2010 RICE BREEDING PROGRESS REPORT
AND
2011 RESEARCH PROPOSAL

P. O. Box 306, Biggs, CA 95917-0306

January 1, 2011

RICE EXPERIMENT STATION STAFF

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Virgilio Andaya, Ph.D. .... Plant Breeder
Jeffrey J. Oster, M.S. .... Plant Pathologist

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OVERVIEW

Kent S. McKenzie

The California Cooperative Rice Research Foundation (CCRRF) is a private nonprofit research foundation [501(c)(5)] and members are California rice growers. The Rice Experiment Station (RES) is owned and operated by CCRRF. RES was established at its present site between Biggs and Richvale, California in 1912 through the cooperative efforts of the Sacramento Valley Grain Association, United States Department of Agriculture (USDA), and University of California (UC). The 478-acre RES facility supports breeding and genetics research, agronomic research and foundation seed production.

Dr. Kent S. McKenzie is the station director and the scientific professional staff of CCRRF includes plant breeders Drs. Farman Jodari, Virgilio Andaya, plant pathologist Mr. Jeffrey J. Oster and research scientist Cynthia Andaya. Eleven career positions consisting of five plant breeding assistants, one DNA lab technician, a field supervisor, one mechanic and field operator, two maintenance and field operators, and two administrative assistants make up the support staff. Approximately 30 seasonal laborers are employed during crucial planting and harvest times.

Organization and Policy

Policy and administration of RES is the responsibility of an 11-member Board of Directors elected by the CCRRF membership. Directors serve a three-year term and represent geographical rice growing areas of California. They are rice growers and serve without compensation. CCRRF works to serve all California rice growers, and its policies generally reflect those of public institutions such as UC. CCRRF cooperates with UC and USDA under a formal memorandum of understanding. The UC and California Rice Research Board have liaisons to the Board of Directors. CCRRF scientists cooperate with many national and international public institutions and also with private industry. Organization and policy of CCRRF encourages active grower input and participation in RES research direction.

Research Mission and Funding

The primary mission of CCRRF is the development of improved rice varieties and agronomic management systems for the benefit of the California rice growers. The plant breeding program at RES is designed to develop rice varieties of all grain types and market classes with high and stable grain yields and quality that will sustain the profitability of rice with minimum adverse environmental impact. Important breeding objectives include the incorporation of disease resistance, high milling yield, seedling vigor, cold tolerance, early maturity, semidwarf plant type and lodging resistance into future rice varieties. Improved milling yield, grain appearance, and cooking characteristics relative to consumer preference are major components of the plant breeding program. A secondary and important objective is to address industry research needs including support of UC and USDA research by providing land, resources, and management for genetic, agronomic, weed, insect, disease, and other disciplinary research.

Rice variety development at RES is primarily funded by the CRRB that manages funds received from all California rice producers through California Rice Research Program assessments. The CRRB acts under the authority of the California Department of Food and Agriculture (CDFA). The CRRB finances approximately 80% of the RES annual budget and 20% is derived from the sale of foundation rice seed to seed growers, grants, and revenues from investments. RES does receive some grants from agribusiness and the Rice Research Trust (RRT). The RRT is a tax-exempt trust [501(c)3] established in 1962 to receive tax deductible contributions for support of rice research. RRT funded a $900,000 greenhouse and DNA lab construction project that was completed in 2009.

Cooperative Research

Cooperative research is an integral part of rice research at RES involving USDA and UC scientists. Dr. Thomas H. Tai, USDA-ARS Research Geneticist, located at UC Davis (UCD), is working with all project leaders to develop improved breeding and genetics methods for rice variety improvement. Rice quality and genetic research has included studies with USDA scientists Drs. Anna McClung, Bob Fjellstrom, Brian Scheffler, Georgia Eizenga, Zhongli Pan, and Ming Chen. Dr. Charles F. Shoemaker and his students are pursuing research on rice quality in the Department of Food Science and Technology, UCD and material and support are provided to that effort. Statewide performance testing of advanced experimental lines and varieties was conducted by Mr. Raymond L. Wennig, UCD staff research associate, under the direction of University of California Cooperative Extension Farm Advisors Dr. Randall G. Mutters (Butte), Dr. Chris Greer (Placer, Sacramento, Sutter, Yuba), Dr. Luis Espino (Glenn, Colusa, Yolo), and Agronomist Dr. James E. Hill, (Department of Plant Sciences, UCD). The information developed from this cooperative research is valuable to the RES Rice Breeding Program and the California rice industry. RES values and works to support a well coordinated team effort with these cooperators.

The CCRRF staff, facilities, and equipment also supported agronomic, weed, disease, and insect research of UCD scientists in 2010. Dr. Albert J. Fischer, (associate professor, Department of Plant Sciences, UCD) and Mr. James Eckert, (UCD staff research associate at RES), conducted UC rice weed research on 18 acres. Drs. Albert Fischer, Randall Mutters, Dr. Bruce Linquist, James Thompson, Richard Plant, Chris Greer, Luis Espino, Willie Horwath, and James Hill are all doing rice research on 18 acres at RES. They are being supported by UCD staff research associate at RES, Mr. Ray Stogsdill. Dr. Larry D. Godfrey, (extension entomologist) and Mr. Evan Goldman, (staff research associate, Department of Entomology,) conducted rice insect research. Please refer to the 2010 Comprehensive Rice Research Report for information on UC, USDA and RES-UC-USDA cooperative research.

RES does provide technical input and support to the California Rice Commission.

CCRRF staff began conducting cooperative research with biotechnology companies in 1996 on transgenic rice for

California. This has been a very limited area of research for CCRRF. All research is conducted under permits and in compliance with USDA-APHIS regulations and under approved protocols required by the California Rice Certification Act. It has included participants from the private and public sectors. No transgenic materials have been grown at RES since 2001. Future research in this area by RES will depend on California's needs, market acceptance, regulatory requirements, and the development of research agreements.

CCRRF has followed an aggressive testing program of foundation seed for the presence of the Liberty Link Trait that was discovered at trace levels in Southern US long-grain rice. All test results have been non-detect. This trait has never been detected in any California grown rice. Further testing required by the California Rice Commission of CCRRF foundation and basic seed samples for 2007-10 sales as well as all California commercial rice were all non-detect.

All research at RES is reviewed annually by the CCRRF Board of Directors, representatives of the University of California, and the CRRB. CCRRF continues to address recommendations from the 2007 Rice Breeding Program Review. This has included a major greenhouse building and renovation, DNA marker facilities and staffing, resource allocation, and investigating the potential for japonica hybrid rice for California.

Seed Production and Maintenance

The production and maintenance of foundation seed of California public rice varieties and new releases is an important RES activity. The foundation seed program is a cooperative program between CCRRF and Foundation Seed and Certification Services at UCD. Its purpose is to assure availability of pure, weed free and high quality seed of public rice varieties for the benefit of the California rice industry. The California public rice breeding program of CCRRF has developed 42 improved rice varieties since the accelerated research program began in 1969. Foundation seed of 13 public rice varieties and basic seed of two Japanese premium quality varieties were produced on 140 acres at RES in 2010. Since 1988, CCRRF has protected new varieties under the Plant Variety Protection Act, Title 5 option that requires seed to be sold only as a class of certified seed. Utility patents have also been obtained. This is being done to ensure that California growers are the beneficiary of their research investments as well as assuring that clean, red rice free seed is produced. Although the foundation seed program is self-sustaining and not supported with CRRB funds, foundation seed and certified seed production provides very significant benefits to the whole California rice industry.◆

Trade names are used to simplify information. No endorsements of named products are intended or criticism implied of similar products not mentioned in this report.

RICE BREEDING PROGRAM

INTRODUCTION

The RES Rice Breeding Program consists of four research projects. Three rice breeding projects focus on developing adapted varieties for specific grain and market types and are each under the direction of an RES plant breeder. The rice pathology project, under the direction of the RES plant pathologist, supports the breeding projects through screening and evaluating varieties for disease resistance, rice disease research, and quarantine introduction of rice germplasm for variety improvement. Project leaders also have areas of responsibility in the operation and management of the overall program. All projects are involved in cooperative studies with other scientists from the UCD, USDA, and industry, including off-station field tests, nurseries, quality research, and biotechnology.

The Calrose medium grain project (see Calrose Medium Grains) is led by Dr. Kent McKenzie. Dr. Virgilio Andaya is the project leader for premium quality, waxy, and California short grains (see Short Grains). He is also handling the early generation stages for the Medium Grain project. Dr. Farman Jodari is the long grain project leader (see Long Grains). Management for the DNA marker lab has been assigned to Dr. Cynthia Andaya. The rice pathology project is led by RES pathologist Mr. Jeff Oster (see Rice Pathology). All breeding program members cooperatively participate in the preparation, planting, maintenance, and harvest of the research nurseries. Staff continues to work to improve rice quality evaluation and selection for all market types. Screening, evaluation, and research in the area of DNA marker technology is progressing at RES.

Weed control in the breeding nursery can be a serious problem due to open water areas, herbicide resistant weeds, and heavy foot traffic. Aerial herbicide options are available at RES as the result of efforts of the California Rice Commission and the cooperation of Butte County Agricultural Commissioner and CDFA. These are very valuable tools for both nursery and foundation seed management.

The focus of the RES rice breeding program is on developing improved rice varieties to meet the needs of California growers now and into the future. This report summarizes the general activities of the 2010 RES Rice Breeding Program, including the various breeding nurseries, selected results from large plot yield tests, disease nurseries, greenhouse, and field experiments at RES and in growers' fields.

BREEDING NURSERIES

Seeding of the 2010 breeding nursery began May 15th, and was completed May 22st. In 2010, 1305 crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 39,713. Crosses made in the early spring were grown during the summer in an F_1 nursery to produce seed for the F_2 generation. Crosses made this past summer were planted in the Hawaii

Winter Nursery and/or the greenhouse so the segregating F_2 generations could be grown for selection purposes in 2011, thereby accelerating the breeding process.

The 2010 RES breeding nursery occupied approximately 74 acres. Water-seeded yield tests included 4230 small plots and 3500 large plots. Small seed increase plots, cooking samples and advanced breeding lines were grown on 3 acres. The nursery included about 51, 000 water-seeded and 28,000 drill-seeded progeny rows. F_2 and F_4 populations from 2008 and 2009 crosses were grown in precision drill-seeded plots on 8 acres. An estimated 150,000 panicles were selected from the various F_2 populations in nurseries for further screening and advancement. Selected material is being advanced in the Hawaii Winter Nursery and greenhouse facilities. The remainder will be screened and processed for planting in 2011.

Headrows (2400) of M-206, M-208, 05-Y-471, Calmochi-101, Calmati-202, and Koshihikari were grown for breeder seed production in 2010. This headrow seed can be used for several years to produce breeder seed because it is stored under low temperature and proper humidity conditions.

The Hawaii Winter Nursery allows the advancement of breeding material and screening for cold tolerance during the winter to hasten variety development. The Hawaii Winter Nursery is a very valuable breeding tool and has been a successful and integral part of the RES Rice Breeding Program since 1970.

Selection and harvest of the 2009-10 winter nursery was completed and seed returned to RES and planted in May. Cold temperature blanking was very high in the nursery (90% on M-205). Soil fertility was not uniform due to uneven incorporation of soil amendments.

