2006 RICE BREEDING PROGRESS REPORT
AND
2007 RESEARCH PROPOSAL

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

January 1, 2007

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OVERVIEW

Kent S. McKenzie

The California Cooperative Rice Research Foundation (CCRRF) is a private nonprofit research foundation [501(c)(5)] with membership consisting primarily of 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. Carl W. Johnson, Farman Jodari, Junda Jiang, and plant pathologist Mr. Jeffrey J. Oster. Eleven career positions consisting of five plant breeding assistants, one postgraduate assistant, a field supervisor, one mechanic and field operator, two maintenance and field operators, and an administrative assistant 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 CRRB 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, lodging resistance, and insect tolerance 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 RRT. The RRT is a tax-exempt trust [501(c)3] established in 1962 to receive tax deductible contributions for support of rice research. RES is not government supported, but is receiving some USDA competitive grant rice research support through the RiceCAP initiative.

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, Department of Agronomy and Range Science, 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 Feldstrom, Stephen R. Delwiche, Elaine T. Champagne and Robert Swank. 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 Mr. W. Michael Canevari (San Joaquin), Dr. Randall G. Mutters (Butte, Placer, Sacramento, Sutter, Yuba), and Dr. Chris Greer (Glenn, Colusa, Yolo, Tehama) and Agronomist Dr. James E. Hill, (Department of Plant and Environmental Science, 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 2006. Dr. Albert J. Fischer, associate professor, Department of Plant and Environmental Science, UCD and Mr. James Eckert UCD staff research associate at RES, conducted UC rice weed research on 18 acres. Drs. Randall Mutters and Bruce Linquist are coordinating the rice systems research in a 13 acre research area established at RES and he is being supported by UCD staff research associate Mr. Steve Bickley. Dr. Larry D. Godfrey, extension entomologist, and Mr. Richard L. Lewis, postgraduate researcher, Department of Entomology, conducted rice water weevil research. Please refer to the 2006 Comprehensive Rice Research Report for information on UC, USDA and RES-UC-USDA cooperative research.

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 initiated a voluntary and 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. This included GIPSA approved third party PCR testing for the LLRice601 event, any Liberty Link trait (35S::bar), and sampling and testing by USDA-APHIS. Results involving a total of 98 pooled PCR tests were non-detect on all samples. In addition, CCRRF foundation and basic seed samples for 2007 sale are being tested as required by the California Rice Commission.

All research at RES is reviewed annually by the CCRRF Board of Directors, representatives of the University of California, and the California Rice Research Board.

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 15 public rice varieties and basic seed of two Japanese premium quality varieties were produced on 172 acres at RES in 2006. 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. 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.◆

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 a 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.

Dr. Carl Johnson heads the breeding effort for the Calrose medium grain project (see Calrose Medium Grains). He is responsible for coordinating the breeding nursery and is the liaison for the UCCE Statewide Yield Tests and the San Joaquin Cold Tolerance Nursery. Dr. Farman Jodari is the long-grain project leader (see Long Grains). He is also providing the data analysis for yield testing and is the liaison to the UCD Cold Tolerance Nursery and Southern U.S. breeding programs. Dr. Junda Jiang was project leader for premium quality, waxy, and California short grains (see Short Grains). The rice pathology project is led by RES pathologist Mr. Jeff Oster (see Rice Pathology). In addition to screening for disease resistance, he has conducted extensive research on bakanae at RES and off-station. All breeding program members cooperatively participate in the preparation, planting, maintenance, and harvest of the research nurseries.

RES has been working to improve rice quality evaluation capabilities in all market types. Physicochemical and grain testing for rice quality components are being expanded to support the breeding program. This has been made possible by the improvement of laboratory facilities, equipment, and the addition and training of support staff. 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 2006 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

For the second consecutive year, planting was delayed due to wet soil conditions. Seeding of the 2006 breeding nursery began May 22nd, and was completed the 27th. Record high temperatures occurred at flowering, causing sterility in some of the material in the nursery. Ripening and harvest conditions produced extremely good samples for appearance and head rice yields in medium and short grain material.

In 2006, 1780 crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 33,555. 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 2007, thereby accelerating the breeding process. In addition, a large number of backcrosses are being made to transfer disease resistance by the Pathology Project.

The 2006 RES breeding nursery occupied approximately 80 acres. Water-seeded yield tests included 4112 small plots and 3292 large plots. Small seed increase plots and cooking samples were grown on 2.5 acres and included 36 advanced breeding lines. Forty–two experimental lines (3368 headrows) were grown for seed increase, quality evaluations, and purification. The nursery included about 50,500 water-seeded and 10,451 drill seeded progeny rows. Selections were made for advancement, quality evaluations, and purification from approximately 10,000 progeny rows. F_2 populations from 2004 and 2005 crosses were grown in precision drill-seeded plots on 10 acres. An estimated 200,000 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 2007.

Headrows (3000) of S-102, M-202, M-204, M-208, Calhikari-201, Calamylow-201, Akitakomachi, and Koshihikari were grown for breeder seed production in 2006. 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.

The 2005-6 winter nursery included 8400 progeny and an F_1 nursery of 557 crosses. The nursery suffered some damage resulting from the 32 inches of rain received in March 2006. Selection and harvest was completed and seed returned to RES and planted in May.

The 2006-7 winter nursery of 8460 rows was planted November 4th and 5th, 2006, and 570 F_1 populations were transplanted to the nursery December 6th to 8th, 2006. Selection and harvest will occur in April, and seed returned for processing and planting in the 2007 RES breeding nursery.

The 2006 UCD Cold Tolerance Nursery contained 3 acres of precision drill-seeded F_2 populations and 9000 dry-seeded progeny rows. In the UCD Rice Facility, blanking in the breeding rows and F_2 populations was at a moderate level. Selections were made from the F_2 populations. The cool temperatures observed at UCD typically are not as low as those observed at the San Joaquin location. The UCD Cold Tolerance Nursery allows selection of materials with moderate resistance to blanking and is a valuable location for advancement, evaluation, and selection of breeding materials.

