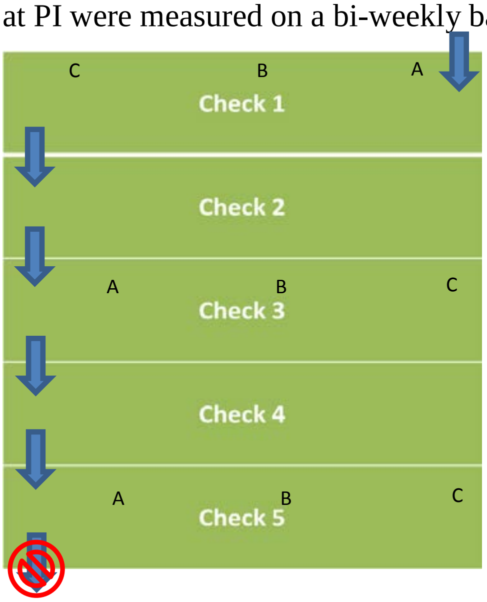


Figure 3. An example of the sampling scheme used for each field. Soil, water and plant samples were taken in the top middle and bottom check of each field. Within each check, there were three sampling points with point "A" nearest the inlet to the check and point "C" furthest from the check inlet.

Preliminary results show that across all fields, flood water EC ranged from 0.06 to 2.45 dS/m (Table 3). As expected, the lower EC values were usually in the top checks and the highest in the bottom checks. Values above 2 dS/m (point considered critical for optimal rice growth) were only observed in one field (B-2) and this was in the bottom check at the point furthest from the inlet. The minimum and maximum soil EC was always higher than flood water EC and ranged from 0.08 to 3.69 dS/m. In four of the six fields, soil EC was above 2 dS/m.

Table 3. Minimum and maximum flood water and pore water (Soil) EC observed during the 2014 growing season.

	Water EC (dS/m)				Soil EC (dS/m)			
Field	Min	Location*	Max	Location	Min	Location	Max	Location
B1	0.33	1-A	1.64	3-B	0.43	1-A	3.69	3-C
B2	0.33	1-A	2.45	M-C	0.73	1-A	2.30	3-C
Glenn	0.08	3-C	0.36	3-A	0.10	2-B	1.36	3-C
Levi	0.06	2-A	0.39	3-A	0.08	1-A	2.17	3-C
F4	0.19	1-C	0.72	3-C	0.24	1-A	1.56	3-C
F8	0.18	1-A	0.80	3-B	0.32	1-A	2.81	3-C

* 1= Top Check, 2= Middle check, 3= Bottom check; A=closest to check inlet and C=furthest from check inlet

Water EC changed during the season. As an example from field B2, looking across checks the top and middle checks changed little during the season but the bottom check the water EC increased through May and then declined to a level that was higher than the other checks (Fig. 4a). A similar seasonal pattern is observed when we look at different positions within checks – that is that the EC increases early in the season and then decreases and plateaus for the last portion of the season (Fig. 4b). Further analysis will determine if this pattern occurs at all locations. Furthermore, this data needs to be analyzed within the context of water management and the height of standing water in each check.

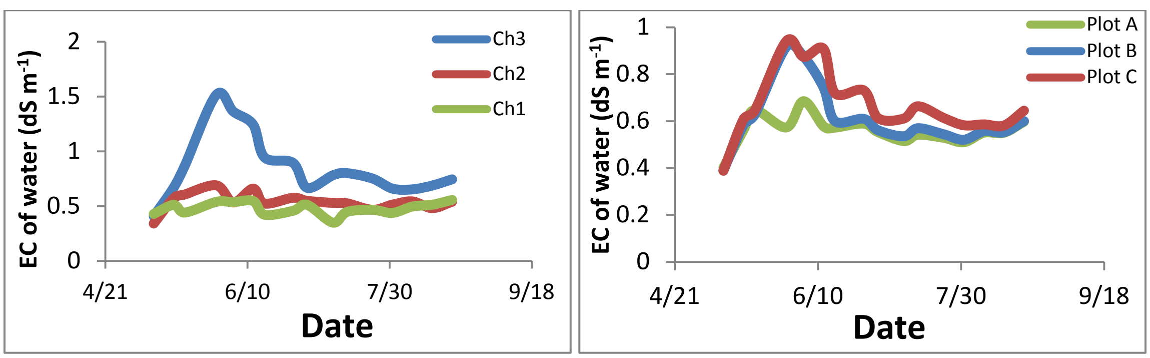


Figure 4. Changes in water EC values during the season. Data are from Field B2 (Table 3).Data are averages of all positions within check (1= Top Check, 2= Middle check, 3= Bottom check) and averages of data of positions within a check (A=closest to check inlet and C=furthest from check inlet).