The 2010-11 winter nursery of 8800 rows was planted November 2, 2010, and 691 F_1 populations were transplanted to the nursery November 24, 2010. Selection and harvest will occur in April, and seed returned for processing and planting in the 2011 RES breeding nursery.

The San Joaquin Cold Tolerance Nursery was planted in cooperation with two local rice growers. The 7 acre drill-seeded nursery included 6800 rows, and 6 acres of F_2 populations. Stand establishment was good, however bird damage and herbicide damage problems did occur with the loss of some material. Very little blanking was observed in the rows, but heavy blanking occurred in the F_2 populations. An additional yield test was grown in cooperation with UCCE on Twitchell Island near Rio Vista. High levels of blanking, extreme delays in maturity were observed in entries at that location. No RES material was planted at the UC Davis Rice Facility in 2010.

The San Joaquin cold tolerance nursery and Hawaii nursery remain an essential part of selecting for resistance to blanking and are used in conjunction with two refrigerated greenhouses at RES.◆

RES Rice Breeding Program Terminology

1. **Germplasm**. Breeding material used in crossing including varieties, introductions, lines, mutants, and wild species.

2. **Crossing (hybridization)**. The process of selecting parent plants and artificially cross-pollinating them. Backcrossing is crossing again to one of the parents of the original cross.

3. **F_1 generation**. The 1st generation after crossing. F_1 plants (hybrids) are grown from the seed produced by crossing. They are allowed to naturally self-pollinate to produce seed of the F_2 generation or may be used as parents (backcrossing).

4. **F_2 generation**. The 2nd generation after crossing. This is the stage that produces the maximum segregation for the different characteristics of the parents. Spaced plants from each cross are grown in large plantings and individual panicles selected, evaluated for seed quality factors, and planted to produce the F_3 generation.

5. **Progeny rows**. Selected rice lines grown in single rows for selection, generation advance, and purification. This may include lines in the 3rd through the 7th generation after crossing.

6. **Small plots**. Promising lines selected from progeny rows are grown in 4 by 6 ft or 2 by 4 ft plots for further screening, evaluation, and seed increase.

7. **Preliminary Yield Tests**. The best small plot entries are grown in replicated 12 by 15 ft plots at two seeding dates and evaluated for agronomic and quality traits.

8. **Statewide Yield Tests**. Outstanding preliminary yield test entries are grown in yield tests at several on-farm locations by UCCE and also at RES. Information on adaptability, agronomic performance, and quality traits is collected in these tests.

9. **Headrows**. Individual panicles of superior lines are planted in individual rows for purification and seed increase as potential new varieties.

10. **Breeder seed**. Headrow seed of varieties and experimental lines is grown in isolation and carefully inspected to maintain its purity to produce breeder seed. Breeder seed is the pure seed source planted each year to produce foundation seed.

STATEWIDE YIELD TESTS

Agronomic performance and adaptation of advanced selections from the breeding program were determined in multi-location yield tests. These tests are conducted annually in grower fields by UCCE and at RES. The 2010 Statewide Yield Tests were conducted at seven locations in commercial fields by Mr. Raymond L. Wennig, Dr. Randall G. Mutters, Dr. James E. Hill, Dr. Chris Greer, and Dr. Luis Espino. Advanced selections were tested in one of the three maturity groups: very early, early, or intermediate to late with standard check varieties included for comparison. Each maturity group was subdivided into an advanced and preliminary experiment. The advanced entries and checks had four replications and the preliminary entries had two replications. Plots were combine-size (10 by 20ft) and the experimental designs were randomized complete blocks.

All of these advanced large plot entries were also tested at RES in a randomized complete block design. The large plot seeding dates at RES were May 18th to 20th, 2010. The plot size was 12 by 15 ft with the center 10 ft combine harvested (150 ft^2). Water-seeding and conventional management practices were used in these experiments. Bolero UltraMax®, and Stam80df® were applied for weed control and one application of Lambda-Cy® was applied for rice water weevil control.

Tables 1 through 6 contain a summary of performance information from the 2010 Statewide Yield Tests. Yields are reported as paddy rice in pounds per acre at 14% moisture. Bird damage was severe to M-104, and yield estimates could not be made. At the San Joaquin location a drill-seeded system was used and herbicide injury was severe on short and medium grains. Experimental yields may be higher than commercial field yields because of the influence of alleys, border effects, levees, roadways, and other environmental factors. Disease scores for stem rot (SR) are averages from the inoculated RES disease nursery. The entries that performed well will be advanced for further testing in 2011. Complete results of the UCCE Statewide Yield Tests can found in the Agronomy Progress Reports, (http://www.plantsciences.ucdavis.edu/ uccerice/main/publications.html).◆

Table 1. Agronomic performance means of very early advanced entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES (4 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
17	05Y343	SWX	4.8	90	95	28	4.9	12140	8860
3	M206	M	4.8	88	101	9	4.6	11290	8740
8	06Y575	LR	4.8	91	101	0	5.6	11030	9690
5	07Y843	M	4.8	86	98	4	5.9	10610	8420
4	05Y471	M	4.7	81	100	6	5.6	10600	8650
2	M202	M	4.9	90	95	1	5.5	10470	8160
7	06Y513	L	4.8	92	86	0	5.8	10400	8290
16	07Y186	MPQ	4.9	89	99	0	5.1	10380	8120
18	07Y293	SPQ	4.8	90	92	0	4.9	10300	7460
11	09Y1053	L	4.7	89	91	0	4.1	10230	7270
6	L206	L	4.7	87	81	0	5.0	10200	8660
9	07Y508	L	4.6	88	100	0	4.7	10040	8530
12	CM-101	S	4.9	82	98	60	5.5	9470	8560
13	S-102	S	4.8	81	92	35	5.8	9380	8550
10	09Y1094	L	4.8	92	89	0	5.6	9190	8180
15	04Y177	SPQ	4.8	85	86	70	5.0	8810	8210
14	CH-201	SPQ	5.0	88	88	18	5.9	8340	6800
1	M104	M	4.8	79	93	5	5.2	-	-
Mean			4.8	88	94	14	5.3	10170	8300
LSD(0.05)			0.1	1.9	4.0	14	0.6	1060	450
CV (%)			1	2	3	74	8	7	8

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, and SWX=short grain waxy.
‡ SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading.
¶SR=stem rot score where 0=no damage and 10=plant killed.
Paddy rice yield in lb/acre at 14% moisture.

Table 2. Agronomic performance means of very early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES (2 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
27	08Y3076	M	4.9	87	95	25	5.6	11070	9370
30	08Y3224	M	4.8	82	93	30	4.9	10900	8580
45	08Y2049	SSR	4.9	83	92	3	5.5	10800	9230
28	08Y3080	M	4.8	86	97	17	5.6	10700	8350
32	M206	M	4.8	86	97	10	5.6	10620	8420
46	08Y2014	MPQ	4.7	88	97	33	5.5	10580	7800
37	08Y1092	L	4.7	90	90	0	5.6	10570	7930
49	08Y2083	MPQ	4.8	88	92	8	5.6	10380	7900
23	08Y3040	M	4.8	87	97	18	5.0	10280	8100
47	09Y2036	S	4.8	87	97	70	5.5	10270	9020
38	09Y1062	J	4.7	85	93	0	5.7	10260	7460
41	L205	LR	4.7	92	90	0	6.2	10140	7740
31	08Y3225	M	4.8	84	94	33	5.4	10110	8460
36	09Y1043	L	4.7	88	91	0	5.1	10090	8200
39	09Y1067	J	4.9	88	99	0	4.8	10000	7870
29	08Y3185	M	4.7	87	100	0	4.6	9990	7500
50	08Y2085	MPQ	4.9	90	102	18	5.6	9980	7860
33	09Y1099	L	4.8	93	88	0	5.9	9950	8390
34	09Y1013	LSR	4.5	93	94	0	4.6	9790	7320
44	08Y2025	S	4.9	82	96	13	5.5	9700	7570
20	08Y3020	M	4.9	80	96	8	5.3	9660	8390
35	09Y1038	L	4.8	92	88	0	5.7	9630	7260
25	08Y3052	M	4.8	80	98	25	5.8	9500	8140
24	08Y3041	M	4.8	88	100	13	5.3	9480	7620
43	08Y2048	SSR	4.8	84	86	0	5.5	9450	7620
19	08Y3016	M	4.9	80	97	20	5.2	9370	8690
48	09Y2062	SWX	4.8	87	95	20	5.5	9370	7860
21	08Y3036	M	4.7	83	97	8	5.2	9300	8480
22	08Y3039	M	4.8	84	94	13	5.6	9280	7930
40	09Y1074	LIM	4.7	90	86	0	5.1	9140	7510
42	KOSH	SPQ	5.0	100	112	**	5.4	5530	5180
Mean			148.6	87	95	13	5.3	9870	7990
LSD(0.05)			0.1	1.8	6	10	.06	970	660
CV (%)			1	2	4	45	9	5	4

† L=long grain, LR=Rexmont type , LIM=long grain imidazilinone resistant, LSR=long grain stem rot resistant, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain and SSR=short grain stem rot. SWX=short grain waxy, LJ=jasmine,

‡ SV=seedling vigor score where 1=poor and 5=excellent.

§ Days to 50% heading.

¶ SR=stem rot score where 0=no damage and 10=plant killed. # Paddy rice yield in lb/acre at 14% moisture.

Table 3. Agronomic performance means of early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (4 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
77	05Y343	SWX	4.6	91	96	23	5.6	11870	10630
65	05Y471	M	4.6	82	98	31	5.4	11530	10260
69	08Y1092	L	4.7	87	88	-	4.9	11480	10160
64	M208	M	4.8	90	95	-	5.5	11370	9700
67	L206	L	4.6	85	86	-	6.1	11090	9750
68	06Y575	LR	4.9	90	98	-	5.8	11010	10360
63	M206	M	4.7	84	94	-	5.1	10980	10080
78	08Y2098	MPQ	4.9	90	100	20	5.2	10970	9800
62	M205	M	4.8	92	91	-	4.9	10790	9830
71	09Y1094	L	4.9	90	88	-	5.4	10770	9380
70	06Y513	L	5.0	91	89	-	6.2	10770	9390
72	09Y1013	LSR	4.5	93	93	-	5.9	10720	9750
66	07Y732	M	4.6	88	87	13	4.9	10610	9470
61	M202	M	4.9	91	96	-	5.7	10210	9880
74	S-102	S	5.0	79	96	65	6.0	9400	9230
75	CH-201	SPQ	5.0	90	89	74	6.2	9390	8790
79	08Y2082	MPQ	4.9	93	98	23	6.0	9370	9110
76	04Y177	SPQ	4.8	84	88	93	4.9	8950	8450
73	CM-101	SWX	4.9	81	93	65	5.2	8000	8260
Mean			5	88	93	45	5.3	10490	9590
LSD(0.05)			0.1	1.2	4.5	19	0.6	872	360
CV (%)			1	1	3	21	9	6	5

† L=long grain, LR=Rexmont type, LSR=long grain stem rot resistant, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, and SWX=short grain waxy.
‡ SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading.
¶ SR=stem rot score where 0=no damage and 10=plant killed.
# Paddy rice yield in lb/acre at 14% moisture.

