ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
Jan. 1, 2011 to Dec. 31, 2011

PROJECT TITLE: Crop Management and Environmental Effects on Rice Milling Quality and Yield. (RP-13)

PROJECT LEADERS:
Randall Mutters, UCCE Butte Co.
Luis Espino, UCCE Colusa Co.

COOPERATORS:
.
Kent McKenzie, Rice Experiment Station
James Thompson, Biological & Ag. Engineering, UCD
Ray Stogsdill, Plant Sciences, UCD
UCD Chris Greer, UCCE Sutter-Yuba Co

LEVEL OF 2011 FUNDING: $15,430

Objectives:

1. Investigate the crop-environmental interactions affecting yield and milling quality of under-studied California public varieties (e.g. S102, M104, & M105) over a range of grain moisture levels during maturation.

2. Determine the range optimal drain times for the selected varieties.

MATERIALS AND METHODS

Field experiment.

Rice varieties S102, M104, M105, M205, and M206 were planted in a series of hydraulically isolated basins at the RES; each basin was equipped with independent water intake and drain outlets. The individual drains and the physical separation of the experimental plots allowed for discrete drain times to be imposed without compromising soil water status from the lateral movement of water between basins. Irrigation water was supplied from a common feeder ditch. Field preparation, fertility and pest management followed standard RES procedures. Seeds were dry planted onto a prepared seedbed at a rate of 150 lb/a, and irrigation water brought to a depth of 3 to 4 inches during germination and stand establishment. The experiment was planted on May 23. One hundred thirty pounds per acre of nitrogen as aqua ammonia, 50 lb/acre of potassium and 50 lb/acre of phosphorus were applied preplant. The experiment was top dressed with an additional 20 lb/acre N as ammonium sulfate 50 days after seeding.

Each variety was subjected to two drain treatments: 16 and 24 days after 50% heading (DAH, Table 1). Fifty percent heading was determined by cutting all plants in five randomly located one-foot squares per basin and counting the total of plants and those with emerge heads. Daily counts ensued when the first heads were visible in each plot and continued until all heads were clear of the boot. Days to 50% heading varied between variety and drain date treatment were applied accordingly. The drain dates were chosen based on the results from previous years' study on M205 and M206. This time interval bracketed the drain time when yield and milling quality were negatively affected (16 DAH) and that when no detrimental effects were observed (24 DAH). Draining later than 24 DAH has not proven to improve yield or quality, but a 16 DAH does reduced yields. Thus for the first year of study on varieties S102, M104, and M105 these were deem a good first proximation of the critical drain time interval. Drain treatments were independentaly applied to each individual basin based on the time to 50% heading. When the basins were drained, the boards were removed and the water was allowed to leave the field without restriction. No free standing water was present in the basins after 5 days.

Environmental conditions were monitored starting four weeks prior to the first harvest and continued through the final harvest date on October 27. Recording relative humidity sensors were deployed at canopy level in all plots. In each basin soil moisture probes (Decagon Em5b) were installed to measure soil moisture in the top 15 cm (~6 inches) of the soil profile. The experimental site was equipped with a two meteorological stations that measured air temperature, relative humidity, and dew point. Single kernel moisture measurements were taken at mid-day starting when kernels reached between 30 and 35% moisture content then continued until the end of the harvest period.

The experiment site received 1.6 inches of rain from October 4 through October 10.

<u>Harvest and sample collection at the RES.</u>

All basins were harvested for milling quality appasials 10 times (Sept. 22, 24, 28, 30 & Oct. 3, 7, 12, 14, 21, 27). Five, one square meter plots (~ 1 square yard) were hand harvested from each basin and threshed with an Almaco stationary thresher. Each basin was harvested for yield on October 27. At yield harvest five, 17 square meter plots (~189 square feet) were harvested from each basin with the UC Almaco plot combine. Plot grain weights were measured in the combine. Yields averaged all plots are presented. Single grain moisture contents were determined on samples from each harvested plot (Kett PQ510). Samples were dried with non-heated air to final moisture content of 13 to 14%. Yields are standardized to 14% moisture content and reported on a per acre basis. A 500g subsample was husked (Yamamoto FC-2K) and milled (Yamamoto VP-32T) and whole kernel percentage was measured using a machine grader (Foss Tectator Graincheck).

RESULTS & DISCUSSION

Heading dates ranged from 84 (S102) to 95 (M205) days after planting (Table 1). Days to 50% heading for the test varieties were comparable to those observed in the statewide variety trials.

Table 1. Planting, heading (50%), and drain dates (days after 50% heading, DAH) for tested varieties in 2011.

Variety	DAH	Days to heading	Date of heading	Drain date
S102	16	84	15-Aug	31-Aug
S102	24	84	15-Aug	8-Sep
M104	16	86	17-Aug	2-Sep
M104	24	86	17-Aug	10-Sep
M105	16	87	18-Aug	3-Sep
M105	24	87	18-Aug	11-Sep
M205	16	95	26-Aug	11-Sep
M205	24	95	26-Aug	19-Sep
M206	16	89	20-Aug	5-Sep
M206	24	89	20-Aug	13-Sep

Soil moisture

Under saturated conditions the soil moisture content in all basins was about 45% on a volumetric basis (Figures 1 thru 5). Drain dates are indicated by the vertical arrows in each figure. Upon draining the soil moisture declined at a similar rate in all drain date treatments. Initially the soil in the 16 DAH treatments for varieties M105 and M206 dried faster than the 24 DAH treatments (Figures 3 & 6). This is in contrast to 2010 where the rate of moisture loss in the 16 DAH treatments proceeded more rapidly than the 24 DAH treatments (Mutters et al., 2010). The high humidity and cool temperatures during this time frame in 2011 may have slowed the evapo-transpirative losses, thus mitigating any striking differences in soil moisture between treatments as observed in the previous years.