The San Joaquin Cold Tolerance Nursery was planted in cooperation with two local rice growers. The 4-acre drill seeded nursery included 14,420 rows and 3.6 acres of F_2 populations. Management and production were excellent. Blanking levels were very high, providing opportunities to select blanking resistant material. The new Hege nursery row planter was used successfully at both UCD and San Joaquin nurseries.

The cold tolerance nurseries remain an essential part of selecting for resistance to blanking and are used in conjunction with two refrigerated greenhouses at RES. In exceptionally cool years, the yield performance of cold tolerant varieties like Calmochi-101, S-102, M-104, and M-206 reflects the value of the cold tolerance nurseries in developing adapted varieties for California.◆

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 2006 Statewide Yield Tests were conducted at seven locations in commercial fields by Mr. Raymond L. Wennig, Dr. Randall G. Mutters, Dr. James E. Hill, and Dr. Chris Greer. 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 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 22nd to 24th and May 25th to 26th, 2006 for replications 1 & 2 and 3 & 4, respectively. 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. Ordram® was used for grass control. Shark® and Londax® were applied for broadleaf weed control. One application of Mustang® was applied for rice water weevil control.

Tables 1 to 6 contain a summary of performance information from the 2006 Statewide Yield Tests. Yields are reported as paddy rice in pounds per acre at 14% moisture. Yield data from the Yuba location was not included due to variability because of weed control problems. The San Joaquin location was not available in 2006, but a new location is being sought for 2007. 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 2007. Complete results of the 2006 Statewide Yield Tests are reported by UCCE in "California Rice Varieties Description and Performance Summary of 2006 and Multiyear Statewide Rice Variety Tests in California" 2006 Agronomy Progress Report, UCD. ◆

Table 1. Agronomic performance means of very early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Sutter, Yolo, and RES locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
13	L206	L	4.8	71	93	29	6.2	9990	9100
17	04Y508	L	4.8	76	97	15	4.9	9800	9150
14	04Y501	LR	4.9	72	105	36	5.2	9520	8850
16	01Y655	LR	4.9	81	102	10	4.5	9490	8980
12	L205	LR	4.9	77	95	38	5.2	9350	8630
9	M206	M	5.0	71	100	74	5.6	9280	8810
3	04Y177	SPQ	4.7	71	94	93	5.4	9210	8520
2	S102	S	4.8	73	100	82	6.0	9170	9230
10	03Y254	M	4.9	75	105	88	5.6	9070	8770
15	02Y516	L	4.8	71	105	26	5.1	9000	8770
8	M202	M	4.9	80	101	59	5.4	8960	8750
5	03Y166	SPQ	4.7	75	90	16	5.2	8930	7800
6	05Y176	SPQ	4.7	71	86	68	5.1	8620	8150
4	03Y164	SPQ	4.8	78	97	49	5.5	8510	8140
1	CM101	W	4.9	74	101	97	5.0	8490	8250
11	04Y227	M	4.9	68	106	82	5.5	8000	8460
7	M104	M	4.9	67	97	91	6.7	7970	8160
Mean			4.8	73	98	56	5.5	9020	8620
LSD(0.05)			0.1	2.6	4.2	22	0.5	1050	420
C.V. (%)			1.7	2.4	3.0	28	6.1	8.2	6.0

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, and W=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 Sutter, Yolo, and RES locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
50	05Y552	J	4.8	71	93	24	5.4	9510	8900
42	05Y528	L	4.8	74	102	44	4.4	9420	8710
44	05Y490	L	4.9	76	94	36	4.6	9390	8820
33	05Y724	M	5.0	70	100	58	5.7	9340	8990
36	05Y802	M	4.8	80	101	46	6.0	9320	8310
43	05Y519	LR	4.8	75	97	4	5.0	9260	8470
24	04Y218	W	4.6	74	97	44	4.7	9110	8450
30	05Y379	M	5.0	72	99	96	5.4	9080	9210
26	04Y332	MPQ	4.8	74	100	43	4.5	9030	8670
21	03Y167	SPQ	4.7	75	93	25	4.7	8980	7750
25	05Y330	MPQ	4.7	74	98	26	5.5	8950	8660
51	99Y529	L	4.7	75	100	6	4.8	8940	8760
49	03Y151	LR	4.8	79	97	5	5.4	8850	8400
39	05Y850	M	5.0	72	96	81	5.4	8830	8650
38	05Y830	M	4.9	70	98	48	5.6	8830	8070
46	05Y547	L	4.8	72	104	36	5.1	8800	8660
20	05Y196	SPQ	4.8	72	95	92	5.6	8790	8770
35	05Y471	M	4.9	70	105	66	5.6	8780	8610
47	05Y536	L	4.7	76	99	6	4.4	8750	8540
27	05Y299	MPQ	4.9	72	103	93	5.6	8740	8620
40	05Y869	M	4.7	71	104	85	5.6	8710	8820
45	04Y492	L	5.0	73	99	13	5.7	8690	8300
48	04Y523	L	5.0	73	102	44	5.8	8650	8850
31	05Y426	M	4.9	70	97	81	5.6	8580	8140
19	05Y194	SPQ	4.8	73	91	43	5.2	8570	7980
29	05Y282	M	4.9	71	99	70	5.9	8560	8800
22	03Y170	SPQ	4.7	73	90	91	5.5	8540	7700
28	05Y262	M	4.7	73	97	48	5.1	8490	8410
23	05Y175	SPQ	4.8	73	93	97	5.8	8290	7960
32	05Y455	M	4.8	69	102	71	5.6	8140	8430
37	05Y804	M	4.8	70	99	51	6.5	8070	8020
18	05Y178	SPQ	4.8	74	95	83	5.5	8040	8130
41	05Y1072	M	4.8	68	97	55	5.7	8030	8010
34	05Y468	M	4.8	70	97	75	5.2	7790	8400
Mean			4.8	73	98	53	5.5	8760	8540
LSD(0.05)			0.2	2.7	4.5	27	0.5	1000	580
C.V. (%)			2.8	2.7	3.3	37	6.1	8.1	6.9

