ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
Jan. 1, 2008 to Dec. 31, 2008

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

PROJECT LEADERS:
James Thompson, Extension Specialist, Biological & Ag. Engineering, UCD
Randall Mutters, Farm Advisor, UCCE Butte Co.
Richard Plant, Professor, Agronomy & Range Science, UCD

PRINCIPAL INVESTIGATORS:
Chris Greer, Farm Advisor, UCCE Sutter-Yuba Co.
Luis Espino, Farm Advisor, UCCE Colusa Co.

COOPERATORS:
Kent McKenzie, Rice Experiment Station

LEVEL OF 2008 FUNDING:
$ 17,380

OBJECTIVES AND EXPERIMENTS:

1. Investigate the crop-environmental interactions affecting yield and quality at a range of soil and grain moisture levels during grain maturation.

2. Evaluate milling quality stability of prominent California public varieties and advanced medium grain breeding lines.

3. Establish practical in-field indicator for determining drain time and grain maturation to optimize yield, quality, and grower return.

MATERIALS AND METHODS:

Field Experiment.

An experiment field at Rice Research Station was divided into three basins each with its own water supply and drain (figure 1). Basins were separated by double drain ditches. Each basin subdivided into a series of equally sized sections and each dry seeded with pre-germinated seeds of M-202, M-205, or M-206 variety of rice. Each variety was at seeded at a rate of 150 pounds per acre on May 29. The field was flooded within 8 hours of seeding. Cultural practices and weed control were identical for all treatments, except for drain date. The east basin was drained

7 days after 50% heading (DAH) on September 5, approximately two weeks earlier than normal. The middle basin was drained 14 DAH on September 12 and the west basin was drained 21 DAH on September 19. Target drain dates were 7, 14, and 21 days after 50% heading. However, heading dates among the test varieties varied by a few days (table 1). As a result of this difference in time of heading and limitations of the irrigation system, the actual 7 DAH drain time was 9, 5, and 13 DAH for M-202, M-205, and M-206, respectively (table 2). The 14 and 21 DAH drain treatments resulted in similar time ranges in terms of actual number of days after heading. To quantify any between basin differences in plant microenvironment as influenced by drain time, each basin was equipped with a meteorological station that measure air temperature, relative humidity, leaf wetness, and soil moisture.

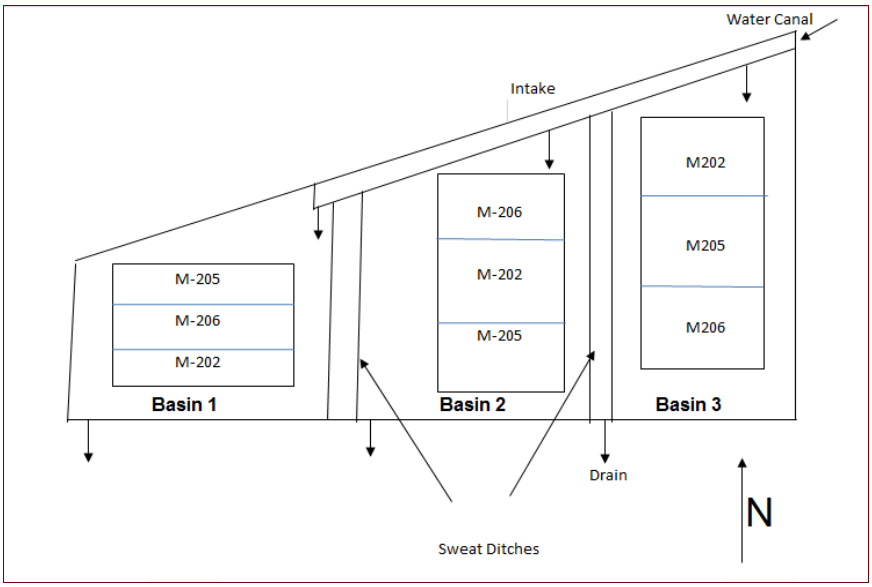

Figure 1. Map of the experimental field at the Rice Experiment Station in 2008.

Table 1. Heading dates for M-202, M-205, and M-206 in the three treatment basins for the 2008 rice quality experiment (RP-13).

Variety	Basin East	Middle	West	Average
M-202	26 Aug	27 Aug	29 Aug	27 Aug
M-205	30 Aug	30 Aug	31 Aug	30 Aug
M-206	22 Aug	21 Aug	21 Aug	21 Aug

Table 2. Actual number of days after 50% heading (DAH) by variety when treatment basins were drained on Sept 5, 12, and 19, 2008.