The time required for the soil moisture levels to decline from saturated conditions to critical moisture levels (~0.35% by volume; Fischer et al., 2011) was 11 days for S102 (Figure 1). Soil moisture levels declined at about one-half of this rate in the other experimental basins. The soil texture and hard pan depth are homogenous across the experiment sites, thus it is unlikely that field location attributed to this disparity. S102 was the earliest maturing of the test varieties. Its slightly advanced state of development may have contributed to the higher rate of moisture loss (use). Interestingly, the diurnal variation in soil moisture was greatest in S102 and M105 as indicated by the vertical hash marks on the data lines (Figures 1 and 3). In this circumstance, the soil surface dries during the day and at night the subsoil moisture migrates toward the surface creating the within day fluctuations in soil moisture.

The rain events starting on October 4 recharged the soil moisture profile to levels slightly less that saturated conditions. The rate of moisture decline after the rain was similar to that observed before the rain. Thereafter there were no discernible differences in the soil moisture levels between drain date treatments. Understandably the rain confounded the interpretation of the the drain time effects. However in 2011 as in 2010, the soil moisture levels between drain times were small. The data suggest that any observed yield and milling differences due to drain date were not directly associated with soil moisture content during the final stages of grain ripening when comparing basins drain 16 and 24 DAH.

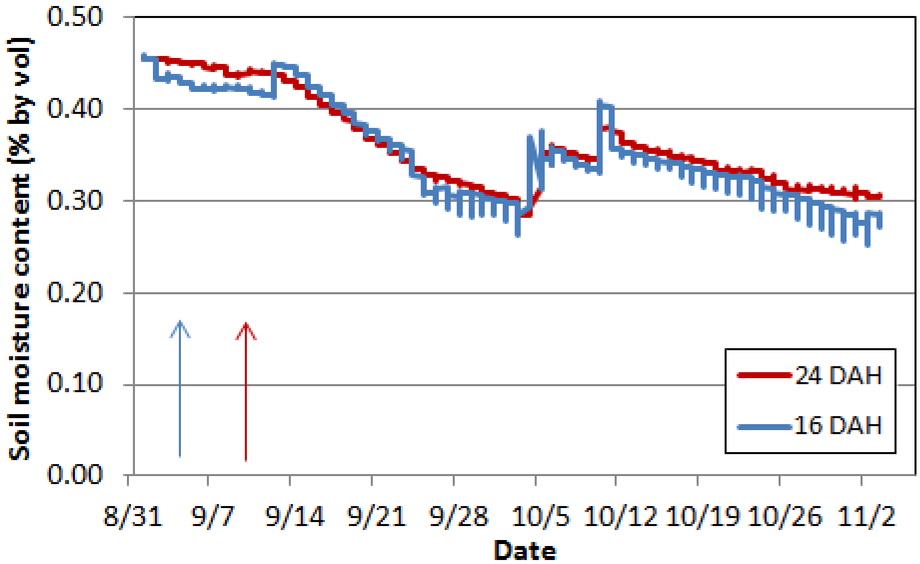

Figure 1. Soil moisture content over time in basins planted with S102 when drained at 16 and 24 days after 50% heading (DAH). The vertical arrows indicate drain date.

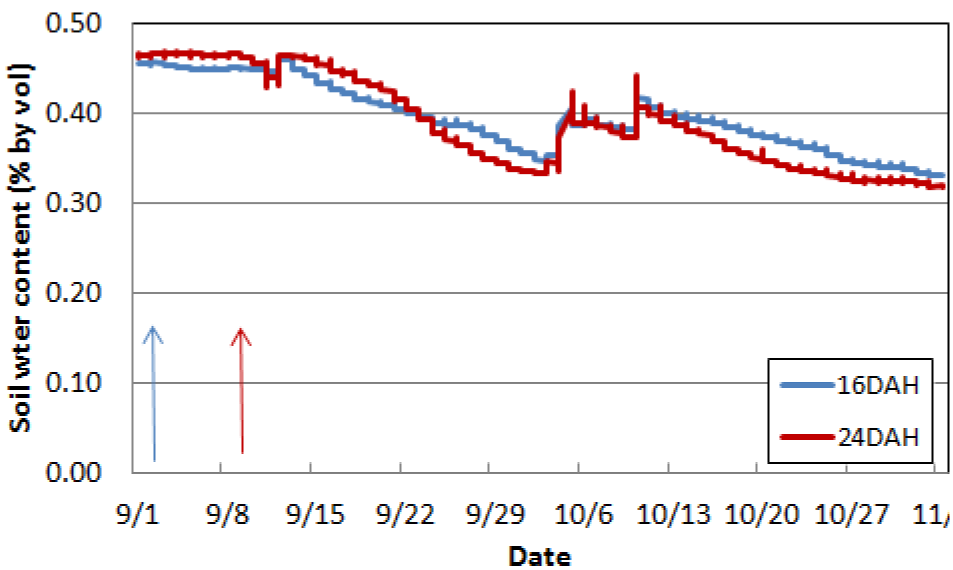

Figure 2. Soil moisture content over time in basins planted with M104 when drained at 16 and 24 days after 50% heading (DAH). The vertical arrows indicate drain date.