Table 4. Agronomic performance means of early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (2 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
81	08Y3126	M	4.8	85	98	25	5.3	11780	10260
107	09Y2171	MPQ	4.8	91	98	43	4.9	11490	9970
112	07Y671	SSR	4.6	88	88	15	4.3	11190	10480
84	08Y3168	M	4.8	87	93	35	5.2	11130	10250
80	07Y414	M	4.8	84	97	10	5.2	11100	10150
88	08Y3197	M	4.8	86	97	23	5.3	11060	10220
83	08Y3147	M	4.7	83	93	-	4.9	11050	9380
92	08Y3269	M	4.8	90	94	-	4.9	10930	10440
87	08Y3182	M	4.8	91	90	-	4.7	10910	10120
89	08Y3232	M	4.9	91	91	-	4.0	10890	9700
90	08Y3239	M	4.7	86	90	-	4.9	10870	9750
85	08Y3175	M	4.7	92	92	-	4.5	10760	9890
113	09Y2141	SWX	4.8	83	102	-	5.6	10740	10460
93	M206	M	4.9	83	99	-	5.3	10680	10890
96	09Y1122	L	4.6	91	86	-	5.0	10640	9820
86	08Y3181	M	4.8	83	96	33	4.9	10600	9630
108	09Y2163	MPQ	4.8	92	90	-	4.7	10590	10520
106	08Y2101	MPQ	4.9	91	89	-	4.8	10530	9630
97	09Y1053	L	4.7	86	90	-	4.5	10360	9720
109	09Y2136	SPQ	4.8	87	89	40	5.2	10290	9620
98	09Y1077	L	5.0	86	85	-	5.2	10230	9340
110	09Y2184	SPQ	4.6	93	88	-	6.2	10190	9630
104	08Y1167	L	4.8	91	85	-	4.5	10070	9340
82	08Y3140	M	4.7	85	92	-	4.7	9770	9850
99	09Y1183	LIM	4.6	93	85	-	5.2	9770	9100
91	08Y3240	M	4.8	83	89	-	5.4	9410	9490
103	07Y489	LA	4.6	83	81	-	5.9	8950	8270
102	08Y1115	LA	4.7	90	86	-	4.7	8910	7720
95	CT202	LB	4.8	93	84	-	6.0	8730	6420
111	07Y301	SPQ	4.9	95	85	-	4.7	8600	8330
94	A201	LA	5.0	97	89	-	5.7	8530	7970
101	08Y1109	LJ	4.6	92	92	-	5.7	8520	8000
105	KOSH	SPQ	4.9	99	115	96	5.5	5570	4980
Mean			5	89	91	36	5.0	10110	9260
LSD(0.05)			0.1	2.3	4	-	0.6	1190	370
CV (%)			1	1	2	-	9	6	5

†L=long grain, , LA=long grain aromatic, LB=basmati, LJ=jasmine, LIM=long grain imidazilinone resistant, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, SSR=short grain stem , and SWX=short grain waxy.
‡ SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading.
¶ SR=stem rot score where 0=no damage and 10=plant killed. # Paddy rice yield in lb/acre at 14% moisture.

Table 5. Agronomic performance means of intermediate to late advanced entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (4 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
124	L206	L	4.7	92	83	0	5.4	11610	9780
132	09Y2179	S	4.8	90	93	0	5.3	11380	10210
122	M205	M	4.8	97	91	0	5.3	11030	9810
123	07Y722	M	4.8	101	87	0	4.8	10930	9290
126	06Y575	LR	4.9	97	99	0	5.4	10920	10620
121	M202	M	4.9	95	93	0	5.6	10440	9630
128	CH-201	SPQ	5.0	90	83	28	5.9	10280	9250
125	06Y513	L	5.0	97	92	0	5.9	9970	9340
130	04Y177	SPQ	4.9	86	84	63	5.2	9550	8510
127	M-402	MPQ	5.0	110	91	0	4.8	8240	8960
131	09Y2185	SPQ	4.6	105	80	0	4.9	8060	8630
129	KOSH	SPQ	4.9	103	109	90	5.8	6870	5760
Mean			4.9	97	90	15	5	9940	9150
LSD(0.05)			0.2	1.3	6.8	14	0.7	1763	670
CV (%)			2	1	5	66	9	12	9.1

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, S=short grain, SSR=short grain stem rot and SPQ=premium quality short grain.
‡ SV and =seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading.
¶ SR=stem rot score where 0=no damage and 10=plant killed.
# Paddy rice yield in lb/acre at 14% moisture.

Table 6. Agronomic performance means of intermediate to late preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (2 reps) locations in 2010.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge %	SR¶	---Grain Yield#--- RES	State
145	09Y1094	L	5.0	94	93	0	5.5	11310	10060
139	08Y3328	M	4.8	97	91	0	4.6	11190	9690
136	08Y3310	M	4.6	93	91	0	4.6	11120	10080
141	08Y3344	M	4.8	97	98	0	4.9	11050	9880
144	09Y1077	L	5.0	93	85	0	5.1	11020	10480
137	08Y3314	M	4.9	98	91	0	4.4	10810	10070
134	08Y3236	M	4.7	98	90	0	5.3	10800	10010
138	08Y3323	M	4.5	97	96	0	5.0	10630	9600
140	08Y3338	M	4.9	97	85	0	4.0	10470	9510
156	09Y2159	SLA	4.8	96	83	0	6.2	10450	10180
142	M205	M	4.7	97	82	0	4.9	10400	9580
155	08Y2163	SPQ	4.9	90	87	0	4.8	10210	9600
133	08Y3234	M	4.7	95	91	0	4.7	9870	9400
154	09Y2176	MPQ	4.7	99	100	0	5.2	9540	9450
146	09Y1183	LIM	4.3	101	83	0	5.7	9550	9230
150	10Y150	LJ	4.7	96	88	0	5.5	9040	7850
135	08Y3308	M	4.7	100	93	0	4.5	8780	9110
149	09Y1059	LJ	4.7	91	93	0	4.8	8470	7910
151	10Y151	LB	4.7	94	85	0	5.5	8440	7820
143	CT202	LB	4.9	96	84	0	5.7	7970	6630
147	08Y1114	LJ	4.6	102	85	0	7.1	7830	7810
148	07Y1174	LJ	4.4	104	86	0	6.3	7650	8030
153	09Y1081	LB	4.2	86	85	0	6.0	5450	5450
152	09Y139	LB	3.5	103	84	0	5.4	3440	-
Mean			4.7	96	89	0	5	9400	9020
LSD(0.05)			0.4	2.0	10	-	0.7	1640	650
CV (%)			5	1	7	-	9	10	6

† L=long grain, LB=basmati, LJ=jasmine, LIM=long grain imidazilinone resistant, M=medium grain, MPQ=premium quality medium grain, SLA=short grain low amylose, , and SPQ=short grain premium.
‡ SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading.
¶ SR=stem rot score where 0=no damage and 10=plant killed.
# Paddy rice yield in lb/acre at 14% moisture.

PRELIMINARY YIELD TESTS

Preliminary Yield Tests are the initial step of replicated large plot testing for experimental lines. The experimental design, plot size, and production practices are identical to the Statewide Yield Tests grown at RES. Two replications are planted at the early and late seeding date. The medium grain preliminary is only a single plot. A summary of the yields of 2010 Preliminary Yield Tests is presented in Table 7. These tests included 1126 entries and check varieties.

Results in Table 7 show that yields of the top experimental lines compare well with the check varieties. Agronomic and quality information will be combined with cold tolerance and disease screening information to identify superior entries for further testing and advancement to the 2011 Statewide Yield Tests. ◆

Table 7. Summary of Preliminary Yield Tests at RES in 2010.

Test	Type	Number of Entries	All	Highest	Top 5	Check	Standard Check
			----------Average Yield (lb/acre)†----------				
Very Early							
Short grains	Conventional	12	10130	11570	10590	9960	S-102
	Specialty rice	45	9360	10560	10460	9320	CH-201
Medium grains	Advanced	45	8730	10680	9890	8860	M-208
	Preliminary	404	9630	13230	12120	10892	M-206
Long grains	Conventional	60	10530	11440	11260	10870	L-206
	Specialty rice	21	9190	10840	10530	--	--
Early							
Short grains	Conventional	16	10280	11180	10930	9040	S-102
	Specialty rice	81	10100	11630	11340	9190	CH-201
Medium grains	Advanced	44	9980	10810	10700	10570	M-205
	Preliminary	201	9780	11900	11870	10230	M-208
Long grains	Conventional	65	10030	10890	10770	10270	L-206
	Specialty rice	16	8320	9660	9230	7800	CT-202
Intermediate-Late							
Short grains	Conventional	5	9940	11430	9940	8480	S-102
	Specialty rice	46	9700	11010	10820	7630	M-402
Medium grains	Advanced	19	9820	10980	10630	10360	M-205
Long grains	Conventional	20	9490	10300	10270	9840	L-206
	Specialty rice	26	7160	11020	9120	6560	CT-202

† Paddy rice yield at 14% moisture.

SHORT GRAINS & PREMIUM QUALITY

Virgilio C. Andaya

The short grain and premium quality rice breeding project (SGPQ) aims to develop improved rice varieties for the following rice types: 1) conventional short grains, 2) premium quality short grains, 3) premium quality medium grains, 4) waxy short grains, 5) low amylose short grains, and 6) big-seeded Arborio-type grains.

Breeding goals for the different grain types vary and great efforts are being exerted to meet the challenge of producing superior rice varieties that combine, among other traits, excellent grain quality, high yield potential, disease resistance, and adaptation to cold environments.

The breeding project is streamlining its breeding procedures and priorities based on the current market realities for each of the grain types. Breeding for improved premium quality medium and short grains are given greater emphasis over conventional short grains. The specialty types such as the waxy short grains, big-seeded rice and low amylose rice are receiving priority based on their respective degree of importance in the rice market. Since the market for the last two specialty types is still not yet fully developed, the project allocates a small portion of its resources for their varietal improvement.

The use of new tools in rice breeding like the DNA markers is becoming routine. The DNA marker lab at the RES develops, validates and employs molecular markers to screen rice lines for grain quality and blast resistance, and is now working towards finding markers to improve stem rot resistance. The impact of these advances in the short grain project is becoming more evident in breeding for premium quality, Japanese-type short grains, where DNA markers for cooking or eating quality are being used side by side with sensory evaluation.

Conventional Short Grains

S-102, a conventional short grain variety, is still in production because of its high yields, very early maturity, and blanking resistance. However, this variety is susceptible to stem rot and has a pubescent hull. The primary goal for the conventional short grain breeding is to develop a high yielding variety with stem rot resistance, smooth hulls, and better grain and cooking quality.

The overall yield of S-102 in the UCCE Statewide yield test for 2010 reached 8890 lbs/acre, down slightly from its 6-year average of 8940 lbs/acre. Highest yields in 2010 were recorded in Yuba and Colusa testing sites with yields over 10,000 lbs/acre. Yields fell below 8000 lbs/acre in Butte, San Joaquin and Yolo sites.