Variety	Basin East 5 Sept	Middle 12 Sept	West 19 Sept
M-202	9	15	20
M-205	5	12	19
M-206	13	21	28

Harvest and Sample Collection at the RES.

Approximately 1000 grams of paddy of each treatment were harvested October 13, 16, 20, and 23. An additional harvest from the early drained basin was taken on October 9. Each treatment was hand harvested between 11:00 and 13:00 hours and threshed with an Almaco plot thresher. Large plot yields were harvested with the SWECO plot combine on October 27. Rice moisture content for each harvested treatment (HMC) was determined with a single kernel moisture meter (Kett PQ510, Japan). Samples were room-air dried and a 500g subsample was husked (Yamamoto FC-2K, Japan) and milled (Yamamoto VP-32T, Japan) and whole kernel percentage was measured using a machine grader (Foss Tectator Graincheck, Sweden).

On-farm Samples.

M-202, M-205 and/or M-206 samples were collected at the statewide varieties trials near Maxwell and Natomas. Plots were harvested at several dates to obtain a range of HMCs. Samples were threshed, dried and evaluated with same procedure described for the RES experiment.

Laboratory Studies.

Controlled laboratory experiments were conducted to determine the effect of moisture exposure time on rice fissuring. The purpose was to better understand the critical number of hours of water (i.e. rain or dew) to which a rice kernel must be exposed to cause fissuring. The approach was to expose milled rice to soaking in water for periods ranging from 0 to 24 hours and determine the fissuring and loss of milling yield in M-202, M-205, and M-206. Three replicate subsamples from moisture equilibrated paddy rice were soaked for 0, 1, 2, 4, 8, 16, and 24 hours. 250 gram subsamples were taken from combined paddy rice from 2007 field tests of each variety of rice. Sample volume were mixed and split three times with Boerner divider before using divider to split samples. Only paddy rice from middle and west checks, harvest dates 10/1, 10/4, 10/15,

10/18 in 2007 was used. Moisture content of the 6 randomly selected samples was measured using a Dickey John meter. To ensure uniformity in the test sample, if the MC range was greater than 1%, the samples were remixed and split again. Rice was placed a jars and covered with distilled water. Following the specified soak time samples were removed from test, drained in colander and placed on sample dryer to dry back to original moisture content. Samples were stored for three days, shelled, and milled to determine the milling yield.

RESULTS:

Prior to draining the basins when they were fully saturated, the soil profile (2 to 6 inches) contained 43% water by volume (data not shown). Presumably by water loss through evapotranspiration, the soil volumetric water content declined to about 30% (0.30) and 20% (0.20) in the 21 DAH and 7 DAH drain treatments, respectively (figure 2). The rate of water loss (slope of the curve) was comparable across treatments. Since drain times of 14 and 21 DAH did not affect the yields of the test varieties in previous years, it appears that a soil moisture content of 0.20 when the rice first reaches a favorable moisture content (~21%) is adequate for good yields. This first approximation of critical soil moisture content and loss rate will be useful for determining acceptable drain times in lighter textured soils.

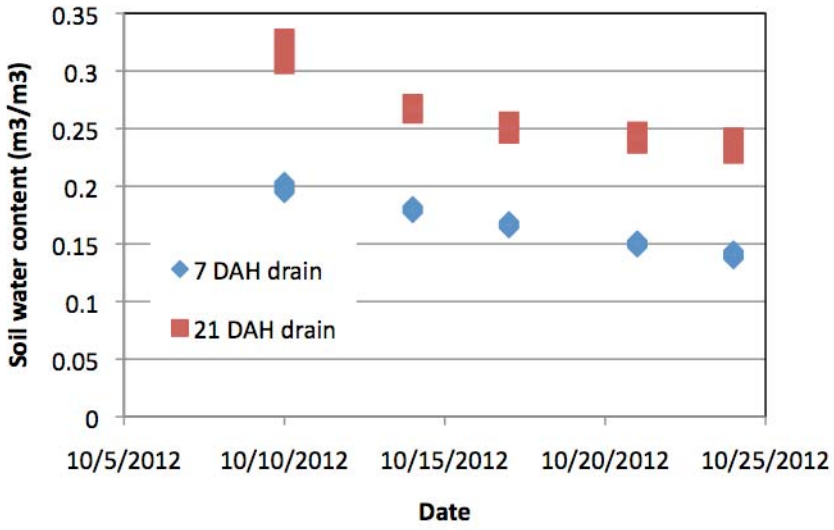

Figure 2. Soil moisture content by volume (m3/m3) in basins drained 7 and 21 DAH.