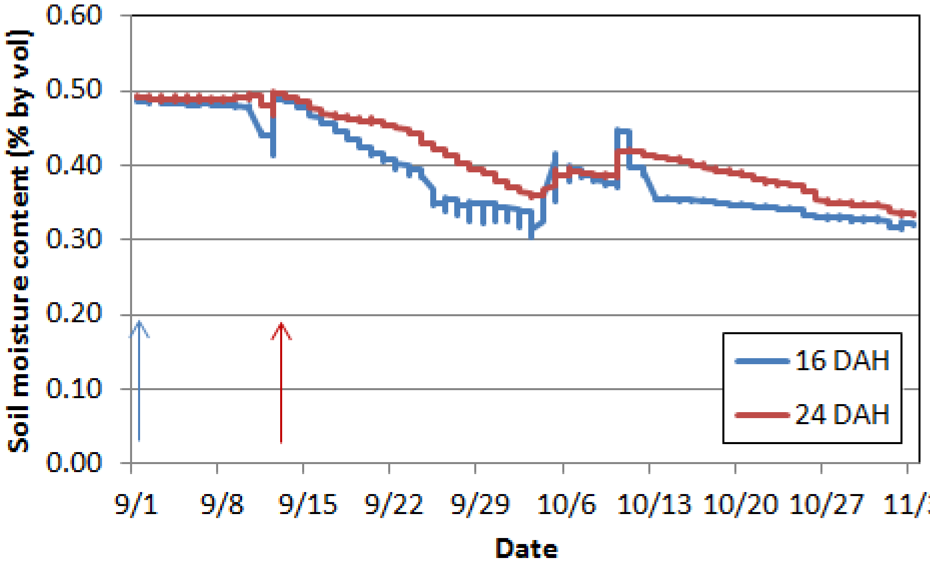

Figure 3. Soil moisture content over time in basins planted with S105 when drained at 16 and 24 days after 50% heading (DAH). The vertical arrows indicate drain date.

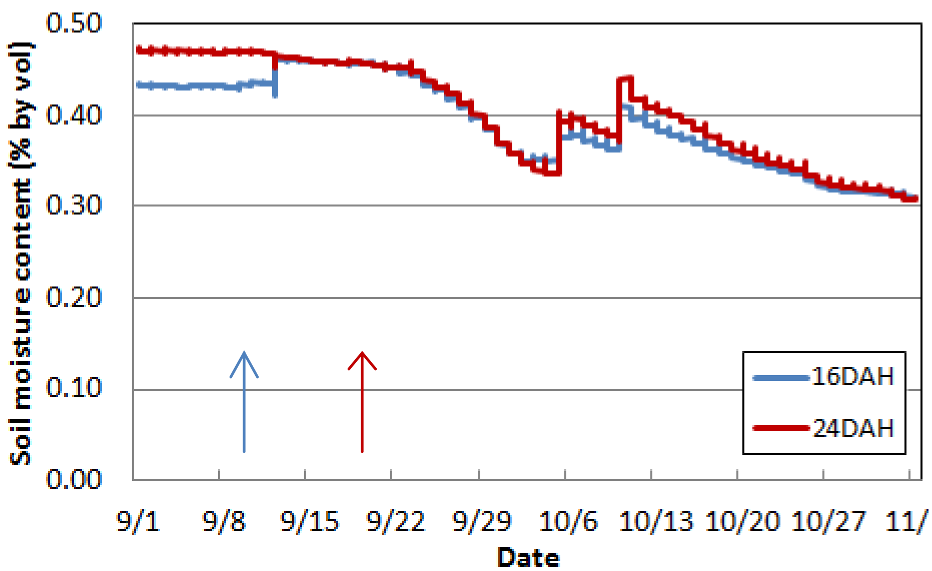

Figure 4. Soil moisture content over time in basins planted with M205 when drained at 16 and 24 days after 50% heading (DAH). The vertical arrows indicate drain date.

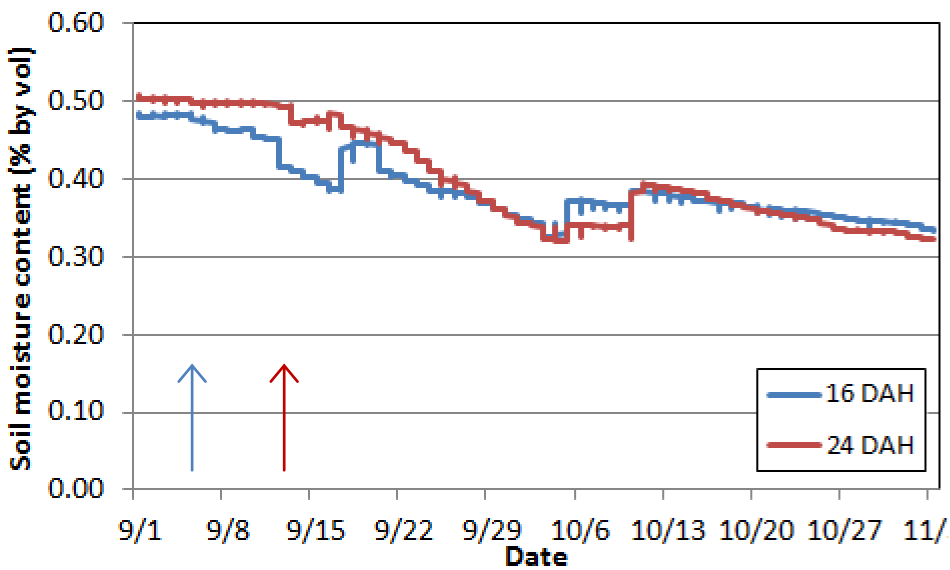

Figure 5. Soil moisture content over time in basins planted with M206 when drained at 16 and 24 days after 50% heading (DAH). The vertical arrows indicate drain date.