Despite these changes in EC throughout the season and the observation of relatively high EC values – above 2 dS/m in flood water and still higher in the soil pore water, there did not appear to be any effect on yields. Fields B1 and B2 had the highest EC values but this did not appear to affect yields (Fig. 5). In all fields, yields in the bottom checks were similar to top and middle checks.

This data from six fields suggest that if a field receives clean water with low EC (in this case <0.33 dS/m) yields will not be compromised, despite the EC values in some cases being higher than 2 dS/m at some point during the season.

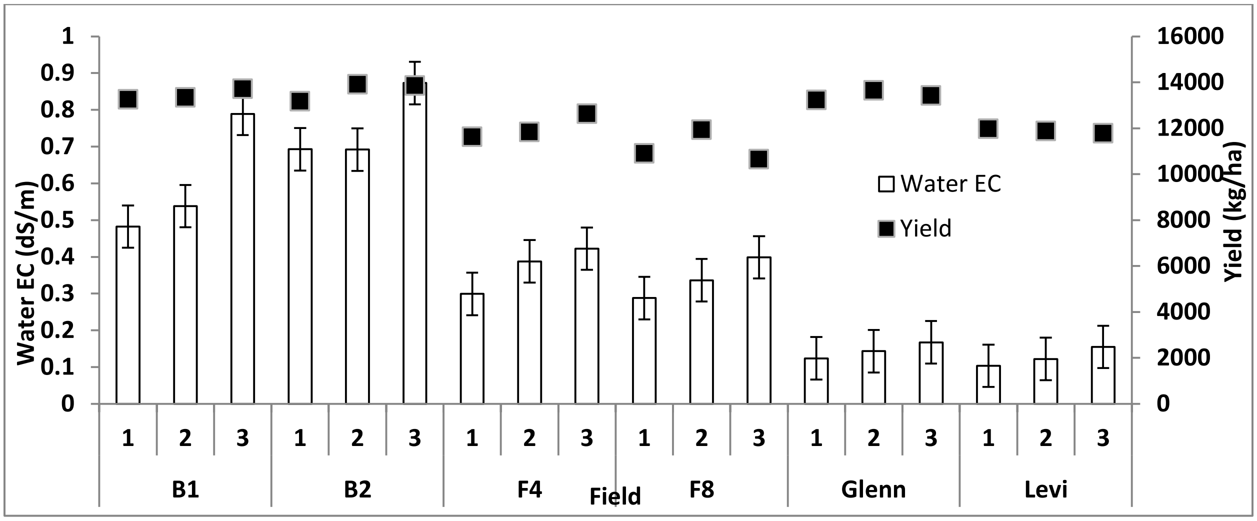


Figure 5. Check average (1= Top Check, 2= Middle check, 3= Bottom check) seasonal flood water EC and grain yield for each field.

PUBLICATIONS OR REPORTS:

Rice field day poster “Modeling rice response to temperature and photoperiod for CA major rice varieties”

CONCISE GENERAL SUMMARY OF CURRENT YEAR’S RESULTS:

1. We have developed model that can predict time to PI, heading and maturity (R7) based on degree day accumulation for 8 commercial California varieties.
2. The data from 2013 and 2014 on crop management practices in RES show that drill-seeding systems delay crop development, especially during the early stage of growth (planting to heading). This reinforced our previous hypothesis that water temperature plays an important role during crop development, and therefore, using water temperature data in the rice model would increase the accuracy of the model.
3. We evaluated no-spill water management on salinity build-up and yields. No-spill water management has the potential to reduce water use by reducing the amount of water delivery to a field. Our results indicate that the EC of flood water within fields receiving fresh water (not recycled) increased during the season and in some fields above the point of rice critical salt sensitivity (2 dS/m); however this had no apparent effect on grain yield.