Critical to understanding the cause and timing of kernel fissuring is the occurrence and duration of dew on the panicle. It would valuable to growers if readily available predictions of relative humidity (RH), for example, could be used to predict dew formation. We have in past years successfully used the number of hours with 90% or greater RH to estimate duration of dew. Results from 2007 indicated that M-206 fissured if exposed to 8 or more hours of dew. In 2008, we used leaf wetness sensors to refine the measurement of period of dew. Free standing water (100% leaf wetness) occurred when the RH was about 75% in both the 7 and 21 DAH basins (figure 3). The RH required to lead to saturated conditions was unchanged by drain date. In

contrast the number of leaf wetness events was greater in the 21 DAH treatment. There were 7 periods of 100% leaf wetness in the 21 DAH treatment as compared to only 3 in the 7 DAH basin. Indications are that drain time (i.e. soil water content) may influence the number of dew events. However in 2008, there were an inadequate number of high humidity days to significantly reduce the head rice yield even in the sensitive M-202 variety (figures 4, 5, and 6).

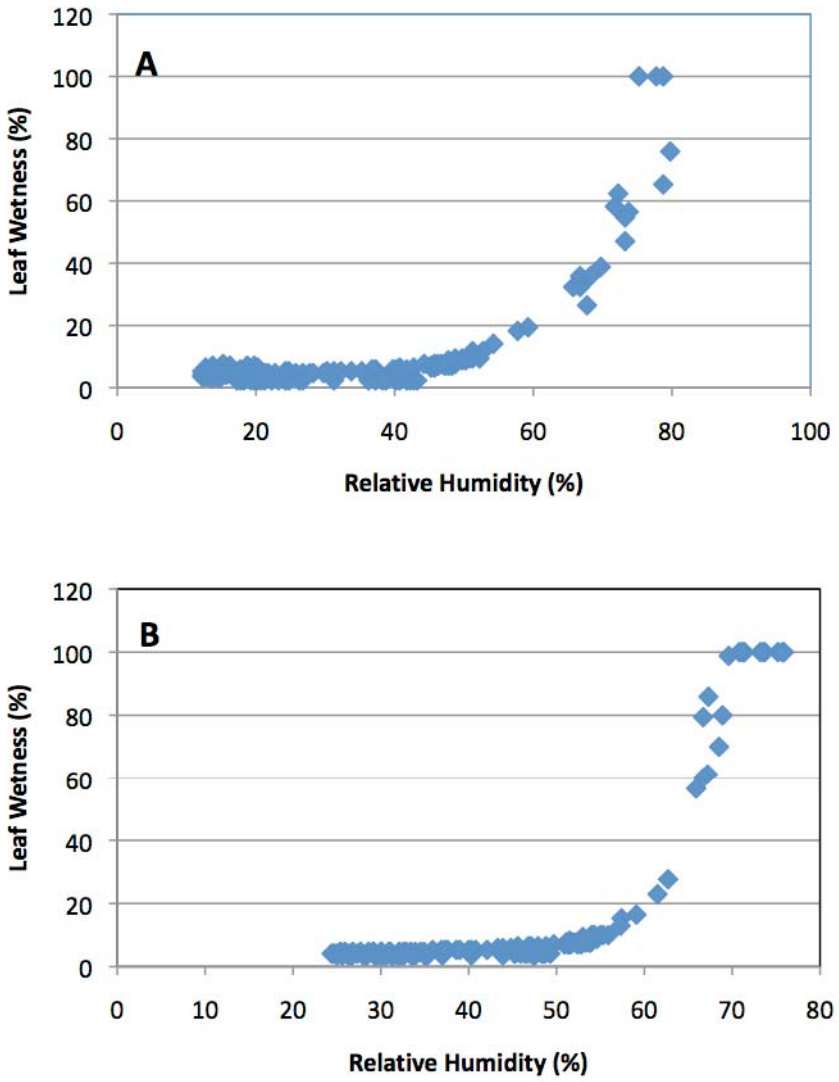

Figure 3. The relationship between relative humidity and leaf wetness in basins drained 7 DAH (A) and 21 DAH (B).