<u>Grain Ripening</u>

Within each variety, the rate of kernel drying (Figures 6 through 10) was similar for all drain date treatments. The fastest rate of drying was M105 at 16 DAH (0.45 pts per day) while the slowest rate was M205 (Figues 8 and 9, respectively). On average S102, M104, M105, M205, and M206 kernel moisture content dropped by 0.36, 0.36, 0.42, 0.33, and 0.38 percentage points per day once the moisture content dropped below 30%.

There was a trend in all varieties for the MC in the 24 DAH treatments to remain about 2 percentage points higher than the 16 DAH treatment in S102, M105 and M206 (Figures 6, 8, and 10). The rice reached a target moisture content of 20% about 10 days sooner in these varieties when drained 16 DAH as compared to 24 DAH. No differences in kernel dry down rate or time required to reach the target 20% moisture content was observed in M104 and M205 as related to drain time (Figures 7 & 9). The rain events starting on October 4 may have slightly slowed the rate of kernel drying in S102, M105, and M206, but did not change the overall trajectory of grain ripening. The grain of the other varieties showed no apparent change in the rate of moisture loss as a result of the wet weather.

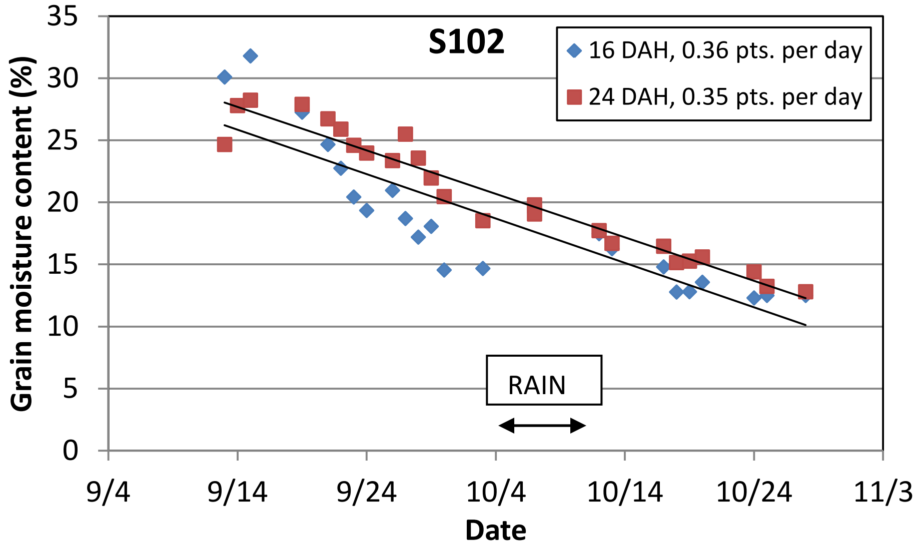

Figure 6. The rate of kernel drying in S102 when drained at 16 and 24 days after 50% heading. The rate of moisture loss is presented in legend.

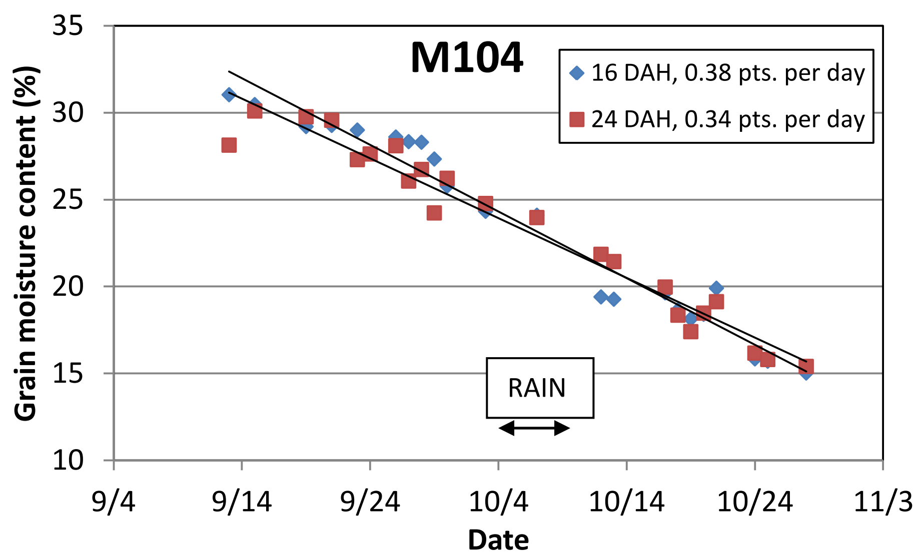

Figure 7. The rate of kernel drying in M104 when drained at 16 and 24 days after 50% heading. The rate of moisture loss is presented in legend.