In 2010, a total of 6 lines that includes 2 stem rot resistant lines (SSR) were entered in the UCCE Statewide Test and 33 lines in Preliminary Yield Tests at the Rice Experiment Station. Table 8 summarized the agronomic performance of selected lines that performed better than S-102. Further yield and agronomic evaluations of these lines will be made in 2011.

Table 8. Performance of selected conventional short grain entries in the 2010 UCCE Statewide and RES Preliminary Yield Tests.

ID	Type†	Mat. ‡	Grain Yield §	SV¶	Days #	Ht. †† (cm)	Lodge (%)	SR ‡‡
Statewide Yield Test								
09Y2036	S	VE	9020	5.0	93	92	20	6.1
08Y2049	SSR	VE	9230	5.0	89	86	12	5.1
07Y671	SSR	E	10480	4.9	89	97	3	4.3
S-102	S	VE	8550	4.9	87	89	32	5.8
RES Preliminary Yield Test								
10Y2043	S	VE	11570	4.9	80	83	38	5.2
10Y2143	S	E	10660	4.9	81	84	0	5.0
10Y2041	S	VE	10150	5.0	80	88	53	5.9
10Y2142	S	E	10120	4.9	80	90	0	5.0
10Y2037	S	VE	10100	4.8	83	94	3	6.0
S-102	S	VE	9660	4.9	78	89	48	5.9

† S=conventional short grain, SSR= stem rot resistant short grain
‡ VE=very early, E=early
§ Paddy rice yield in lb/acre at 14% moisture.
¶ seedling vigor score where 1=poor and 5=excellent.
# Days to 50% heading.
††Ht. Plant height
‡‡ stem rot score where 0=no damage and 10=plant killed.

Premium Quality Medium and Short Grains

For both medium and short grains, the California rice market defines premium quality rice as the class of rice with the following cooking and eating characteristics: very glossy in appearance, slightly soft and sticky, smooth texture, tastes tender, slightly sweet, subtle aroma, and remain soft even after cooling. Since there is no unified and standard definition of premium quality (varies depending on consumers and/or cultural or ethnic groups), breeding for premium quality rices takes into account all these cooking characteristics.

The standard premium quality medium grain rice is M-401, a late maturing variety known for its excellent eating quality. In 1999, M-402 was released as an alternative to M-401. It is about a week earlier maturing, has more translucent grains, higher grain and milling yields, but has slightly smaller kernels which affected its market acceptability. The development of early maturing and high yielding alternative to M-401 and M-402 are the primary goals in breeding.

Calhikari-201 (CH201) is the first and only premium quality short grain variety developed and released in California. Released in 1999, CH201 is high yielding, approximately 50% higher than CA-grown Koshihikari, early maturing, has good seedling vigor, is lodging resistant, and has slightly bigger kernels compared to premium quality Japanese varieties. Though the cooking and eating characteristics of CH201 are considered premium quality, the premium quality short grain market is still dominated by the low yielding but high quality Koshihikari.

Grain yields of CH201 in the 2010 Statewide Yield Tests ranged from 3800 lbs/acre (Sutter East site) to 9520 lbs/acre (Sutter West site) with an average across location yield of 8190 lbs/acre. This is slightly higher than the 6-year grain yield statewide average of 8000 lbs per acre. Grain yield at the RES reached an average of 9400 lbs/acre which was the highest average yield recorded over the past six years.

A total of seven premium quality short grain lines were entered in the Statewide Yield Test and 35 lines in the Preliminary Yield Test at the station using CH201 as the standard check variety. The performance of selected premium quality short grain entries in the Statewide and Preliminary Yield Tests is summarized in Table 9. These lines will be evaluated further for their grain quality and cooking characteristics. In 2010, a total of 10 premium quality medium grains were tested in the Statewide and 84 lines in the Preliminary Yield Tests. The grain yield and agronomic performance of selected entries is presented in Table 9. M-402, the check variety in both the Statewide and Preliminary Yield Tests, averaged 8970 lbs/acre in combined Biggs, Glenn and Sutter West locations. This yield level is similar to the plot yield averages in the Preliminary Yield Trials at RES. Selected lines will undergo additional grain quality evaluation and cooking tests will be made on these selections.

Premium quality short grain 04Y177

04Y177, a premium quality short grain advanced line, has undergone seed purification in head rows since 2007 and has been approved for foundation seed increase in 2011. 04Y177 is a semi-dwarf, early maturing, pubescent, premium quality short grain line derived from the cross R20885, with the pedigree "Koshihikari*2/S-101//Koshihikari/S-101/3/Hitomebore". This cross was made in the spring of 1995. It has been in the UCCE Statewide Test since 2005 undergoing a total of 38 yield tests across all test sites. Since 2008, 04Y177 was evaluated together with CH201 in the same test locations for a total of 27 tests.

Compared to CH-201, the strengths of 04Y177 include better cooking and taste test scores given by a number of marketing organizations, slight milling yield advantage, 4 days earlier maturity, higher stem rot resistance rating, and more synchronous heading. Its weaknesses include: slightly smaller kernels, tendency to lodge, and lower seedling vigor score. Table 10 summarized the comparison of agronomic and grains characteristics of 04Y177 and CH-201. Looking at grain yields across location and years in the Statewide Yield Tests from the period 2005-2010, 04Y177 registered an average grain yield of 8600 lbs/acre against 8060 lbs/acre for CH201. Additional quality evaluation tests are scheduled for 2011.

Table 9. Performance of selected premium quality short and medium grain entries in the 2010 UCCE Statewide and RES Preliminary Yield Tests.

ID	Type†	Mat. ‡	Grain Yield §	SV¶	Days#	Ht. †† (cm)	Lodge (%)	SR‡‡
Statewide Yield Test								
09Y2136	SPQ	EP	9620	4.9	85	94	14	5.2
08Y2163	SPQ	ILP	9600	5.0	91	94	1	4.8
CH201	SPQ	EA	8790	5.0	89	94	38	6.2
KOSH	SPQ	ILA	5760	4.9	104	114	95	5.8
07Y186	MPQ	VEA	8120	5.0	95	92	2	5.1
08Y2101	MPQ	EP	9630	5.0	91	91	9	4.8
09Y2171	MPQ	EP	9970	5.0	90	99	54	4.9
M402	MPQ	ILA	8960	5.0	110	97	6	4.8
RES Preliminary Yield Test								
10Y2049	SPQ	VE	10090	4.9	81	84	30	5.3
10Y2153	SPQ	E	10050	4.9	87	89	15	5.6
CH201	SPQ	VE	9320	4.9	87	84	30	6.4
10Y2123	MPQ	E	10790	4.8	85	94	8	5.3
10Y2202	MPQ	IL	10590	4.9	95	88	0	-
10Y2019	MPQ	VE	10560	5.0	86	90	23	5.1
10Y2086	MPQ	E	10460	5.0	89	91	0	6.2
10Y2082	MPQ	E	10420	4.9	88	96	5	6.0
10Y2121	MPQ	E	10420	4.8	89	92	0	5.4
10Y2087	MPQ	E	10410	4.8	89	93	0	5.9
10Y2188	MPQ	IL	10380	4.9	92	94	13	5.6
10Y2175	MPQ	IL	10270	4.9	90	94	6	5.8
10Y2081	MPQ	E	10200	4.9	90	92	0	6.0
10Y2122	MPQ	E	10160	4.8	87	95	0	5.3
10Y2016	MPQ	VE	9890	5.0	90	87	0	5.3
M402	MPQ	IL	7630	4.9	106	91	0	4.3

†SPQ=premium quality short grain, MPQ= premium quality medium grain
‡ VE=very early, E=early
§Paddy rice yield in lb/acre at 14% moisture.
¶SV=seedling vigor score where 1=poor and 5=excellent.
#Days to 50% heading.
††Ht. Plant height
‡‡SR=stem rot score where 0=no damage and 10=plant killed.

Table 10. Comparison of agronomic and grain characteristics of 04Y177 and CH-201.

Trait	04Y177	CH-201
Overall Location Grain Yield†		
Butte	8,170 (3) ‡	7,400 (6)
Colusa	8,360 (3)	8,310 (6)
Glenn	6,030 (1)	7,600 (6)
Biggs	8,650 (10)	8,410 (15)
San Joaquin	8,230 (5)	7,780 (3)
Sutter	8,900 (7)	7,940 (9)
Yolo	9,240 (6)	9,760 (3)
Yuba	8,620 (3)	7,500 (5)
Overall Average Grain Yield	8,600 (38)	8,060 (53)
Seedling vigor§	4.8	5.0
Days to heading¶	86	88
Stem rot score #	5.6	7.1
Milling Yield (Head/Total) ††	71/71	69/72
Grain Dimension		
Length (mm)	4.65	4.84
Width (mm)	2.86	2.98
Length/Width ratio	1.63	1.62
Protein content (%)‡‡	6.7	7.0
Apparent Amylose Content	16.3	15.2
Alkali Spreading Value	7.0	6.7

† Paddy rice yield in lb/acre at 14% grain moisture content
‡ Number of statewide yield test conducted within the period 2005 to 2010
§ SV=seedling vigor score where 1=poor and 5=excellent
¶ Days to 50% heading
# SR=stem rot score where 0=no damage and 10=plant killed
†† H/T= Head/Total milled rice, USDA Federal Grain Inspection Service analysis
‡‡Data provided by Kituko-Shinryo, Japan.

Specialty Rices

There are three sub-groups in the category of specialty rices: a) waxy short grains, b) low amylose short grains, and c) Arborio-type, big-seeded rice.

Calmochi-101 (CM101) is a waxy short grain with high yield potential, excellent blanking tolerance, and large kernels but has rough hulls. Calamylow-201 (CA201) is the first and only low-amylose variety (~7% apparent amylose content) developed through the mutation of Calhikari-201.

A total of 30, 16 and 11 advanced lines of waxy, low amylose, and big-seeded rices, respectively, were entered in either the Statewide Yield Test or Preliminary Yield Tests in 2010. The agronomic characteristics of waxy, low amylose and big-seeded rice selections and check varieties are summarized in Table 11.

Grain yields of CM101 in the 2010 Statewide Yield Tests average 8410 lbs/acre and ranged from 6770 to 9500 lbs/acre. The average yield was slightly higher than the 6-year all-location average of 8250 lbs/acre.

A waxy short grain entry, 05Y343, which is entered in both the very early and early group in the Statewide Yield Test, registered a highly significant grain yield advantage over CM101 in 2010. It is about seven days later maturing, has slightly lower seedling vigor and has comparable stem rot resistance rating and plant height. 05Y343 has heavier and bigger kernels. The grain quality is yet to be evaluated by marketing organizations for acceptability as whole rice or rice flour. This entry will be tested again in all locations in 2011 UCCE Statewide Yield Test and will be further purified in head rows.

A low amylose entry, 09Y2159, registered an average yield of 10,940 lbs per acre across 4 locations in the Statewide Test. Pending the additional grain quality data, this entry may be further tested in 2011.

Table 11. Performance of selected 2010 UCCE Statewide and RES Preliminary Yield Tests of specialty rices.