Results from the 2008 Rice Experiment Station experiment partially confirmed the results from previous seasons. In that, the head rice yields (HRY) of M-205 and M-206 remained stable across a range of harvest moisture contents (MC). However in contrast to previous years, the HRY at different MC was not influenced by an early drain time (figure 4). At all drain times the HRY of M-205 and M-206 remained above 60% in all but the driest samples (<15%). In 2007, drain time did not affect yield but HRY declined at MC < 20% when the basins were drained earlier than 21 DAH. To maintain high HRY at earlier drain times, the rice had to be harvested at 20% MC or higher (example M-205, figure 7). Good HRY required harvesting at 20% or above when the fields were drained 7 or 14 DAH.

In contrast to previous years, the HRY of M-202 was stable across a range of MC and was unaffected by drain time (figures 4, 5, & 6). This is explained by the fact that the RH remained low throughout our harvest. Aside from a rain event in early October, there were no nights with more than 6 hours of dew (figure 8). Eight hours or more are needed to fissure dry kernels (<15%). Consequently, all test varieties of rice could be harvested at very low MC with little or no loss of HRY. The dry kernel did not experience any substantive periods of rehydration during the season. The few samples with low HRY were associated with areas in the field that were desiccated by the wind; kernels low on the panicle in those areas failed to mature properly.

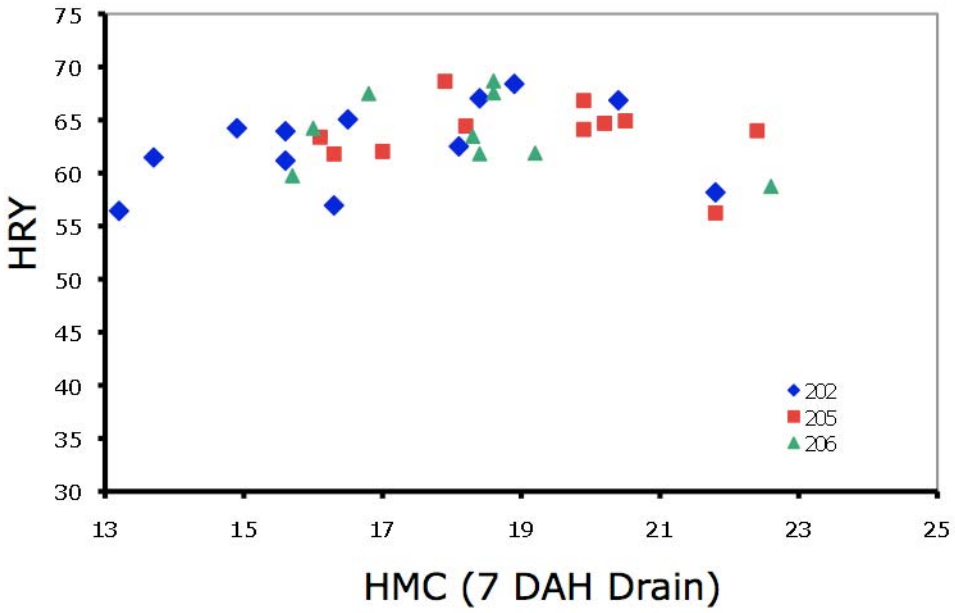

Figure 4. Effect of drain the field 7 days after 50% heading (DAH) and rice moisture content at harvest (HMC) on head rice yield (HRY) of M-202, M-205, and M-206 rice. Experiment conducted at the Rice Experiment Station in Biggs, CA in 2008.