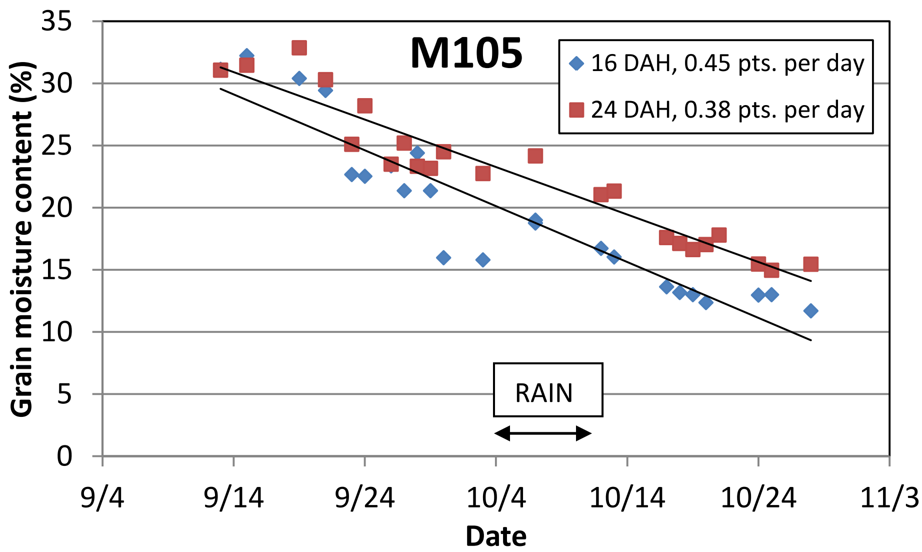

Figure 8. The rate of kernel drying in M105 when drained at 16 and 24 days after 50% heading. The rate of moisture loss is presented in legend.

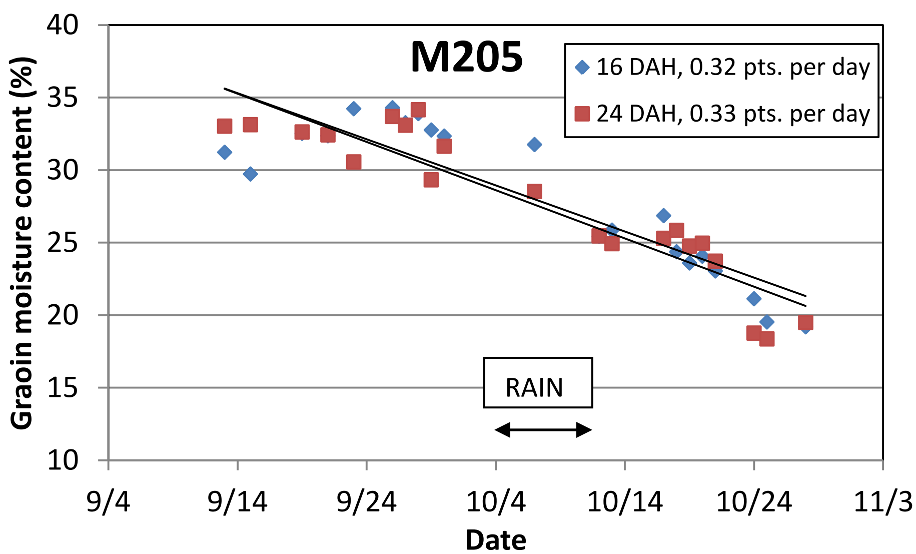

Figure 9. The rate of kernel drying in M205 when drained at 16 and 24 days after 50% heading. The rate of moisture loss is presented in legend.

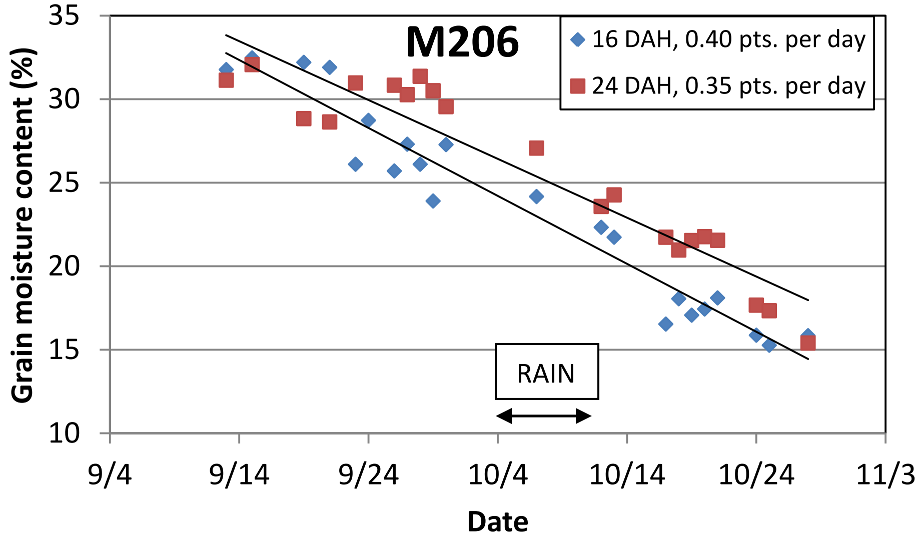

Figure 10. The rate of kernel drying in M206 when drained at 16 and 24 days after 50% heading. The rate of moisture loss is presented in legend.

<u>Yield</u>

Drain date did not significantly affect the yields of any of the test varieties (Figure 11). If comparing simple averages, yields at the 24 DAH trended higher than the 16 DAH treatment but the differences were not statistically separable. M205 yielded the highest (10082 lb/a) and S102 the lowest (8709 lb/a). In contrast in 2010, a measurable yield gain was observed when the drain date was postponed from 16 DAH to 24 DAH (Mutters, et al., 2011). One possible examination is that the evaporative and transpirative demands were greater in 2010 than in 2011; soil moisture was depleted more rapidly in 2010 amplifying the drain time effects as compared to 2011. Also work in 2010 suggested that M206 is the sensitive to low soil moisture content about 20 to 25 after heading. The 2011 data showed no differences in soil moisture content during that period of growth. It is possible that at 16 DAH the heavy basin soils marginally provide enough water to complete grain fill if the temperatures remain moderate and the relative humidity high. On the other hand, draining at 24 DAH did not adversely affect yields in 2011 or in previous years. However in terms of on-farm management, a planned drain date of 28 DAH is recommended to provide a degree of assurance should the harvest season remain hot and dry.