ID	Type†	Mat. ‡	Grain Yield §	SV ¶	Days #	Ht. †† (cm)	Lodge (%)	SR ‡‡
Statewide Yield Test								
05Y343 §§	SWX	VEA	8860	4.8	100	90	9	4.9
CM-101	SWX	VEA	8560	5.0	90	89	39	5.5
05Y343	SWX	EA	10630	4.9	91	102	19	5.6
CM-101	SWX	EA	8260	5.0	83	99	49	5.2
09Y2141	SWX	EP	10940	4.9	84	104	10	5.6
09Y2159	SLA	ILP	10180	4.8	96	94	12	6.2
RES Preliminary Yield Test								
09Y2063	SWX	VE	10520	5.0	85	89	48	5.5
09Y2060	SWX	VE	10230	4.9	83	93	45	6.0
09Y2064	SWX	VE	10170	4.9	85	89	30	5.6
09Y2094	BG	VE	9480	4.9	88	100	0	5.4
10Y2031	LA	VE	10270	4.9	81	84	13	5.0
CM-101	SWX	VE	8210	4.9	79	88	60	5.5
10Y2158	SWX	E	11000	4.9	84	91	20	4.8
10Y2109	BG	E	10750	5.0	85	94	0	5.6
10Y2117	LA	E	9780	4.8	81	91	5	5.2
10Y2115	LA	E	9770	5.0	80	88	3	5.6
CM-101	SWX	E	8880	4.9	80	91	21	4.7
10Y2193	SWX	IL	10600	5.0	86	87	20	6.3
CM-101	SWX	IL	8400	4.9	84	85	50	5.2

†SWX=waxy short grain, SLA=low amylose short grain, BG=big-seeded
‡VE=very early, E=early, IL=Intermediate late
§ Paddy rice yield in lb/acre at 14% moisture.
¶ SV=seedling vigor score where 1=poor and 5=excellent
#Days to 50% heading.
††Ht. Plant height
‡‡SR=stem rot score where 0=no damage and 10=plant killed.
§§ Entered in the VEA and EA group of Statewide test

Mapping Stem Rot Resistance Genes

The DNA marker lab formulates and implements procedures to identify, develop, validate, and use DNA markers to select for traits that include, but are not limited to; grain quality, stem rot resistance, and blast resistance. The establishment of a functional, service-oriented DNA marker lab is a major accomplishment since the use of the marker technology is expected to expedite breeding for improved short, medium and long grain varieties and to speed up the blast resistance gene introgression work in the medium grain project.

The work in stem rot resistance gene mapping is being given a big push with the goal of identifying DNA markers for use as a selection tool in the future. Incorporating stem rot resistance into California rice varieties is essential but has proven to be difficult, especially in medium-grain rice. In an initial effort to improve stem rot resistance, the resistance gene from *Oryza rufipogon* was transferred to a long grain line designated as 87Y550, and was subsequently used in crosses at RES.

The genetic basis and the location of the stem rot resistance genes have not been fully determined. By taking advantage of the progress in the backcross project by the RES pathologist, an advanced backcross inbred line mapping population from the cross 87Y550/M-206 was developed in an effort to locate stem rot resistance genes. A mapping population consisting of 188 BC_1F_5 lines was used to genotype 100 polymorphic microsatellite markers. The lines were planted in a replicated trial with three replications. Quantitative Trait Loci (QTL) analyses were done using both Qgene® and Mapmaker® program using the single marker, composite interval mapping and multiple trait multiple interval mapping.

Three putative QTL regions were identified in chromosomes 4, 6, and 10 between the marker intervals RM5414-RM8213, RM7412-RM340, and RM25633- RM590. Additional trials are scheduled to verify the stem rot scores and results of the initial QTL mapping.

LONG GRAINS

Farman Jodari

The long grain breeding project continues its research and breeding efforts to develop superior long grain varieties of four major quality types for California, including 1) Conventional long grain, 2) Jasmine, 3) Basmati, and 4) Aromatic types. Milling and cooking quality improvements of conventional and specialty long grain types remain a major priority objective in this program followed by resistance to cold induced blanking and other agronomic and disease resistance traits.

Conventional Long Grain

The long grain rice market in the US is based on quality characteristics of Southern US varieties. Cooking quality of conventional long-grain types are characterized, for the most part, by intermediate amylose content (21 to 23%), intermediate gelatinization temperature (alkali spreading value of 3 to 5), and a moderate viscogram profile. Extensive cooking quality screening and selection efforts in recent years have eliminated the majority of soft texture types from the California long-grain breeding material. Consequently less intense cooking quality screening is required within the conventional long-grain breeding material. The primary focus is currently being directed toward milling yield and cold resistance improvements.

L-206, a conventional long-grain quality variety, was released for commercial production in California in 2006. Cooked grain texture of L-206 is harder than L-204 as indicated by its amylographic profile and therefore compares favorably with Southern US produced long grains. Milling yield of L-206 is 1-2% lower than L-204. Recent studies however, indicate that L-206 is significantly more resistant to grain fissuring than L-204, indicating more stable milling yield at lower harvest moisture. Primary advantages of L-206 over L-204 are improved cooking quality, higher grain yield, and earlier maturity.

L-206 is a very early to early maturing semidwarf variety. Average heading date is 1 day earlier than M-206. Plant height is 14 cm shorter than M-206. Lodging potential is significantly lower than M-206, however, due to earlier maturity plants may lean due to excessive dryness after harvest maturity. Similar to Southern long grain types, L-206 has intermediate amylose and gelatinization temperature types.

Grain yield of L-206 in 2010 multi-location Statewide Yield Tests averaged 9200 lb/acre (Tables 1 and 3). Average yield for M-206 within the same tests were 9400 lb/acre. Yields of L-206 at colder locations of Yolo and San Joaquin have not been as competitive as M-206. Based on the results from multiple locations and multiple years, L-206 has shown good yield stability and is adapted to most of the rice growing regions of California except the coldest locations of Yolo and San Joaquin Counties. Average head rice yield of L-206 during 2005–2010 seasons was 62%. Kernels of L-206 are shorter than L-204 and slightly larger than L-205.

Other promising conventional long grains that were evaluated in detail in advanced generations included 06Y513 and 06Y575. Due to excessive disease susceptibility of 06Y513 that was observed in 2010, this line is being eliminated from further testing. Performance results of 06Y575 experimental line are listed in Tables 1, 3, 5, and 12. Entry 06Y575 is a high amylose type, similar to L-205, with high yield potential, good milling yield, and cold tolerance. This experimental line has shown exceptional yield potential for 3 consecutive years in cooler location experiments, which have traditionally been harder for long grains to be competitive with medium and short grains. This line was tested in all 8 off-station locations in 2010 statewide trials.

Grain yield in all locations, except Yuba county, was within the highest two entries among all grain types, averaging 10,220 lb/acre as compared to 9210 for L-206. Yields of M-206 in 6 locations in addition to RES averaged 9410 lb/acre (Tables 1, 3, and 5). Potential uses for 06Y575 include canning and parboiling as well as table rice. High amylose types grown in California may also be used as conventional table rice, where they tend to have softer cooked grain texture than those grown in Southern US.

Table 12. Performance of selected conventional long-grain entries as compared with standard varieties in 2010 yield and milling tests.

Entry	Type †	Identity	-----Yield‡----- Statewide	RES	Head Rice§ (%)
Very Early Statewide					
8	LR	06Y575	9690	11030	63
6	L	L-206	8660	10200	58
3	M	M-206	8740	11290	--
Early Statewide					
68	LR	06Y575	10360	11010	--
69	L	08Y1092	10160	11480	--
67	L	L-206	9750	11090	--
63	M	M-206	10080	10990	
Intermediate Statewide					
126	L	06Y575	10620	10920	63
124	L	L-206	9780	11610	61
122	M	M-205	9810	11030	--
Very Early Preliminary					
1018	L	09P241	--	11440	59
1025	L	09P435	--	10880	63
1067	LIM	09P864	--	10810	61
1001	L	L-206	--	10890	60
Early Preliminary					
1124	L	09P324	--	10890	59
1148	L	L-206	--	10550	61
Intermediate Preliminary					
1178	L	09P525	--	10270	65
1203	L	L-206	--	9940	59

† High amylose type (LR), intermediate amylose type (L), Medium grain (M), Stem rot resistant (LSR), Imidazilinone herbicide resistant (LIM).
‡Grain yield in lb/acre at 14% moisture.
§Head rice yields are from solid seeded stands for statewide tests and single rows for Preliminary tests

Specialty Long Grains

Expanded breeding efforts in the specialty long grain area continued in 2010. Specialty types include Jasmine, Basmati, and conventional aromatics such as A-201. Agronomic and milling quality of selected specialty lines is shown in Table 13.

Calmati-202 is a true basmati variety released in 2006. It is an early maturing, semi-dwarf, pubescent, aromatic, elongating long grain. Susceptibility to cold induced blanking is significantly higher than standard varieties and therefore is not adapted to cold locations. Average yield of Calmati-202 in 2010 Early and Intermediate-Late tests were 6530 lb/acre as compared to 9770 for L-206 (Tables 3-6).

Grain and cooking qualities of Calmati-202 is considerably closer to imported basmati types than Calmati-201. Due to finer grain shape, the yield potential of Calmati-202 is 10% lower than Calmati-201. Calmati-202 is not intended as a replacement for a higher yielding conventional aromatic variety such as A-201.

Milled rice kernels of Calmati-202 are longer than Calmati-201 and slightly shorter than imported basmati rice available in the US market. Grain width is more slender than Calmati-201, but not as slender as imported basmati rice. Cooked kernel length of Calmati-202 is also slightly longer than Calmati-201. The overall appearance of cooked basmati type rice is an important quality feature among basmati rice consumers. Cohesiveness of the cooked grains as well as grain shape and texture of Calmati-202 are distinguishable improvements over Calmati-201. Cooked rice of Calmati-202 that was aged nearly one year was preferred by taste panelists over Calmati-201. Grain fissuring studies have shown that both Calmati-201 and Calmati-202 are susceptible to fissuring at low harvest moistures (data not shown). Timely harvest and proper handling is recommended to preserve milling as well as cooking qualities of this variety. Due to slender grain shape and pubescent hull and leaf, drying rate of the grain at harvest is significantly faster than standard varieties. Recommended harvest moisture is 18 percent.

A new series of basmati type selections that have shown a significant cooking quality advantage over Calmati-202 were tested in 2010 statewide and preliminary trials. A collection of these promising lines are included in the 'Rapid Generation Advance' grow out in the new greenhouse facility. Some of the entries that were tested in the 2010 statewide trials, including 10Y151 and 09Y1081, possess true basmati qualities that are nearly indistinguishable from imported basmati types. Their primary features include higher elongation, more flaky texture, more slender grain, and minimal curving of the cooked grain. Both grain yield and milling yield of these lines, however, are lower than Calmati-202. Further testing is underway to determine their suitability for commercial production. Efforts are also already underway to improve both their yield and milling quality. Emphasis in basmati type breeding continues to be placed on recovering slender and flaky-cooking kernels, good water uptake, and higher elongation ratios.