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, J=jasmine, and W=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 3. Agronomic performance means of early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte and RES locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
78	03Y496	SR	4.8	78	107	1	4.8	10660	10090
77	03Y151	LR	4.8	80	97	1	5.3	10100	9620
76	L206	L	4.7	71	94	36	7.0	10040	9420
74	04Y404	M	4.4	82	98	35	6.0	9870	9750
62	S102	S	4.9	71	103	95	6.1	9740	9080
68	M206	M	4.9	70	106	58	5.3	9560	8980
64	04Y165	SPQ	4.8	81	93	60	5.8	9550	9050
71	M207	M	4.9	74	179	88	5.9	9530	9060
79	99Y529	L	4.7	75	104	16	5.2	9490	9700
72	M208	M	4.8	79	102	59	6.3	9310	9250
75	L205	LR	4.8	79	95	14	5.4	9280	8680
65	04Y189	SPQ	4.7	80	98	91	5.9	9270	8680
70	M205	M	4.8	84	98	16	5.4	9250	9600
66	04Y308	MPQ	4.9	78	100	29	5.4	9130	9130
69	M202	M	4.9	81	102	71	5.3	9000	8980
80	01Y655	LR	4.8	82	108	4	4.9	8870	9080
67	05Y300	MPQ	4.7	81	104	80	5.2	8850	8620
73	03Y804	M	4.8	72	104	73	5.6	8750	8560
63	CH201	SPQ	5.0	80	99	83	7.3	8650	8040
61	CM101	W	4.8	72	100	99	5.4	8590	7520
Mean			4.8	77	104	51	5.7	9380	9040
LSD(0.05)			0.2	3.3	NS	24	0.6	760	380
C.V. (%)			2.7	3.0	33	32	6.6	5.7	5.2

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, S=short grain, SPQ=premium quality short grain, SR=stem rot resistant and W=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 and RES locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
112	02Y565	SR	4.9	76	101	5	4.5	10220	10010
92	05Y408	M	4.6	83	95	13	4.6	9940	9680
108	05Y566	L	4.9	78	97	8	5.3	9830	9790
100	05Y906	M	4.9	70	103	39	5.4	9490	9610
93	05Y446	M	4.8	80	98	34	5.8	9490	9270
106	04Y702	SR	4.6	81	89	1	5.3	9450	8580
98	05Y727	M	4.8	77	98	41	4.9	9440	9530
105	05Y543	L	4.8	76	99	6	6.2	9300	9240
96	05Y704	M	4.5	80	99	18	5.2	9220	9370
107	05Y625	L	5.0	75	98	1	5.7	9180	8730
109	05Y757	L	4.9	75	95	1	5.9	9020	8880
97	05Y712	M	4.8	79	99	44	5.4	9010	9160
95	05Y698	M	4.8	81	99	26	5.3	8980	9350
82	04Y178	SPQ	4.8	75	95	80	5.9	8940	8640
90	05Y281	M	4.8	69	99	68	5.2	8920	8990
91	05Y284	M	4.8	69	101	78	5.6	8820	8490
110	05Y754	SR	4.7	78	95	7	4.6	8750	8880
94	05Y453	M	4.8	82	98	24	4.9	8680	9150
89	05Y244	M	4.8	79	102	31	5.3	8630	8960
83	05Y172	SPQ	4.9	80	100	99	5.8	8490	8150
101	05Y1150	M	4.8	71	96	8	5.5	8470	8370
85	05Y334	SR	4.9	78	102	43	6.1	8470	8400
84	05Y192	SPQ	4.9	77	102	99	5.9	8350	7770
99	05Y900	M	4.9	70	98	16	6.1	8330	8620
88	04Y314	MPQ	4.8	77	101	68	5.4	8260	8600
81	05Y357	LA	4.8	79	100	79	6.8	8030	7820
87	03Y559	MPQ	4.7	77	99	40	5.3	7960	8450
104	05Y629	B	5.0	78	108	28	5.3	7710	7340
86	05Y202	MPQ	5.0	77	101	15	5.2	7700	7710
102	CT201	B	0.9	79	108	11	5.5	7480	7430
111	04Y537	B	5.0	69	104	2	6.9	6950	7300
103	CT202	B	0.9	77	103	40	5.8	6740	6460
Mean			4.8	76	99	33	5.7	8690	8660
LSD(0.05)			0.2	2.5	4.1	21	0.6	820	510
C.V. (%)			3.0	2.4	2.9	45	6.6	6.8	6.0

† B=basmati, L=long grain, LA=low amylose, M=medium grain, MPQ=premium quality medium grain, SPQ=premium quality short grain, and SR=stem rot resistant.
‡ 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 locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
126	03Y576	SR	4.2	89	99	8	4.9	10130	8450
125	04Y641	SR	4.9	83	99	24	4.5	9980	8740
124	05Y657	SR	4.5	84	105	39	5.3	9940	8440
133	03Y151	LR	4.8	84	97	8	5.8	9640	8560
134	04Y706	L	4.8	82	101	18	5.1	9500	8680
129	04Y656	M	4.8	84	97	65	5.2	9360	8190
132	99Y529	L	4.7	79	103	25	5.2	9310	8530
131	L206	L	4.7	73	97	80	7.7	9210	8240
130	L205	LR	4.8	82	97	25	5.2	8920	8150
127	M205	M	4.7	87	98	53	6.0	8840	8120
128	M202	M	4.9	83	103	84	5.5	8620	7730
123	05Y663	SPQ	4.9	84	94	59	6.9	8540	8000
122	CH201	SPQ	5.0	80	99	90	8.2	8420	7430
121	M402	MPQ	5.0	103	101	3	5.0	8280	7850
Mean			4.8	84	99	41	5.6	9190	8220
LSD(0.05)			0.2	5.5	4.3	2.5	1.1	890	460
C.V. (%)			3.3	2.5	3.1	42	9.3	6.8	11.1