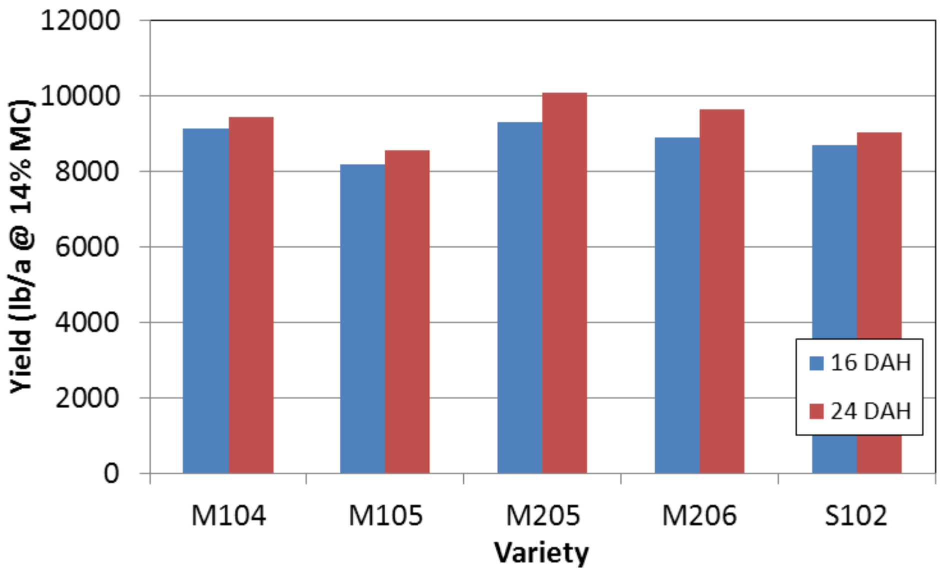

Figure 11. The of varieties M104, M105, M205, M206, and S102 when drained at 16 and 24 days after 50% heading (DAH).

<u>Grain Uniformity within the Field</u>

The 16 DAH treatments reduced the head rice yields (HRY) of S102, M105, and M205 across a wide range of harvest moisture contents (Figures 12, 14, and 15). The HRY of S102 and M205 at 16 DAH was about 5% less than it was at 24 DAH across harvest moisture contents (MC) of 15 to 27%. The HRY of M206 was negatively affected by the 16 DAH drain date treatment only at the outer range of the MC sampling spectrum (Figure 16). M206 HRY was lower at 16 DAH from MC 15 to 20% and from 24 to 30%. Only the HRY of M104 displayed no response to drain date (Figures 13).

The HRY of S102 declined rapidly at MC less than 20%, but remained consistently high up at MC of about 26% (Figure 12). M104 showed a decline in HRY when MC fell below 21% MC; the rate of decline was less than that observed for S102. The critical MC for M105 was 19%, below which the HRY loss was rapid, but HRY remained stable at MC as high as 26%. Based on these results, M105 exhibited better HRY stability than M104 at low harvest MC.

M205 ripened very slowly in 2011, thus there was robust data set of MC samples above 20% (Figure 15). As demonstrated in previous years, the HRY of M205 is stable down to 17 or 18% MC. HRY of M205, however, declines quickly at MC above 25%. Of course it is not recommended to harvest M205 at such high MC, but in wet, cool years the need may arise. Also if sodium chlorate is used under such circumstances, it may be prudent to apply it when the MC is around 25% rather than the 27% that is sometimes recommended on the label. The HRY of M206 was more stable at high and low MC at the 24 DAH as compared to 16 DAH (Figure 16).

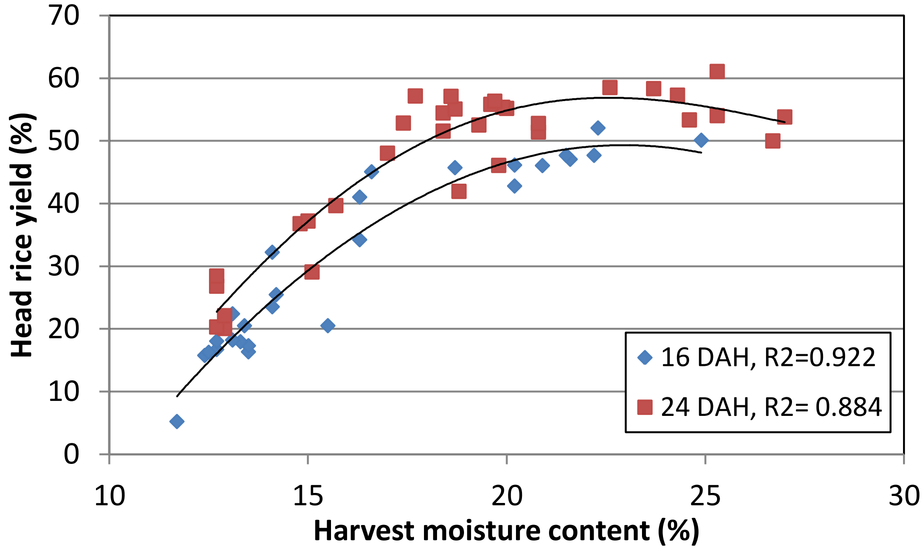

Figure 12. Head rice yield (HRY) as a function of harvest moisture content for S102 when drain at 16 and 24 days after 50% heading (DAH).