Efforts were continued in 2010 to develop jasmine types through pedigree and mutation breeding. Crosses and backcrosses were made with jasmine type material from various sources including Southern U.S. breeding programs and foreign introductions. The extreme photoperiod sensitivity of the original Thai Jasmine variety, Kao-Dak-Mali 105 (KDM), has been a significant breeding barrier. KDM was irradiated in 2010 with a high dose of gamma rays. In winter of 2010, the M_1 population was produced in the new green house facility. M_2 rows will be produced and evaluated at RES for early maturity or photoperiod insensitivity in the summer of 2011. Other mutants that were obtained previously are still being used as a valuable germplasm source for further agronomic improvements. Fifty-eight jasmine type selections were tested in 2010 Preliminary and Statewide Yield Tests. Breeding objectives for jasmine type quality include low amylose, strong aroma, a high degree of whiteness, and a smooth cooked grain texture.

Table 13. Performance of specialty long-grain entries in 2010 yield and milling tests.

Entry	Identity	Specialty Type	--------Yield†-------- Statewide	RES	Head Rice‡ (%)
Very Early Statewide					
39	09Y1067	Jasmine	7870	10000	62
6	L-206	--	8660	10200	58
Early Statewide					
100	07Y599	Jasmine	8410	8825	65
102	08Y1115	Aromatic	7720	8910	61
94	A-201	Aromatic	7970	8530	57
67	L-206	--	9750	11090	58
Intermediate/Late Statewide					
150	10Y150	Jasmine	7850	9040	61
147	08Y1114	Jasmine	7810	7820	62
151	10Y151	Basmati	7820	8440	38
153	09Y1081	Basmati	5450	5450	56
143	CT-202	Basmati	6630	7970	62
124	L-206	--	9780	11610	61
Preliminary					
1059	09P782	Jasmine	--	10330	65
1143	09P685	Jasmine	--	9540	58
1060	09P796	Jasmine	--	8870	61
1199	09P946	Basmati	--	5300	31
1165	A201	Aromatic	--	8250	50
1164	CT202	Basmati	--	6560	58

† Grain yield in lb/acre at 14% moisture.
‡ Head rice yields are from solid seeded stands for all entries.

Hybrid Vigor Evaluation

As part of preliminary studies to evaluate the degree of heterosis or hybrid vigor among long grain breeding material, a study was conducted to compare the agronomic performance of a long grain hybrid population with its parents. Crosses were made to generate sufficient hybrid seed between a long grain experimental line 06Y575 and a Chinese short grain introduction, ‘Liaojing 294’. A four-replication test was conducted using evenly spaced transplants for each experimental unit at a density of 10 plants per square foot. Due to incompatibility of the two genotypes however, 60% of the kernels were found to be sterile. In 2009 a similar study using 2 long grain genotypes, 06Y575 and L-206, indicated that the hybrid line showed 3% yield advantage over the higher yielding parent.

Milling quality

Continued improvement in milling yield and milling stability of new long grain varieties to the level of medium grains remains a major objective. Grain characteristics are being evaluated and selected that will lend milling yield stability to long-grain lines under adverse weather conditions and allow a wider harvest window. These may include hull cover protection, grain formation, or physicochemical properties of the grain that result in fissuring resistance. In 2010, all selections in preliminary and advanced yield tests were evaluated in special small or large solid seeded plots to obtain more accurate milling yield evaluation. Advanced lines were evaluated at 6 to 8 different harvest moistures and preliminary entries were tested at two harvest moistures. The goal for long grain is to maintain a minimum of 64% headrice yield in the advancing breeding lines.

Disease Resistance

SR resistance originating from *Oryza rufipogon* continues to be incorporated into an increasing number of high yielding long-grain lines. Twenty-four entries with a range of SR resistance were tested in 2010 Statewide and Preliminary Yield Tests. Performance of a selected number of these lines is shown in UCCE Statewide Yield Tests (Tables 1–6). Despite a close linkage in the SR resistance trait with increased chalkiness and cold susceptibility, selections are being obtained that have broken such a linkage and have combined low SR score, low blanking, and high milling yield. Efforts are currently underway, with cooperation of RES plant pathologist, to modify field screening procedure for stem rot resistance based on maturity stage with the goal of increasing selection efficiency.

CALROSE MEDIUM GRAINS

Kent S. McKenzie

Beginning in 2010, leadership for the Calrose Medium Grain Rice Project has been assumed by Dr. K.S. McKenzie because of the resignation and departure of Dr. J. Lage. The decision was made to put the project under the supervision of Dr. McKenzie because of his experience and familiarity with the medium grain project to ensure continuity and evaluate the projects status and future direction. Medium grain varieties are the foundation and bulk of California rice production and it is paramount that the program continues to be productive. To lend more support to this effort, Dr. V.C. Andaya has begun working with the Medium Grain Project focusing on the early generation stages and the work on disease resistance germplasm developed in the RES pathology project. This shift has been possible by the hiring of Dr. C. B. Andaya as a research scientist to DNA marker research, and assigning her to manage the DNA marker laboratory. RES project leaders and staff have also stepped up support of this effort.

The fundamental objectives of the Medium Grain Project have not changed.

Yield Potential and Stability

California offers a high-yielding environment and efforts continue to take advantage of that resource by developing varieties with high yield potential. Incremental yield increases on our current high yields will be difficult. Large plot yield tests (combine harvested) have been expanded for medium grains and that will be facilitated with the arrival of a new research combine in 2011.

High Grain Quality Calrose

Improvements must be acceptable to the market and the high milling yield and stability will continue to be a priority. Harvest moisture milling tests and grain measurement are routine steps in evaluation of lines reaching the yield testing levels.

Cold Tolerance

Resistance to low temperature induced blanking is an important trait giving insurance in a cold year like 2010. The cold screening greenhouse and San Joaquin nursery are important tools being used for screening.

Early Maturity & Lodging Resistance

Early maturity provides help in reducing the growing season, planting flexibility, and lodging resistance for harvest efficiency, quality, and high and stable yield.

Disease Resistance

SR, blast and aggregate sheath spot are all threats to productivity and quality, thus remain areas of breeding emphasis for medium grains. An intense effort is being made in SR resistance marker identification with the Pathology Project and also rice blast resistance.

Materials put in the “pipeline” by Dr. Carl Johnson (ret.) continue to move forward being evaluated in yield tests. The newer materials, ideas and approaches instituted by Dr. Lage are being evaluated and incorporated as appropriate. New materials generated from crossing with new foreign germplasm introductions, high yield materials from the long and short grain projects, or medium grain lines continue to flow in to the project. These require multiple crosses, heavy screening and selection, with very few acceptable medium grains lines selected for advancement. Those reaching the preliminary yield testing stage are; screened through the San Joaquin cold nursery, RES refrigerated greenhouses and the Hawaii winter nursery for cold tolerance, harvest moisture and milling plot evaluation at RES, and scored for disease resistance by the Pathology Project.

New Variety

M-105 is a very early, semidwarf, California glabrous, Calrose quality medium-grain cultivar that was approved for foundation seed release for 2011. It has been evaluated in large plot yield tests since 2005 under the experimental designation 05-Y-471. It is a very early selection from the Rice Experiment Station 2000 summer greenhouse cross R25878 and has the pedigree S-301/M-204//M-104. The female parent S-301/M-204 (98-Y-242) was later released as M-206, and is currently the predominant medium-grain cultivar in California. M-104 is a very early maturing, cold tolerant, medium-grain rice also released by the Rice Experiment Station.

05-Y-471 (M-105) days to 50% heading averaged 3 days earlier or later heading that M-206 and M-104, respectively. Yield averages were M-206>05-Y-471>M-104 with warmer locations favoring M-206 and cooler locations favoring M-104 and 05-Y-471. Tables 14 and 15 show 2006-2010 UCCE test averages for 05-Y-471 (M-105) and the check parents M-104 and M-206. These lines were also tested in replicated UCCE strip test in 2010 and the results presented in Table 16. Resistance to cool temperature blanking of 05-Y-471 is not a high as M-104 and no statistically significant improvement or reductions from parents were observed in disease resistance testing.

By far the greatest attribute observed in testing 05-Y-471 was its head rice milling yield and stability that represents a very significant improvement over M-104 and equivalent to M-206. Figure 1 shows the result of two years of harvest moisture studies at RES and illustrates the higher head rice yield and stability of 05-Y-471 when compared to M-104. This was considered as one of most important justifications for releasing it as a new variety.

Approximately 600 cwt of foundation seed will be allocated for seed production to California seed growers by the California Crop Improvement Association. Protection and registration of M-105 is being sought under the US Plant Variety Protection Act (Title V option) as well as an US Utility Patent and registration with the Crop Science Society of America.

Large Plot Yield Tests

Tables 1 to 7 show results from large plot testing in 2010. Medium grain lines that outperform M-206 and M-205 are rare, but some promising entries observed in 2010 include entries 5 (blast resistant), 19, 27, and 28 in the very early group; 81, 88, and 92 in the early group, 136 and 137 in the intermediate or late group (Tables 2, 4, and 6). New medium grain selections from preliminary yield test will be advanced for testing in 2011 (Table 7.) Selections of material for advancement are made based on data collected on yield, maturity, disease resistance, low temperature blanking, and quality from the nursery.

Herbicide Tolerance

Varieties show differences in tolerance to rice herbicides and this is often reflected in performance in the breeding nursery in the weed control programs. The RES Breeding Program is working with the UC weed scientists in this area to try to characterize these differences in varieties and breeding materials to ensure that existing and new products are adequately evaluated for varietal sensitivity and develop screening and selection technique for breeding material. Induced mutation was used very successfully by the LSU Program to recover Imidazilinone herbicide resistant rice. This non-transgenic trait has been incorporated into adapted material in the Long Grain Project. However, efforts to introduce this technology to the California rice industry with involvement of the CRRRB, CRC and UC to have been rejected by the herbicide manufacturer.

A limited effort has been made to recover plants with increased tolerance to the ALS herbicide Granite GR®. In 2009-2010 approximately 250,000 mutagenized M-206 seedlings were screened in the greenhouse and 250 putative mutants selected for advancement and further testing. The selection will be tested to determine if any enhanced levels of herbicide tolerance has been found. Screening using some other rice herbicides is also underway and EMS and irradiated seed are being generated for use in 2011.

Hybrid Rice

Hybrid rice continues to be getting attention in the rice growing areas of the Southern US with the public rice breeding programs at LSU and University of Arkansas establishing hybrid rice breeding projects. The RES Breeding Program began investigating potential for japonica hybrid rice in California in 2008. Regarding the issue of significantly higher yields, in small plot field test in 2009, one hand crossed hybrids of RES long grain showed less than a 5% yield increases. Crosses between 2 medium and long grain varieties showed no yield advantage. In 2010 hand crossed hybrids involving a long, medium and short grain line with 3 Chinese introductions showed no yield advantage over the RES parent and sterility problems in two of the three crosses. Small plot evaluation of the LSU rice hybrid may be possible in 2011; however these evaluations are too limited. Any further meaningful evaluation will require acquisition of the male sterile and restorer components and the funding and support to continue to look at the yield potential, quality, and seed production issues in considering japonica hybrid rice for California.

Table 14. Agronomic performance in UCCE Statewide Yield Tests - Very Early Locations 2006-2010.

Very Early Statewide Variety	Overall	Average Yield (lb/acre) Location Yields Biggs	Sutter	Yolo	San Joaquin	Harvest Moisture (%)	Seedling Vigor (score)	50 % Heading (Days)	Lodging (%)	Height (cm)
M104	9130	8520	9510	9060	8930	17.3	5.0	83	25	90
M206	9460	10290	9420	9390	8690	18.9	4.9	89	17	91
05Y471	9250	9480	9510	9260	8790	18.1	4.9	86	15	93

Table 15. Agronomic Performance in UCCE Statewide Yield Tests - Early Locations 2006-2010.