† L=long grain, LR=Rexmont type, M=medium grain, MPQ=premium quality medium grain, SPQ=premium quality short grain, and SR=stem rot resistant.
‡ 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 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 locations in 2006.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
137	05Y343	W	4.8	85	104	76	5.4	10110	8510
151	01Y501	SR	4.9	77	102	3	5.0	9740	8650
150	99Y494	LW	5.0	91	97	4	5.7	9450	8660
139	05Y386	M	4.8	81	103	68	5.4	9250	7830
140	05Y387	M	4.7	82	101	78	5.7	9120	7920
152	05Y758	L	4.7	84	96	4	4.9	9090	8130
141	05Y441	M	4.9	82	104	40	5.5	9000	8170
143	05Y714	M	4.9	79	103	74	5.1	8900	7700
142	05Y450	M	4.8	84	93	51	4.8	8850	7910
154	05Y1274	L	4.8	77	96	41	4.8	8720	7940
135	05Y301	MPQ	4.8	85	97	81	6.3	8590	8000
144	05Y913	M	5.0	71	105	91	5.6	8580	7660
145	05Y949	M	4.9	80	106	70	5.9	8480	7830
146	05Y979	M	5.0	74	107	74	6.6	8270	6850
136	04Y625	MPQ	4.7	88	104	56	5.2	8180	8230
147	05Y1000	M	4.9	80	101	49	5.6	8000	7350
138	05Y226	M	4.7	73	104	48	6.1	7790	6740
153	05Y744	J	4.2	93	103	45	7.0	7640	7880
148	CT201	B	4.9	83	105	53	6.2	7140	6730
149	CT202	B	4.9	80	101	85	6.0	6480	6260
Mean			4.8	81	102	54	5.6	8570	7950
LSD(0.05)			0.2	4.8	5.5	24	1.1	790	520
C.V. (%)			3.2	4.2	3.8	31	9.3	6.5	6.6

† B=basmati, L=long grain, M=medium grain, MPQ=premium quality medium grain, LW=long grain waxy, J=jasmine, W=waxy and SR=stem rot resistant.
‡ 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. A summary of the yields of 2006 Preliminary Yield Tests is presented in Table 7. These tests included 784 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 2007 Statewide Yield Tests. ◆

Table 7. Summary of Preliminary Yield Tests at RES in 2006.

Test	Number of Entries	All	Highest	Top 5	Check
		---------------------Average Yield (lb/acre)†--------------------			
Very early					
Short grains	63	8350	9350	9190	9070
Medium grains (A)	34	8500	9080	8920	7960
Medium grains (B)	41	8620	9310	9100	8500
Long grains	75	8600	9840	9760	8510
Early					
Short grains	73	8040	9330	9140	7870
Medium grains (A)	52	8510	9340	9100	8440
Medium grains (B)	52	8680	9920	9570	8710
Long grains	68	7930	9120	8970	8010
Intermediate-Late					
Short grains	34	9000	9970	9750	8090
Medium grains	46	8770	9500	9430	8560
Long grains	30	8370	10400	9830	9240
Special Blast (1 rep)					
Medium grains	216	8050	10510	10210	8260

† Paddy rice yield at 14% moisture.

CALROSE MEDIUM GRAINS

Carl W. Johnson

Calrose medium-grain (CRMG) breeding continues to incorporate improved characteristics into varieties for present and future markets. High stable yield potential, resistance to lodging and disease, seedling vigor, improved milling yields, and resistance to cold temperature blanking are a few of the goals.

Efforts to incorporate blast resistance into CRMG's began in 1996 with crosses involving various cultivars (Southern and foreign) with various genes resistant to the California IG-1 race. In every greenhouse crossing season (summer and winter) resistant material from original crosses plus new sources continue to be back-crossed to adapted germplasm. The Hawaii winter nursery, winter greenhouse, and modified breeding procedures were and continue to be utilized to advance resistant lines. A modified backcrossing scheme is utilized to develop material that is then subject to disease screening, quality, and yield testing. These efforts have resulted in the release of two varieties (M-207 and M-208) with *Pi-z* gene resistance to California blast race IG-1.

In the breeding process, the number of pedigrees that are advanced is reduced each generation by the selection process. This may narrow the genetic base and increase the risk of genetic vulnerability. To reduce this risk, California long grains, premium quality medium grains, and other promising plant introductions from China continue to be used as parents in the medium-grain project.

Plant breeding is a process that involves production of genetic variation and requires time. Integration of old and new techniques, elimination of undesirable genotypes, and identification of superior ones for California's unique environment is a continuing process. Progress in yield improvement, for example, is illustrated by the higher yields of the experimental entries than the highest yielding check variety (Table 7).

Calrose Medium Grain Quality

California's medium-grain market was developed using the variety Calrose released in 1948. The name "rose" indicates medium-grain shape and "Cal" to indicate California origin and production. Specific processing and cooking properties were associated with Calrose. Over the years new varieties with the same cooking properties as Calrose were released. These medium-grains were commingled with Calrose in storage and later replaced the variety in commercial production. Calrose, as a market class, was established and is still used to identify California medium-grain quality. Physicochemical and cooking tests are used to screen experimental entries and verify that new medium-grain variety releases have acceptable Calrose cooking and processing characteristics.

M-208 Released

M-208 was released in the spring of 2006 (see Appendix). M-208 (tested as experimental entry 02-Y-816) is an early, smooth, high yielding semidwarf, Calrose quality medium-grain rice with resistance to California blast race IG-1 derived from the *Pi-z* gene.

M-208's pedigree is M-401/3/ Mercury//Mercury/Koshihikari (97 row 17126)/4/M-204 and this cross, R23324 was made in 1997-1998 winter greenhouse. 97 row 17126 was derived from the cross R19610 made in 1993-1994 winter greenhouse. The male parent of cross 19610 was later released as the medium grain Lafitte (PI593690) by Louisiana State University and was the source for *Pi-z* blast resistance gene.

Table 8. Summary of Agronomic Characteristics in 2003-2005 UCCE Very Early and Early Statewide Yield Test for M-206, M-208, M-207, and M-202.