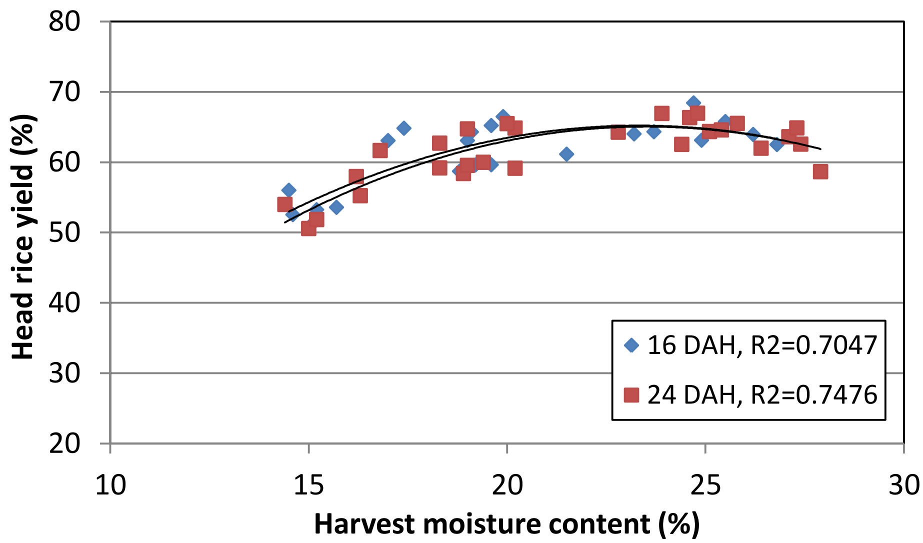

Figure 13. Head rice yield (HRY) as a function of harvest moisture content for M104 when drain at 16 and 24 days after 50% heading (DAH).

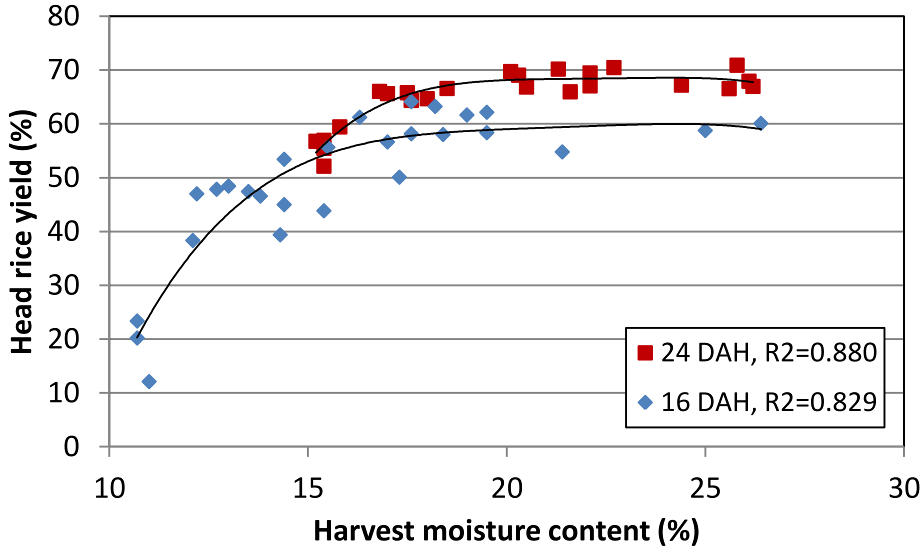

Figure 14. Head rice yield (HRY) as a function of harvest moisture content for M105 when drain at 16 and 24 days after 50% heading (DAH).

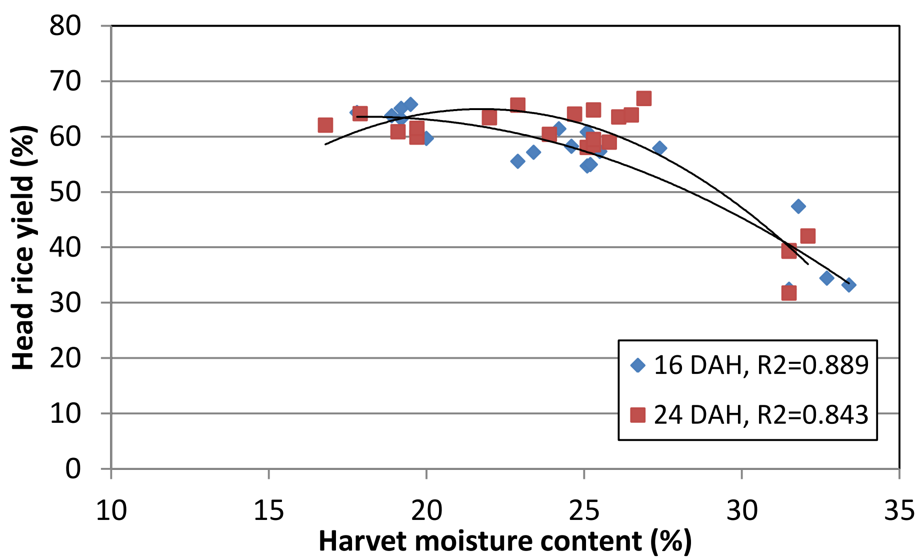

Figure 12. Head rice yield (HRY) as a function of harvest moisture content for M205 when drain at 16 and 24 days after 50% heading (DAH).