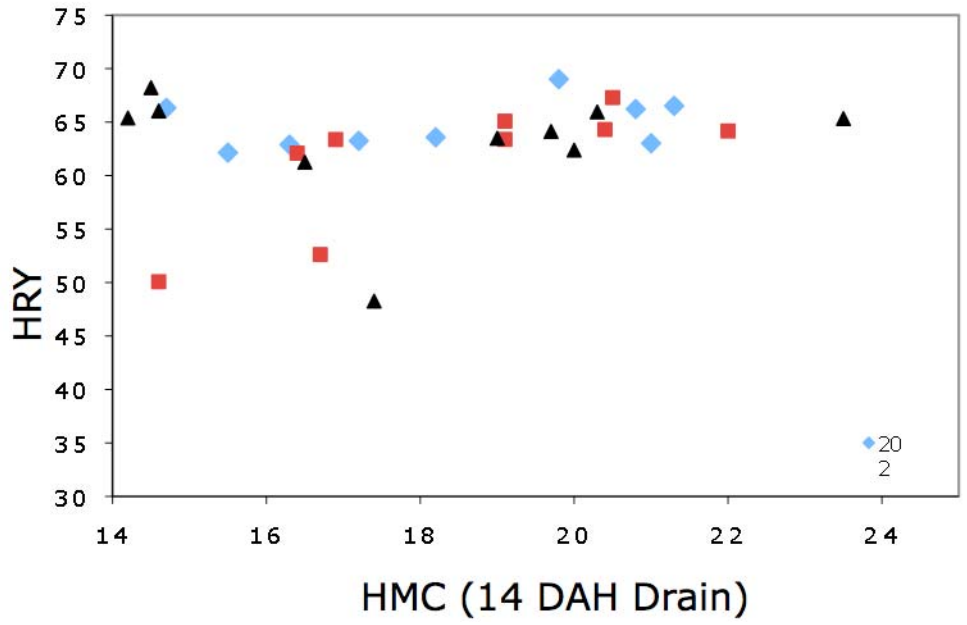

Figure 5. Effect of drain the field 14 days after 50% heading (DAH) and rice moisture content at harvest (HMC) on head rice yield (HRY) of M-202, M-205, and M-206 rice. Experiment conducted at the Rice Experiment Station in Biggs, CA in 2008.

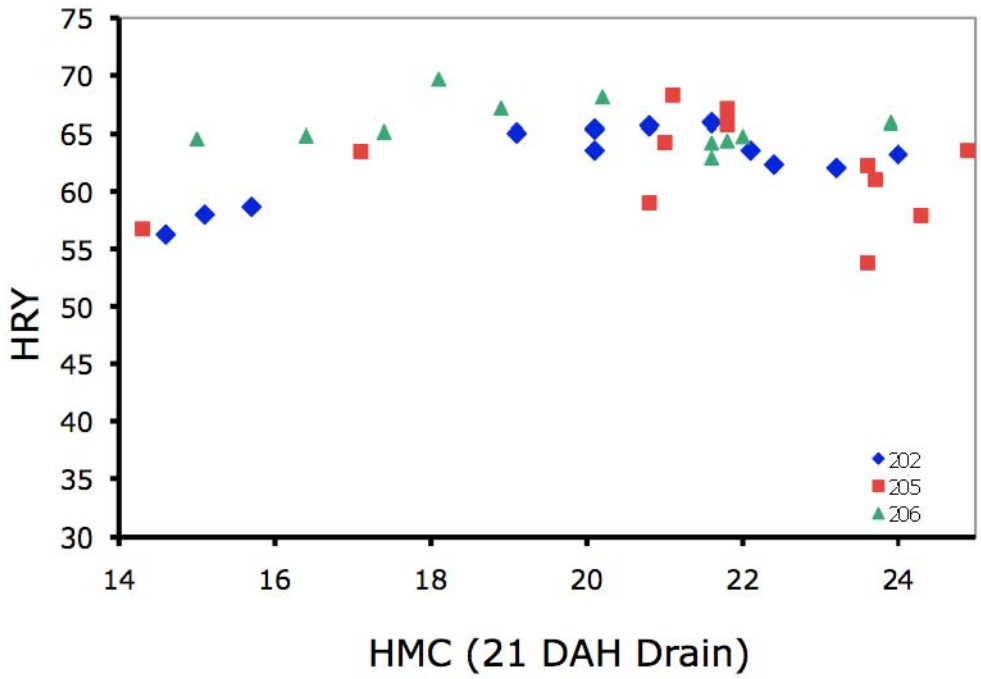

Figure 6. Effect of drain the field 21 days after 50% heading (DAH) and rice moisture content at harvest (HMC) on head rice yield (HRY) of M-202, M-205, and M-206 rice. Experiment conducted at the Rice Experiment Station in Biggs, CA in 2008.