Character	M-206	M-208	M-207	M-202
Seedling Vigor Score)	4.9	5.0	4.8	4.9
Days to 50% Heading	80	86*	82	85
Plant Height (cm)	98	100	98	98
Lodging (%)	33	33	42	32
Greenhouse Blanking (%)	8	9	11	12
Blanking at Davis (%)	9	15	25	17
Blanking at San Joaquin (%)	7	10	11	13
Overall Blanking (%)	8	11	16	14
Stem Rot Score	6.4	6.6	7.5	6.3
Harvest Moisture (%)	20.9	19.7	18.9	20.9
Yield lbs/acre @ 14 %	8812	8641	8334	8465
Total Milled Rice (%)	68.4	67.9	66.7	68.2
Whole Grain Milled Rice (%)	64.7	63.8	61.3	63.1
1000 Brown Rice Kernel Weight (g)	23.8	24.4	21.6	23.2
Brown Rice Kernel Length (mm)	6.26	6.60	6.42	6.24
BR Brown Rice Kernel Width (mm)	2.82	2.85	2.71	2.85
Brown rice Length/Width Ratio	2.22	2.32	2.36	2.19
Apparent Amylose Content (%)	16.8	17.3	15.3	15.6
Alkali Spreading Score(1.7% KOH)	6.0	6.7	6.2	6.6

* Significantly different than M-206 and M-207 at the .05 level.

M-208, for evaluation purposes, was compared very-early to early M-206, M-207 (first CRMG with *Pi-z* blast resistance) and M-202 (Tables 8 & 9). M-208 is essentially an M-202 agronomic type CRMG that is a significant improvement over M-207. M-208 averaged 1 day and 6 days later than M-202 and M-206, respectively. Compared to M-202, M-208 is similar to M-202 in seedling vigor, lodging (even though it is 2 cm taller), and kernels of M-208 are slightly larger in size and weight (4%) compared to M-206, M-207 and M-202. Resistance to blast has been confirmed by multiple greenhouse and molecular marker tests. The presence of the *Pi-z* gene has been confirmed and rated fixed by two different labs using different markers. Laboratory analyses for physicochemical characteristics by the USDA-ARS Rice Research Unit, Beaumont, Texas, indicate it fits Calrose medium-grain standards. Milled rice samples of M-208, M-206, M-207 and M-202 were distributed to various California rice marketing organizations and individual evaluators. Responses from evaluations indicated M-208 is similar to M-206, M-207 and M-202 with small improvements noted in taste and texture for M-208. M-208 can be commingled with other Calrose medium grains. The parentage of M-401 and Koshihikari appears to have made contributions seed size, weight and cooking quality.

Table 9. Statewide Yield Test over location yield averages of M-206, M-208, M-207 and M-202 for 2003 to 2006. †

Year	Test	M-206	M-208	M-207	M-202
2003	VE SWYT	8680	9020	8460	8340
2004	VE SWYT	9850	9120	9050	9560
2005	E SWYT	7905	7783	7491	7496
2005	Strip Trial	7713	7767	7600	7950
2006	E SWYT	8980	9250	9060	8980
Mean		8626	8598	8332	8465

†Yield in pounds/acre at 14.0% moisture.

M-208 is adapted to the majority of M-202 growing areas north of Yolo/Colusa county line and west of Highway 70. It has specific applications in those areas in Glenn and Colusa counties that have fields with varying degrees of blast damage every year that reduce yields and milling quality. It also provides another CRMG variety option for CRMG production.

Promising Medium-Grain Entries

Medium-grain experimental entries in the very early group of the Statewide Yield Tests ranged from M-104 to M-202 in maturity (Tables 1 & 2). Grain filling duration and rate of dry-down-to-harvest varied among experimental entries, thus moisture at harvest was used as an indicator of maturity. Harvest moisture values at the cool (Yolo), cooler (Sutter), and cold (San Joaquin) locations are useful in eliminating entries that show low temperature delayed maturity or blanking in high N environments.

CRMG lines in the Statewide Yield Tests have harvest moistures lower than M-202. The lower moistures resulted from selection for earlier heading dates and/or more uniform flowering that contributed to faster dry-down rates in ripening. In 2006, ninety-seven percent of 37 1st time entries (2 rep) were 1-2% lower harvest moistures but their heading dates were in the range of regular CRMG checks respectively for each maturity test. Selection for improved lodging resistance, seedling vigor and milling yield is continuing. Eighteen of 37 1st time entries (2 rep) had 1-2 points more head rice than the recognized head rice leaders M-206 and M-205. Increased emphasis in developing rice varieties with blast resistance has produced a large volume of breeding materials. Thirteen CRMG blast resistant entries were evaluated (6 in VE, 3 in E, and 4 in I-L). In general as new generated blast materials are brought on line for statewide testing they are improving in the overall yield stability and head rice potential required by California medium-grain varieties. Pending final review of 2006 data and quality tests, only one CRMG blast resistant entry will be re-tested in 2007.

04-Y-227 (06-Y-11) is a very early, smooth, high-yielding, semidwarf CRMG in the second year of Very Early Statewide Tests. Compared to M-104, it has improved yield (7.3% in cool/cold locations) and stable higher head rice (2 points). It's maturity is 2 days later and seedling vigor are similar to M-104. It will be again retested in 2007. 03-Y-254 mentioned in last year's report will not be tested due to high temperature blanking.

Preliminary Yield Test Entries in Hawaii

There are 30 CRMG entries from 2006 yield tests being grown in the Hawaii Winter Nursery for purification, seed increase, and additional agronomic evaluation (Table 10). Maturities of these entries range from M-104 to M-205. These entries have greater yield potential than their respective highest yielding maturity checks. Their lodging resistance is superior to M-202 and whole grain milling is 2-3 points higher. Overall, these entries are 1-2 inches taller than M-205.

Blast Resistance

RES generated, southern U.S., and foreign germplasm with confirmed resistance to IG-1 continue to be crossed with adapted California germplasm. Experience indicates it will take three to five backcrosses to obtain a respectable high yielding medium-grain with Calrose cooking qualities. Twenty-eight percent (117 of 417) of the CRMG crosses were for blast resistance. Thirty-eight percent of CRMG 2006-07 Hawaii rows (1081 rows) were for IG-1 blast resistance and included 169 pedigrees.