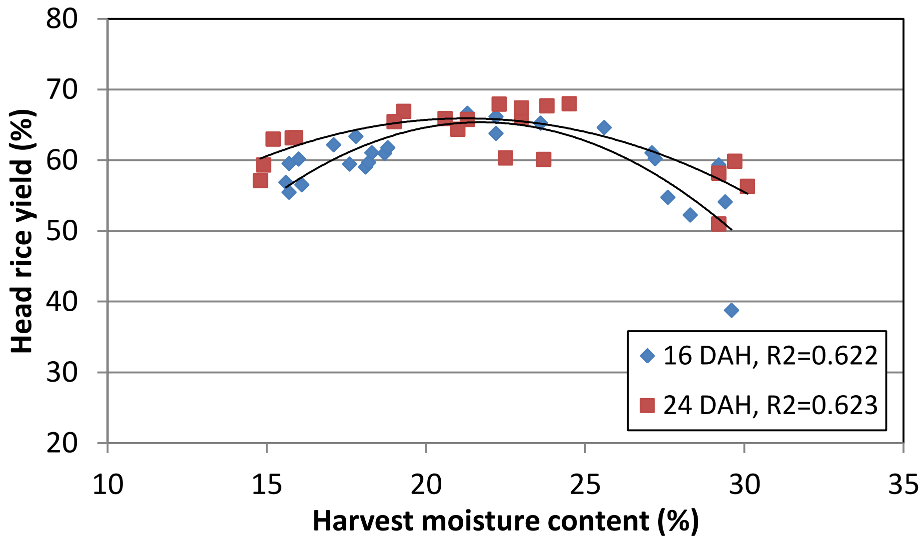

Figure 12. Head rice yield (HRY) as a function of harvest moisture content for M206 when drain at 16 and 24 days after 50% heading (DAH).

Grain moisture content was above 20% for all varieties at the onset of the rainy period, with the exception of S102, 16 DAH where the MC was around 17% (Figures 6 through 10). The HRY of the test varieties varied somewhat in their response to the rain events (Table 2). Over all there was little indication that any fissuring occurred as a result of rehydration during this time period. HRYs remained virtually unchanged with the exception of M205 and M206, which showed an increase. This is presumably due to the advancing grain maturity during this time. Thompson and Mutters, 2008 showed that the individual kernels with a MC of less than 16% in a sample are likely to fissure due to rehydration. Therefore the likelihood of HRY loss due to rehydration in samples with average moisture content above 25% as a result of the rain was not anticipated.

Table2. Head rice yields (HRY) before (Oct 3) and after (Oct 12) a rain event.

		Variety				
		S102	M104	M105	M205	M206
Date	Treatment			HRY		
3-Oct	16 DAH	28.9	64.3	55.8	36.9	61.3
	24 DAH	54.6	66.4	69.4	38.1	56.3
12-Oct	16 DAH	24.9	64.8	45.5	54.8	65.5
	24 DAH	50	64.3	68.3	58.8	67.3

The acceptable range of harvest moisture contents for the tested varieties is presented in Table 3. The new variety, M105, has a greater milling stability at lower harvest moisture contents than does M104. M105 can be successfully harvest at MC as low as 18 percent, while HRY for M104 declines below 20%. In general, the newer varieties (i.e. M105, M205, and M206) exhibit great milling stability at the lower MC than do the older varieties (S102 & M104).

Table 3. The range of acceptable harvest moisture contents (HMC) with no milling penalty

Variety	Range of acceptable HMC
S102	20 to 25
M104	20 to 26
M105	18 to 25
M205	18 to 25
M206	18 to 24

SUMMARY OF 2011 RESEARCH

Within each variety, the rate of kernel drying below 25% MC ranged from 0.32 to 0.45% per day with the 16 DAH treated plants drying slightly faster. The overall rate of moisture loss averaged across varieties was about 0.4 percentage points per day. This was comparable to 2010, but lower than in 2009 when temperatures were high and relative humidity low during the harvest season. The 16 DAH treatments reached harvestable moisture content 2 to 5 days sooner than the 24 DAH treatments in varieties S102, M105, and M206. The time required to reach harvestable moisture in M104 and M205 was not affected by drain date. There were no significant differences in yield due to drain date, although yield in the 16 DAH treatments trended a bit lower. All test varieties showed a comparable level of sensitivity to environmental conditions during agronomic maturity phase as evidenced by the HRY. Observed differences in HRY were not associated with soil moisture content. As a result of the rain there were no differences in soil moisture content between treatments during the latter part of the harvest season. Therefore any observed differences in plant performance due soil moisture would have occurred during the early stages of kernel maturation. The HRY may be adversely affected by the loss of flooded conditions; in that yield and grain quality are unfavorably compromised when the soil transitions from an anaerobic to an aerobic state. M105 displayed better milling stability across the range of harvest moisture contents than did M104.

REFERENCES

Mutters, RG, LA Espino, and JF Thompson. 2010. Crop Management Effects on Milling Quality and Yield. Annual Report to the California Rice Research Board, Yuba City, CA.

Thompson, JF, RG Mutters, and LA Espino. 2009. Crop Management Effects on Milling Quality and Yield. Annual Report to the California Rice Research Board, Yuba City, CA.

Fischer, A.J., G. L. Strong, K. Shackel, and R. G. Mutters. 2010. Temporary drought can selectively suppress Schoenoplectus mucronatus in rice. Aqua. Bot. 92:257-264.