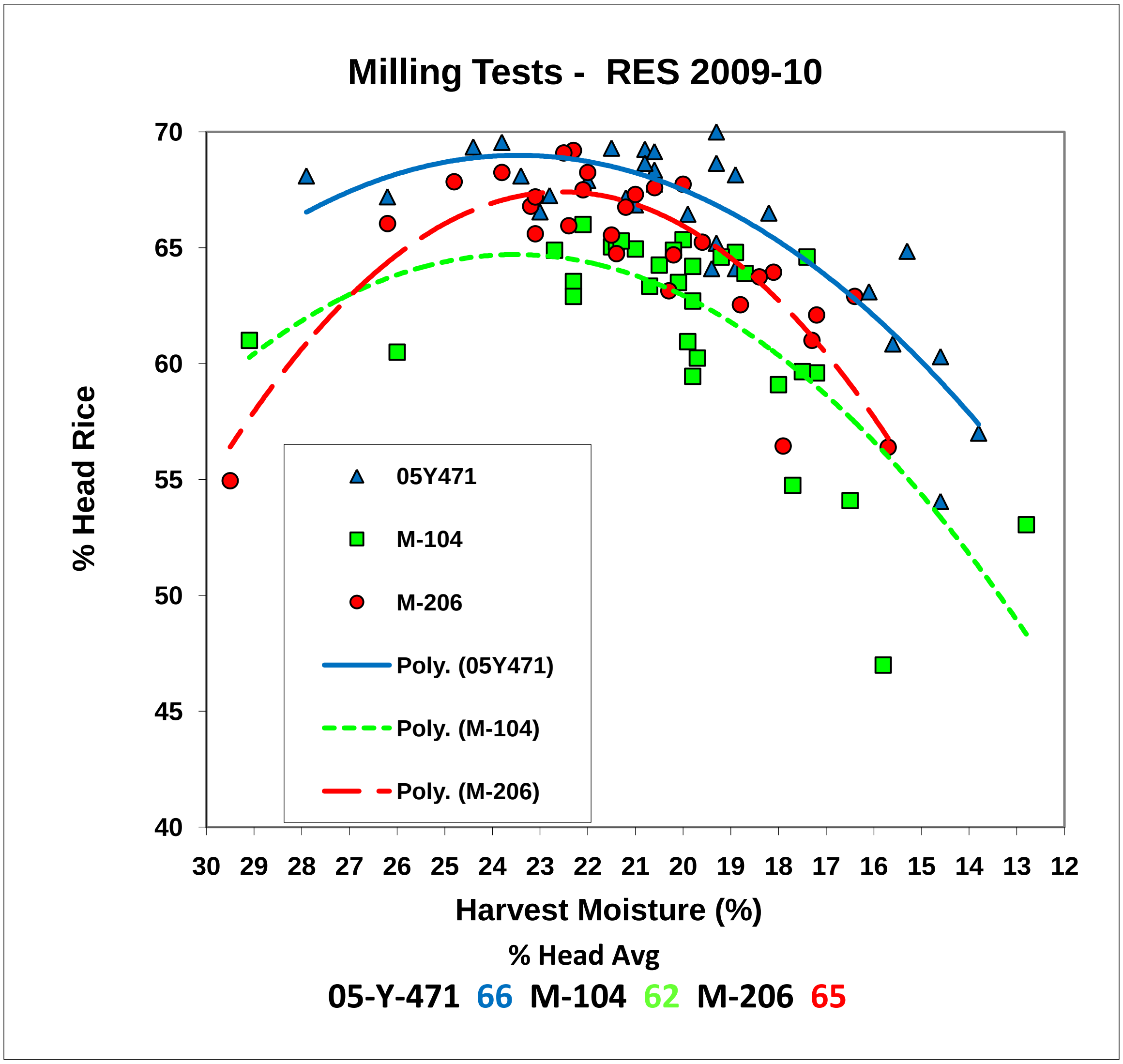
Early Statewide Variety	Overall	Average Yield (lb/acre) Location Yields Biggs	Butte	Colusa	Yuba	Harvest Moisture (%)	Seedling Vigor (score)	50 % Heading (Days)	Lodging (%)	Height (cm)
M206	9610	10230	8530	9940	9740	17.8	4.9	85	17	99
05Y471	9560	10270	8500	9790	9670	17.7	4.8	82	17	97

Table 16. Agronomic results of Strip Trials at three 2010 UCCE Statewide Yield Test Sites.

Location	Entry	Seedling Vigor	Days to 50%	Height (cm)	Harv Moist	Grain Yield	Milling Samples (%)† H20	Head	Total
BUTTE	M206	5.0	81	96	18.5	9000	22.9	63.5	72.3
	05Y471	5.0	79	97	17.4	8770	20.5	66.1	74.2
	M104	5.0	73	95	16.6	7760	19.4	58.2	72.1
LSD(0.05)	--	NS	0.1	NS	1.1	NS	--	--	--
CV (%)	--	--	--0	4	4.0	10	--	--	--
COLUSA	M206	5.0	93	104	19.9	11353	26.7	60.4	69.2
	05Y471	4.9	88	104	19.5	10810	25.0	65.3	71.3
	M104	5.0	87	99	18.9	10740	24.1	64.1	70.7
LSD(0.05)	--	NS	0.5	NS	0.6	470	--	--	--
CV (%)	--	2.0	0.3	4.0	2.0	3.0	--	--	--
SUTTER	M206	5.0	85	89	18.9	9680	21.2	67.5	72.7
	05Y471	5.0	90	90	18.4	9430	21.0	68.2	72.3
	M104	5.0	84	91	20.0	9230	21.6	65.8	72.0
LSD(0.05)	--	NS	0.1	NS	0.4	NS	--	--	--
CV (%)	--	--	--0	2	1	5	--	--	--
OVERALL	M206	5.0	88	96	18.9	9930	23.5	64.1	71.3
	05Y471	5.0	84	97	18.6	9760	22.2	66.3	72.7
	M104	5.0	81	95	18.5	9150	21.7	62.7	71.6
LSD(0.05)	--	NS	0.1	NS	0.4	470	--	--	--
CV (%)	--	1.2	0.2	3	3	6	--	--	--
ENTRY*LOC		*	**	NS	**	NS		--	--

†Milling samples are averages of 4 sequential harvests with two replications each.

Figure 4. Head rice milling yields from harvest moisture test at RES 2009 and 2010.



RICE PATHOLOGY

Jeff Oster

Breeding for disease resistance is a cooperative effort between the plant breeders and plant pathologist. The pathologist produces disease inoculum, conducts a disease nursery, identifies resistant germplasm, makes crosses to introduce disease resistance, and screens statewide and preliminary trial breeding lines and varieties (about 2000 rows per year) for stem rot resistance in the field. Since 2005, the immediate backcross program involved screening entries for blast (1806 crosses), SR (1195 crosses) and SS (971 crosses) resistance with three generation advances per year. The objective was to transfer resistance genes into an M-206 background for use by the breeders. The crossing programs are now being transferred to the breeders. In addition, early generation materials derived from breeder's crosses are cycled through the disease nursery to identify and verify disease resistant lines (about 2520 rows). Intense selection pressure is applied for important agronomic traits because sources of disease resistance have a number of undesirable characteristics. The sources of SR resistance also confer aggregate and bordered sheath spot (SS) resistance. Conversely, the sources of SS resistance also seem to confer SR resistance in some materials.

Stem Rot

Screening for SR resistance in inoculated nurseries and greenhouses usually begins in the F_1 generation for the immediate backcross program and in F_3 for materials provided by the breeders. Resistant germplasm often has low seedling vigor, low tillering, susceptibility to blanking, and late maturity. Only a small percentage of the lines screened show higher levels of SR resistance than current varieties. There were about 7745 rows in the 2010 SR nursery.

This year, 5225 rows in the stem rot nursery were drill-seeded. This resulted in less seed drift, establishment of a more uniform stand, and allowed use of higher nitrogen without inducing lodging. Increased nitrogen results in greater disease severity and better screening.

Promising long and short grain resistant lines are emerging, but progress has been slow with the medium grains.

Because progress in the medium grain has been difficult, an immediate backcross program was started in 2005. Three long grain and two short grain lines with resistance from *O. rufipogon* and two lines with resistance from *O. nivara* have been backcrossed into M-206. Because inheritance of SR resistance from *O. rufipogon* is due to more than one gene, and the error associated with single plant selection, large populations must be used. One hundred forty-four crosses were made this year for this purpose. Some crosses for all donor parents are now at BC_6. The crossing program is now being transferred to the breeding projects. Existing segregating populations from the various backcrosses will now be rapidly advanced.

As in the past, some lines (derived from all donor parents) again showed SS resistance equivalent to that found in sheath spot donor parents (see section below).

This year 1501 BC_1F_5 rows derived from the 2009 mapping population were evaluated for SR resistance in the field. The parents were M-206 and 87Y550 (long grain with resistance derived from *O. rufipogon*). The results have been used by Drs. Cynthia and Virgilio Andaya to map SR resistance genes and develop molecular markers useful in breeding for SR resistance. Three candidates have been identified. Field tests will continue in 2011 to confirm these results.

A similar population has been developed for the *O. nivara* resistance source. Nine hundred ninety-five rows were evaluated in a replicated test in 2010.

Molecular markers would enable selection for disease resistance without having to perform biological screening. Such markers would allow early generation identification of resistant seedlings before crossing, thus greatly speeding the breeding process.

Sheath Spot

An immediate backcross program was started in 2005 to transfer SS resistance genes from Teqing, Jasmine 85, and MCR10277 to M-206 and L-206 (102 crosses this year). BC_6 has been made. The crossing program is now being transferred to the breeding projects. Existing segregating populations from various backcrosses will now be rapidly advanced.

SS resistant progeny from earlier backcrosses were again grown in the SR field nursery this year. As in the past, some lines (derived from all three donor parents) again showed SR resistance equivalent to that found in the wild species.

Blast

Rice blast disease in California was identified for the first time in 1996 in Glenn and Colusa Counties. It spread over significantly more acres in 1997, and has reached Sutter (1998), Butte (1999), and Yuba (2000) counties. In 1998 to 2009, blast severity was much lower than in previous years. A few affected fields continue to be found, mostly on the west side of the valley. Severity in 2010 was higher than most previous years. M-104 appears to be more susceptible than other varieties, followed by M-205. None of the Statewide Yield Tests have been affected by blast since 1997, so the entries could not be evaluated.

Blast infection was found in M-208 fields this summer. DNA tests confirmed that infected plants were M-208 and DNA markers indicated the *Pi-z* resistance gene was present. Fungi will be isolated and analyzed by researchers at UC Riverside to determine if infections are due to a mutation of the IG-1 race present in California, or a new race. The RES also has fungal isolates and seed from the infected plants. Lines with different blast resistance genes from the M-206 backcross program (below) are being screened against these isolates. In addition, race determination tests are being conducted. The components of M-208 are also being tested individually. If some components are resistant and others are susceptible, susceptible components could be eliminated from seed production. It is too early to judge whether *Pi-z* resistance has been overcome in an epidemiological sense. Fields of resistant varieties in the southern US occasionally also have susceptible plants, but major gene resistance has not been overcome in most cases. In California, it may be difficult to determine whether the blast fungus has overcome *Pi-z* resistance in subsequent years if environmental conditions are not as favorable to disease as in 2010.