A special test of blast resistant entries was conducted at RES (Table 7). Breeding efforts have overcome the 30% yield drag, higher blanking levels, and lower milling yields, and have produced improved experimental lines with blast resistance. There are 71 entries with blast resistance that yielded more (up to 24%) than the average of all checks. The 63% discard rate of experimental lines attests to the challenges of developing adapted blast resistant lines in the CRMG. Selected entries range from M-104 to M-202 maturities. Each generation of blast materials show increases in resistance to blanking and improved head rice. Ten blast resistant lines have shown sufficient agronomic merit and are being advanced in Hawaii for testing in 2007.

Another yield test with selected entries from 852 rows is planned for 2007. Greenhouse tests confirm they have at least one gene for blast resistance. The performance of these entries suggests that more CRMGs with blast resistance will be in some stage of seed increase in the next five years. The blast gene incorporation is one of the most exciting areas of CRMG research for yield and quality advances.

Table 10. Preliminary Yield Test Calrose medium-grain entries selected and advanced in the 2005-06 Hawaii Winter Nursery.

Source	No. of Entries	No. Selected	No. in Hawaii
All entries	441	148	30
Stem rot	4	1	0
Seedling vigor	2	1	0
Blast resistance	216	71	10

Herbicide Resistance

Several crosses made onto herbicide resistant Clearfield® rice germplasm were advanced, but will be abandoned at the request of the patent holder. No breeding research was conducted on transgenic herbicide resistant M-202 in 2006 by RES.

Milling Quality

Selection for grain quality factors continues to be an integral part of the RES medium-grain breeding effort. Increased emphasis has been placed on identifying experimental lines with improved milling yields. Head rice yield is one of the important criteria for advancing a breeding line. Harvest moisture, plant density, and morphological characteristics are continually being examined to determine their effects on milling yield. Characteristics identified in superior head rice lines and their progeny continue to be evaluated as selection criteria to help expedite breeding progress for milling yield.

Milling tests for CRMG lines begin on entries in the Preliminary Yield Tests. There were 441 entries at this stage in 2006. Fifty-two of the 151 saved entries had head rice similar to the best CRMG check. The current standard bearers for best head rice checks are M-103, M-206, and M-205. Thirty-four of 71 advancing blast entries had head rice equal to the respective CRMG check. There is a significant tendency for lower yielding entries to have higher head rice values, but there are exceptions for several of the higher yielding entries.

Advanced experimental lines in the second year of statewide testing and/or at the breeder increase stage were evaluated for head and total milled rice. Samples were collected from seed increase fields and side by side experimental plots for comparison with standard varieties. Milling samples were harvested twice a week from these experiments as the grain moisture levels decreased from 25 to 17%. In addition, all other CRMG experimental lines plus check medium-grain entries in the Statewide Yield Tests were grown in adjacent triplicate rows. The first row was harvested 45 days after heading; the second row was harvested one week later; and the last row harvested 5 to 8 days later. These samples were used to determine an average head and total milled rice from high (23 to 25%), intermediate (19 to 21 %), and low (16 to 17%) grain harvest moistures. Selection for head and total milled rice using multiyear results continues to be successful assuring that future releases will have the potential for improved head rice.

The environmental effects on head rice yield vary every year. An important breeding goal is to minimize these environmental influences by selecting for various genetic characters influencing head rice. Ninety-nine percent of milling rows for Statewide and Preliminary Tests headed in a 10 day period. No particular trends were noted. In previous years the dry down rate in VESW test has proven to be a useful tool.

SR Resistance

Increased effort in breeding for improved SR resistance continues to obtain only M-201 level of resistance in adapted CRMG. The breeding pipeline continues to utilize more resistant lines from the short-grain and long-grain projects. Lines with reasonable agronomic performance show average SR scores only a half point below M-201. Poor seedling vigor, high floret blanking, and low yield performance are also strongly associated with low SR scores in CRMG germplasm.

Selection criteria and breeding procedures for early CRMG's with high yield, blanking resistance, good milling quality with high SR resistance are being modified to identify building blocks in evolving germplasm. General plant health at harvest has always been an important selection criterion for lodging and indirectly has influenced SR scores in a positive manner. Until SR resistant CRMGs are available as building block germplasm, selection will focus on a combination of SR score (35 days after heading) and the ability of all tillers to stay green (observed at 55 days after heading).

Genetic Discovery

Before the advent of herbicides, the only control for water grass was deep water for the tall varieties being grown. In 2005, adapted CRMG germplasm was discovered that could have the potential to allow growers to maintain a continuous 8 inch or deeper flood. A special 2006 yield test demonstrated that this germplasm would come through continuous 8 inch flood, produce a yield within 300#'s/A of the check variety, and has head rice similar to check variety. 2007 experiments are planned in conjunction with the UC weed control project to further evaluate this germplasm in water-depth/weed emergence experiments. This germplasm is not related to the submergence gene, but has the potential to add another tool for weed control. This germplasm has been, and will continue to be, incorporated into standard varieties, evaluated for inheritance, and for any positive/negative effects on agronomic characters.

2006 CRMG Breeding Observations

1. The 3 weeks of high July temperatures appeared to cause 2 time frames of sterility that helped to discard 5% of early generation materials (F_2's) and 15% progeny rows.
2. The cold Delta nursery was the best since 1989 in evaluating blanking resistance and delay caused by cool temperatures.
3. There was a good correlation (r=0.80) between high temperature sterility at RES and cold temperature blanking in F_2 CRMG populations.

4. The high sustained temperatures in 2005 and 2006 created kernel development responses to identify superior milling germplasm.

Other Activities

Efforts to transfer high levels of seedling vigor continue to be decreased because of higher priority of blast resistance. Progress has been made in improving straw strength with experimental lines having lodging resistance equal to or better than M-204. This represents progress over M-104 and M-202 lodging scores. Resistance to low temperature blanking continues to be screened in the refrigerated greenhouse and in cool and cold locations. The re-established San Joaquin nursery continues to provide important screening characters for yield test entries, early generation and F_2 nursery (blanking, maturity delay, adaptation, awns, premature dying, growth response, and emergence).