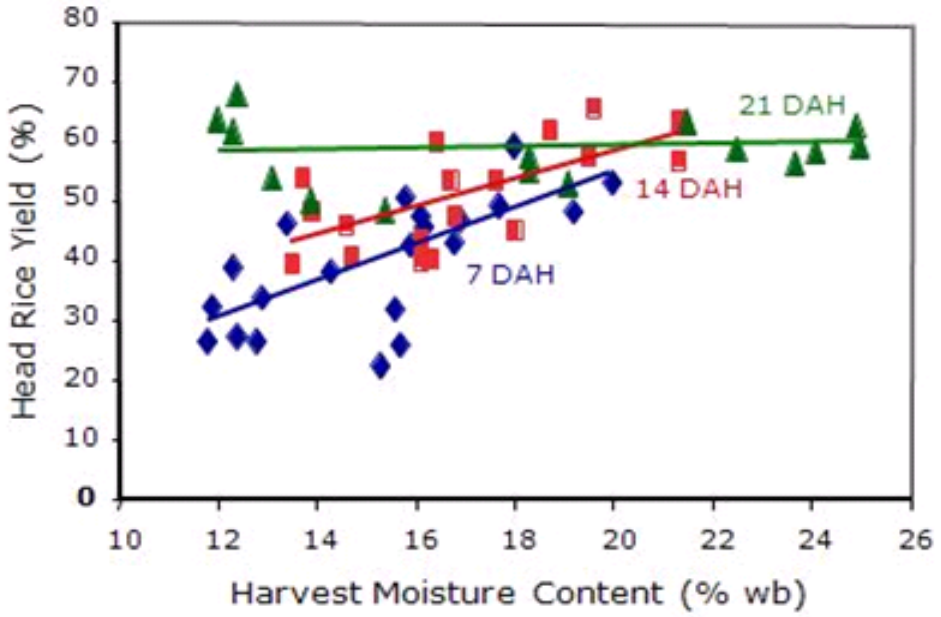

Figure 7. Relationship harvest moisture content and head rice yield at different drain dates (7, 14, and 21 days after heading, DAH) for M-205 in 2007.

	2003	2004	2005	2006	2007	2008
Oct						
1	17	14	0	5	1	0
2	16	14	3	6	2	9
3	14	14	6	7	4	18
4	13	12	2	0	6	10
5	16	10	0	0	4	12
6	16	14	0	13	2	11
7	15	8	0	11	4	4
8	16	10	0	0	0	0
9	14	0	3	0	10	0
10	1	0	0	0	13	0
11	12	0	0	2	16	0
12	15	0	0	1	16	0
13	3	5	0	4	12	0
14	15	8	2	8	12	0
15	16	0	8	10	17	2
16	16	0	0	5	16	3
17		0	0	0	5	2
18		0	0	1	5	0
19		0	8	0	13	6
20		0	8	0	0	4
21		0		0	0	0
22				0	7	0
23				0	7	1

Figure 8. Number of hours with RH > 90% during October 2003 to 2008.

Samples taken adjacent to the statewide variety trials near Colusa and Natomas, showed that both M-205 and M-206 produced higher HRY as compared to M-202 when harvested at low MC (Table 3). When MC was 22% or higher there were no significant differences in the HRY between varieties. At MC <18% the HRY superiority of M-205 and M-206 as observed in control studies at the RES were confirmed. Noteworthy, these samples were taken from a non-controlled study in grower's fields where large differences in HRY would be needed to overshadow the high variability inherent in random field sampling.

Table 3. The difference is HRY between M-202 and M-205 or M-206 at contrasting MC at two locations in the Sacramento Valley in 2008.

	Colusa		Natomas		
	27-Sep	3-Oct	5-Oct	15-Oct	22-Oct
Avg HMC	22.9	17.8	25.0	22.1	16.5
HRY diff 205-202	0.2	**6.4**	-3.4	-3.6	**2.1**
HRY diff 206-202	0.2	**7.9**	-2.6	1.5	**5.6**

Bold indicates statistically significant difference, alpha=0.05

In laboratory studies conducted in the spring of 2008, the HRY stability of M-202, M-205, and M-206 were determined under water saturated conditions. A replicated laboratory test where paddy rice was continuously soaked in distilled water verified that M206 is less susceptible to fissuring than M-205 which is less susceptible than M-202 (figure 9). Variety M-205 has better stability in head rice quality than the older variety M-202 but not quite as good as M-206. All varieties demonstrated a decline in HRY after a 2 hour soak. Maximum loss in HRY occurred after about 8 hours of soaking. During that period, M-202 lost about 40 points of HRY and M-206 lost about 15. Soaking in water is likely a more severe test of moisture adsorption than exposure to high relative humidity and dew in the field. It is likely that this test represents the maximum head rice loss for a given exposure time, damage in the field would be less.