Major resistance genes limit blast symptom expression to small brown flecks at most, but different races of the blast fungus can overcome this resistance within several years after variety release. The first blast resistant variety (M-207, possessing the *Pi-z* gene) was released in 2005, followed by M-208 (also with *Pi-z*) in 2006. All material presently advancing through the medium grain program possesses only this gene. Since molecular markers for blast resistance genes are available, they have replaced biological screening for the *Pi-z* gene. If future varieties with the *Pi-z* gene are developed, they will first be subjected to a confirmatory biological screen for blast resistance before release.

IRRI reported development of monogenic lines each containing one major gene for blast resistance. These lines were brought through quarantine and tested to verify their blast resistance to the IG-1 race present in California. A backcross program was started in 2005 to introduce these genes into M-206.

Only genes with a wide spectrum of blast resistance in worldwide tests were chosen (*Pi-b*, $Pi\text{-}k^h$, $Pi\text{-}k^m$, $Pi\text{-}z^5$, *Pi-9*, *Pi-40*, and $Pi\text{-}ta^2$). Seven backcrosses were made and screened for blast resistance. Theoretically, 99.6% of genes in this material are from M-206. In 2009, homozygous resistant lines were selected from the F_2 aided by molecular markers. Selections were made from these lines and brown rice has been evaluated for seed traits by the medium grain breeder. Almost all lines closely resemble M-206. In 2010, the breeders selected lines from the BC_7F_5, and seed from these rows has been put in cold storage. The backcross program for these genes is now complete.

Forty nine crosses were made in 2010 to complete BC_7 for *Pi-1*, *Pi-2*, and *Pi-33* blast resistance genes into an M-206 background. Lines will be grown for breeder selection in 2011, when this project will be complete.

The project by Dr. V.C. Andaya to develop molecular marker screening for blast has been successful. The following table summarizes findings from this project.

Marker	Gene
RM224	*Pi-1*, $Pi\text{-}k^h$
RM1233	$Pi\text{-}k^m$
AP5930F	*Pi-2*, *Pi-z*, $Pi\text{-}z^5$, *Pi-9*, *Pi-40*
RM7102	$Pi\text{-}ta^2$
RM208	*Pi-b*
RM331	*Pi-33*

All blast lines containing introduced genes are being screened against California blast isolates (including isolates pathogenic to M-208) to confirm resistance.

Quarantine Introductions

The building blocks for any breeding program are varieties with traits desirable in commercial production. From time to time, varieties are imported for use in the breeding program. Three introductions with cold temperature vigor were brought through quarantine this past year.

All introductions were grown under procedures developed and approved by USDA and CDFA to prevent introduction of exotic pests and rice diseases. This expedited process helps the breeding program and the industry to maintain a competitive edge in the world rice market while preventing the introduction of new pests to California.◆

THE CALIFORNIA RICE INDUSTRY AWARD

The California Cooperative Rice Research Foundation is proud to annually sponsor the California Rice Industry Award. The purpose of this award is to recognize and honor individuals from any segment of the rice industry who have made outstanding and distinguished contributions to the California rice industry. Recipients of the award are nominated and selected by a committee of rice growers and others appointed by the CCRRF Board of Directors. The California Cooperative Rice Research Foundation has been proud to recognize and honor the following individuals with the California Rice Industry Award in the past. Their distinguished service and contributions have advanced the California rice industry.◆

1963 - Ernest L. Adams
1964 - William J. Duffy, Jr.
1965 - Florence M. Douglas
1966 - Fred N. Briggs
1967 - Loren L. Davis
1967 - George E. Lodi
1968 - Karl I. Ingebretsen
1969 - Glen R. Harris
1970 - Milton D. Miller
1971 - James J. Nicholas
1972 - George W. Brewer
1973 - Johan J. Mastenbroek
1974 - Leland O. Drew
1975 - Marshall E. Leahy
1976 - Fritz Erdman
1977 - Carroll W. High
1978 - B. Regnar Paulsen
1979 - W. Bruce Wylie
1980 - Robert W. Ziegenmeyer
1981 - Maurice L. Peterson
1982 - Jack H. Willson
1983 - James G. Leathers
1984 - Francis B. Dubois
1985 - Morton D. Morse
1986 - Chao-Hwa Hu
1986 - J. Neil Rutger
1987 - Howard L. Carnahan
1988 - Narval F. Davis
1989 - Duane S. Mikkelsen
1990 - Melvin D. Androus
1991 - Albert A. Grigarick
1992 - Ralph S. Newman, Jr.
1993 - Carl M. Wick
1994 - David E. Bayer
1995 - Gordon L. Brewster
1996 - Phil Illerich
1997 - D. Marlin Brandon
1998 - Shu-Ten Tseng
1999 - Robert K. Webster
2000 - Lincoln C. Dennis
2001 - Alfred G. Montna
2002 – Dennis O. Lindberg
2003 – John F. Williams
2004 – Carl W. Johnson
2005 - James E. Hill
2005 – Don Bransford
2006 – Michael Rue
2007 – Lance Tennis
2008 – Charlie Mathews
2009 – William V. Huffman
2010 - James Erdman

D. MARLIN BRANDON RICE RESEARCH FELLOWSHIP

Dr. Marlin Brandon began his career in 1966 as the UC Rice Farm Advisor in Colusa, Glenn, and Yolo Counties He later served as UC Rice Extension Agronomist, LSU Professor of Agronomy, and Director and Agronomist at RES until passing away in 2000. He was a mentor and teacher of rice production science to colleagues, students, and growers everywhere.

In tribute, the California Rice Research Board and the Rice Research Trust established a fellowship in his memory that is awarded at Rice Field Day. Recipients will be known as D. Marlin Brandon Rice Scholars.

In 2010, a fellowship of $2,500 was awarded to Mark Lundy. A total of 20 fellowships have been awarded.

Rice Research Proposal

Rice research at RES in 2011 will continue toward the primary objective of developing improved rice varieties for California.

Project leaders will concentrate efforts on developing rice varieties for the traditional medium, short, and long-grain market classes. Research efforts will continue to improve and develop specialty rice such as waxy (mochi or sweet) rice, aromatic rice, and others as an adjunct breeding effort. Major breeding emphasis will continue on improving grain quality, yield and disease resistance. Efforts will be made to effectively use new as well as proven breeding, genetic, and analytical techniques. RES staff will expand DNA marker screening capabilities. Following are the major research areas of the RES Rice Breeding Program planned for short, medium, and long-grain types in 2011.

Quality

Efforts to identify, select, and improve culinary and milling quality in all grain types will continue to receive major emphasis. Improved cooking evaluation techniques are being used that include use for DNA markers for amylose content, gelatinization temperature, and RVA profiles. The RES quality lab is supporting quality evaluation and research for variety development.

Resistance to Disease

The RES Rice Breeding Program is continuing efforts to improve disease resistance in our California varieties. Evaluation and screening for stem rot and sheath spot resistance will be conducted by the plant pathologist on segregating populations, advanced breeding lines, and current varieties. Rice blast disease presents an additional threat to California. Research and breeding activities to address rice blast to develop improved blast resistant varieties will continue. Materials from backcrossing efforts to transfer disease resistance have been transferred to the breeding projects for evaluation. New resistant sources and foreign germplasm will continue to be evaluated as potential parental material. Foreign germplasm will be introduced through quarantine for use in breeding and research.

Yield

Yield is a complex character that results from the combination of many agronomic traits. Emphasis will continue on breeding varieties with high grain yield potential, minimal straw for high yield, and more stable yields while maintaining and/or improving grain quality.

Tolerance to Low Temperature

Tolerance to low temperature remains an essential character needed at seedling and reproductive stage in California rice varieties. Segregating populations and advanced experimental lines will continue to be screened in the San Joaquin nursery for resistance to blanking, normal vegetative growth, a minimum delay in maturity, and uniform grain maturity. Selection at UCD has been discontinued due to concerns about adjacent UC research activities. Cold tolerance data will include two seeding dates of advanced material at RES, UCCE Statewide Yield Tests, refrigerated greenhouse tests, and data from cold tolerance and the Hawaii winter nurseries.

Lodging and Maturity

Improved lodging resistance will receive continued emphasis in all stages of variety development. Efforts will continue to develop improved varieties that have a range of maturity dates with major emphasis placed on early, very early rice, synchronous heading, and uniformity of ripening.

Other Areas

The program will continue to look for mutants with herbicide tolerance or resistance as well as characterizing varietal differences in response to rice herbicide for screening purposes.

Cooperative Projects

Cooperative research by the rice breeding program staff with USDA, UC, RiceCAP and others in the area of biotechnology, genetics, quality, agronomy, entomology, plant pathology, and weed control will be continued in 2011. Emphasis will be placed on applied research and more basic studies that may contribute to variety improvement.

Rice Research Priorities and Areas of Breeding Research

General Rice Research Objectives of Rice Experiment Station

The primary research objective of RES is the development of high yielding and quality rice varieties of all grain types (short, medium, long) and market classes to enhance marketing potential, reduce cost, and increase profitability of rice. Rice breeding research priorities at RES can be divided into general priorities, that are applicable to all rice varieties developed for California, and specific priorities, that may differ between grain types, market classes, special purpose types, and the special interests of the plant breeding team members.

A secondary but important objective is to support and enhance UC and USDA rice research through cooperative projects and by providing land, water, and input resources for weed control, insect, disease, and other disciplinary research.

General Rice Breeding Priorities Applicable to All Public California Rice Varieties

- High and stable yield potential
- Cold tolerance
- Lodging resistance
- Resistance to blast, stem rot, and aggregate sheath spot diseases
- Seedling vigor
- Early maturity
- Synchronous heading and maturity
- Improved head rice milling yields
- High quality rice consistent with grain type, market class, or special use
- Develop and utilize DNA marker assisted selection

Specific Rice Breeding Priorities by Grain Type, Market Class, and Special Use

Short Grains and Premium Quality Medium Grains

- Improve California short grain rice
- Develop superior premium quality short and medium grain varieties
- Improve waxy, low amylose, and bold grain rice
- Use DNA markers for grain quality and disease resistance breeding

Calrose Type Medium Grains

- Improve conventional medium grains
- Improve stem rot resistance in medium grains
- Improve blast resistance in medium grain M-208
- Increase yield potential, cold tolerance, and genetic diversity
- Explore opportunities to provide herbicide tolerance

Long Grains

- Superior quality for table and processing
- Improve head rice milling yields and fissuring resistance
- Improve basmati types
- Develop jasmine types
- Develop aromatic types
- Improve cold tolerance

Rice Pathology

- Screening and evaluation of advanced breeding lines for blast, stem rot, and sheath spot.
- Facilitate transfer of stem rot and aggregate sheath spot disease resistance from wild species of rice and disease resistance genes identified in RiceCAP
- Mapping of stem rot resistance genes and marker aided selection for stem rot and blast
- Facilitate germplasm introduction and pathology related research