2006 Project Summary

1. 02-Y-816 was released to growers in 2006 as M-208. It is an early CRMG with IG-1 blast resistance and is adapted to the majority of M-202 production areas. 04-Y-427 (VE CRMG) has shown improved yield and stable head rice (2 points) when compared to M-104 after two years of statewide testing.
3. Fast track efforts to develop other CRMG blast resistant varieties continue with lines being advanced in Hawaii. These lines, along with other blast material, continue to show increased potential.
4. Germplasm discovered in 2005 continues to show potential as another week control tool by allowing a continuous 8 inch flood after sowing.
5. Chinese introgression lines continue to show increase yield potential.

2007 Research Direction

1. 04-Y-427 will be thoroughly evaluated for adaptation the cooler/cold rice production areas. Purification for seed increase will continue.
2. Continue fast track development of CRMG varietal development with blast resistance to include yield, head rice and cooking evaluation. Special blast yield trial results indicate there could be another 5-7% yield increase. Plan for the use of DNA markers in early generation blast selection and evaluate the 7 day earlier M-208 selections.
3. Evaluate the potential of 2005 germplasm discovery in utilizing an 8 inch continuous flood as an additional tool for weed control.
4. Conduct a preliminary yield test in the Delta for specific variety types in this cultural system.
5. Incorporate new germplasm for SR and sheath spot resistance from other RES projects and using a combination of low SR score and stay green types as selection criterion.
6. CRMG variety development will continue evaluating CRMG materials that are in the breeding pipeline that do not have blast resistance but have significant improvements for beneficial agronomic and quality traits.

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) Newrex, 3) Jasmine, and 4) Basmati types. Milling and cooking quality improvements of conventional long-grain and specialty 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 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. California long-grain varieties have improved considerably in recent years in cooking quality components. L-204, has an intermediate amylose and gel type and moderate viscogram profile. A subtle difference still exists in softness of cooked rice of L-204 and Southern long grain. Extensive quality research and breeding efforts are underway to address this issue in future long-grain varieties.

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 percent lower than L-204. 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 (Table 11). Average heading date is 4 days earlier than L-205 and M-202. Plant height is 6 cm shorter than L-205 and 11 cm shorter than M-202. Lodging potential is not significantly higher than L-205, however, due to earlier maturity plants may lean due to excessive dryness after harvest maturity. Susceptibility to cold induced blanking and reactions to stem rot and aggregate sheath spot pathogens are not significantly different from L-205 and M-202. Plants of L-206 are glabrous and anthocyanin pigmentation occurs only in apiculi. L-206 has slightly stronger amylographic profile, as shown by higher cool paste viscosity and RVA setback values. Consequently cooked grain texture of it is less sticky than L-204. Similar to Southern long grain types, L-206 has intermediate amylose and gelatinization temperature types.

Grain Yield of L-206 has been significantly higher than M-202 at the RES location and similar to L-205 and M-202 at Sutter-East test location, averaging 8930 lb/acre in cooler location of Sutter-east and 10,170 lb/acre at RES (Table 11). Yields at colder locations of Yolo and San Joaquin and the warmest location of Glenn were not as competitive as M-202. Grain Yields tested in additional locations during 2005 and 2006 were not significantly different from L-205 or M-202. Based on these results, L-206 should be adapted to most of the rice growing regions of California except the coldest locations of Yolo and San Joaquin Counties and the warmest locations of Glenn County. Average head rice yield of L-206 during 2001 – 2005 seasons was 62.8 % which is 0.6% lower than L-205. Kernels of L-206 are shorter than L-204 and slightly larger than L-205.

Other promising conventional types that are being evaluated in detail in advanced generations include 04-Y-508, 02-Y-516, 99-Y-529, and 04-Y-706, which posses improved agronomic and quality traits. During the 2006 season, a total of 92 advanced conventional long-grain selections were tested in statewide and preliminary yield tests. Performance results of a selected number of these entries are listed in Table 12. A selected number of long-grain germplasm lines from southern US breeding programs and Indica introductions from USDA were used in 2006 crossing program for blast resistance, cooking quality, and milling quality improvements.

Table 11. Agronomic Characteristics of L-206, L-205 and M-202 Averaged Over Sutter East and RES Locations During 2000-2005 (Grain Yields are Averaged Within Locations).

Character	L-206	L-205	M-202
Seedling Vigor Score†	4.5	4.6	4.8*
Days to 50% Heading	82	86*	86*
Plant Height (cm)	86	92*	97*
Lodging (%)	24	11	41*
Yield lbs/acre @ 14 %, RES	10170	10050	8900*
Yield lbs/acre @ 14 %, Sutter-East	8930	8850	9000
Harvest Moisture (%)	14	16	19*
Head Rice Yield (%)	62.8	63.4	--
Greenhouse Blanking (%)	8	5	15
Stem Rot Score‡	5.5	5.6	5.2
Aggregate Sheath Spot Score§	2.4	2.6	2.2

† Seedling vigor visual score where 1= poor and 5=excellent
‡ Stem rot score where 0=no damage and 10=plant killed.
§ Number of top leaves killed by aggregate sheath spot.
* Significantly different than L-206 at the 0.05 level.

Table 12. Performance of conventional long-grain entries in 2006 yield and milling tests.

Entry	Identity	-----Yield (lb/acre) †-----		Blanking	Head Rice
		Statewide	RES	(%)	(%)
Very Early Statewide					
14	02Y516	8770	9000	18	66
17	04Y508	9150	9800	15	65
48	04Y523	8850	8650	22	63
13	L-206	9100	9990	15	60
Early Statewide					
79	99Y529	9700	9490	12	66
108	05Y566	9790	9830	15	65
76	L-206	9420	10040	12	62
Intermediate Statewide					
134	04Y706	8680	9500	8	65
132	99Y529	8530	9310	12	66
131	L-206	8240	9210	12	62
Very Early Preliminary					
510	05P3031	--	9800	15	65
507	05P2922	--	9580	25	63
477	L-206	--	9650	12	63
Early Preliminary					
605	05P3294	--	9120	8	68
599	05P3111	--	8920	12	66
552	L-206	--	8750	8	63
Intermediate Preliminary					
704	05Y743	--	10400	18	66
701	05Y753	--	9860	35	65
699	L-205	--	9240	8	64

† Grain yield at 14% moisture.