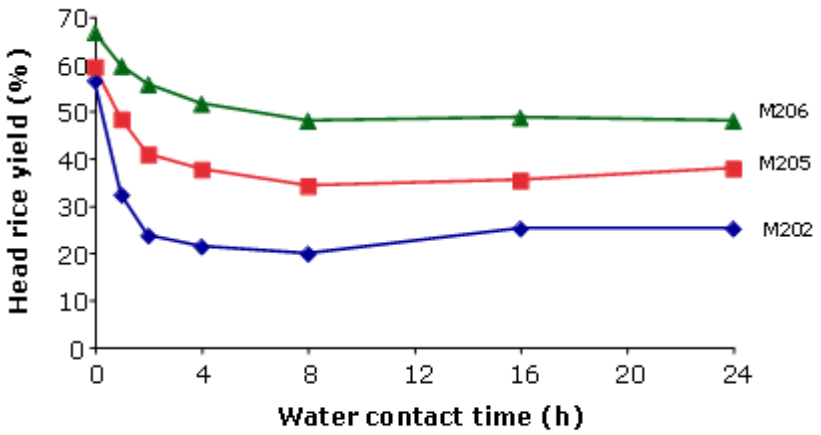

Figure 9. Head rice yield (%) on three varieties of rice as effected by soaking in water for different periods of time.

SUMMARY OF 2008 RESEARCH:

Previously work demonstrated that varieties M-206 and to a lesser extent M-205 maintain high head rice yield at low harvest moisture content levels compared with the M-202 variety. However during 2008 because of the near continuously dry weather during our harvest all three varieties produced good HRY even when harvested at MC as low as 16%. Laboratory studies and samples taken from grower's field confirmed that M-206 and to a lesser extent M-205 are less susceptible to fissuring due to rehydration over a wide range of MC. Drain time did not affect HRY in 2008. A soil moisture content of 20% by volume when the rice first reaches a MC of 21% may prove to be a good bench mark by which adjustments in drain time can be determined in lighter texture soils in conjunction with controlled studies.

If validated for additional seasons and over a wider range of soil and weather conditions, these two findings could potentially revolutionize the management of rice harvest and drying. Particularly so should this unique characteristic be fully integrated into the selection criteria for future medium grain varieties. The ability to harvest M-206 near 15% moisture content and still maintain high HRY, will allow growers to harvest at low moisture contents in order to reduce drying costs and increase their return per acre. Each percentage point decrease in moisture content reduces drying cost by about 2 cents per hundredweight (a conservative estimate given the volatility energy prices). Harvesting at lower moisture content will decrease the seasonal demand for column drying capacity and eliminate the need to restrict daily harvest amounts because of limited drying capacity. In our experiments drain date was based on days after 50% heading. This appears to be a useful index to predict drain date rather than relying on color and shape of panicles near the time of draining.

The data for the 2007 and 2008 harvests suggest the new varieties may be drained earlier than is typically done. More information is need to verify this especially on light textured soils, but if feasible early draining may allow growers to reduce amount of water needed for their crop.

PUBLICATIONS OR REPORTS:

Thompson, JF, RG Mutters, and RE Plant. 2007. Optimum harvest moisture for California medium grain rice. Bocchi S, Ferrero A, Porro A, eds. Proceedings of the 4th Temperature Rice Conference, 25-28 June 2007. Novarra, Italy.

Thompson, JF, RG Mutters, and RE Plant. 2008. Headrice Yield and Yield Stability of California Medium Grain Rice Varieties. Groth, D and R Mutters eds. Proceeding of the 32nd Rice Technical Working Group. 18-21 February 2008. San Diego, CA.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Tests at the Rice Experiment Station and at yield trials near Colusa and Natomas demonstrated for the third year that M-206 rice maintains high head rice quality over a wide range of harvest moisture contents, even to moisture contents near 15%. This year's results confirmed it has high head rice quality and high yield when drained about one week earlier than normal. Variety M-205 has better stability in head rice quality than M-202 but not quite as good as M-206. The stability of head rice quality for M-206 will allow the industry to harvest at lower moisture content and reduce the need for column drying. In our experiments drain date was based on days after 50% heading. This appears to be a useful index to predict drain date rather than relying on color and shape of panicles near the time of draining.