Use of DNA markers to determine the type of amylose synthesis gene has been successfully tested in this program and is being gradually merged with the current wet chemistry methods. This effort is in cooperation with USDA rice genetics lab at UCD and depends on the use of high capacity instruments for DNA analysis. A smaller capacity and less expensive system have been assembled in 2006 in breeding lab at RES. This system is being used for the analysis of blast and waxy marker genes in a limited number of breeding materials. Availability of on-site DNA analysis system can be a valuable tool for breeding programs at RES, especially with the development and availability of new genetic markers.

Newrex Type

Newrex is special quality rice that has 2 to 3% higher amylose content and a stronger viscogram profile than conventional long grains. Because of these characteristics, Newrex types cook dry, exhibit minimal solids loss during the cooking, and are a superior type for canned soups, parboiling, and noodle making. The dry cooking characteristics of a Newrex type variety may help address the soft cooking tendency of California grown conventional long-grain rice.

The Newrex type variety L-205 has shown superior processing qualities and excellent agronomic characteristics. Milling yield reductions in post harvest handling have been reported. Modifications in milling and storage procedures are expected to alleviate this problem. Fissuring studies are also underway in the long grain project to monitor fissure developments of advanced breeding lines during a period of time and storage condition that simulates commercial storage.

Performance of selected Newrex type entries in 2006 yield tests are shown in Table 13. Several experimental lines performed well in statewide trials, with yields, averaged over location, ranging between 8850 and 10,090 lb/acre compared 8490 for L-205. Several entries have also shown similar or higher head rice yields as compared with L-205.

Table13. Performance of Newrex type long-grain entries in 2006 yield and milling tests.

Entry	Identity	----Yield (lb/acre)†-–		Blanking	Head Rice
		Statewide	RES	(%)	(%)
Statewide					
78*	03Y396	10090	10660	12	65
49, 77, 133	03Y151	8860	9530	18	66
16, 80	01Y655	9030	9180	8	62
14	04Y501	8850	9510	15	61
12, 75, 130	L-205	8490	9130	8	62
Preliminary					
497	05P2659	--	9250	18	64
502	05P2735	--	9130	8	64
575	05P2781	--	8970	12	68
476, 551	L-205	--	8260	8	63

*Entry 78 is also a stem rot resistant line
†Grain yield at 14% moisture.

Specialty Long Grains

A considerable number of basmati lines were evaluated in 2006 tests for their agronomic and cooking quality characteristics (Table 14). Twenty-one advanced selections with improved cooking qualities were tested in statewide and preliminary yield tests. A number of basmati lines with considerably more slender grain and flaky cooked grain texture are currently being advanced in the Hawaii Winter Nursery and will be tested for yield performance in 2007. Emphasis in basmati selections is being placed on recovering slender and flaky-cooking kernels with higher elongation ratios.

Efforts continued in 2006 to breed 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 KDM has been a significant barrier. The original Thai Jasmine variety, Kao-Dak-Mali 105 (KDM), was irradiated with gamma ray and a number of early mutants, including 02-Y-710 and 02-Y-712, were obtained. These early mutants are serving as valuable germplasm source for further agronomic improvements. Twenty-six advanced jasmine type selections were tested in 2006.

A limited number of high yielding waxy long-grain lines are also being advanced. Waxy lines are used as donor parents in cold tolerance and yield improvement efforts. Resulting waxy selections can be developed into a waxy long-grain variety if needed.

Table 14. Performance of specialty long-grain entries in 2006 yield and milling tests.

Entry	Identity	Specialty Type	---Yield (lb/acre)†--- Statewide	RES	Blanking (%)	Head Rice (%)
Statewide						
153	05Y744	Jasmine	7880	7640	50	52
104	05Y629	Basmati	7340	7710	15	57
102, 148	CT201	Basmati	7080	7310	35	62
103, 149	CT202	Basmati	6360	6610	18	59
76, 131	L-206		8830	9630	8	61
Preliminary						
545	05P3644	Basmati	--	7760	12	48
547	05P3661	Basmati	--	7210	12	50
612	05P3421	Jasmine	--	7390	18	57
707	05Y745	Jasmine	--	7460	75	58

†Grain yield at 14% moisture.

Calmati-202

A true basmati type variety was released for commercial production in California in 2006 as ‘Calmati-202’. This variety is an early maturing, semi-dwarf, pubescent, basmati type, long-grain. Seedling vigor is similar to L-205 and M-202 (Table 15). Days to 50% heading is 6 days later than L-205 and 4 days later than M-202. Plant height is the same as L-205 and 8 cm shorter than M-202. Susceptibility to cold induced blanking (greenhouse blanking score), is significantly higher than L-205 and therefore is not adapted to cold locations. Calmati-202 has shown significantly lower yield potential than L-205 and M-202 at the statewide yield test during 2003 to 2005, averaging 6740 lb/acre, which is 73% of L-205 and 74% of M-202 yield potentials.

Grain and cooking quality of Calmati-202 has significant improvement over Calmati-201, and is expected to compete with the imported basmati rice. Due to finer grain shape, potential yield of Calmati-202 is 10% lower than Calmati-201. Lower yield potential, however, can be offset by the higher value that it can obtain in a basmati rice market.

Milled rice kernels of Calmati-202 are longer than Calmati-201 and slightly shorter than imported basmati rice available in the US market (Table 16). Grain width is more slender than Calmati-201, but not as slender as imported basmati rice. L/W ratio shows a significant improvement over Calmati-201. 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.

Table 15. Agronomic characteristics of Calmati-202, L-205, and M-202 averaged over three intermediate/late UCCE Statewide Yield Test locations during 2003 to 2005.

Character	Calmati-202	L-205	M-202
Seedling Vigor Score†	4.9	4.8	4.9
Days to 50% Heading	91	85*	87*
Plant Height (cm)	94	94*	102*
Lodging (%)	21	36	76*
Yield lbs/acre @ 14 %	6740	9230*	9040*
Harvest Moisture (%)	14	16	19*
Head Rice Yield (%)	59.4	63.4	--
Greenhouse Blanking (%)	30	5*	18*
Stem Rot Score‡	6.2	6.3	6.5
Aggregate Sheath Spot Score§	2.7	2.6	2.2

† Seedling vigor visual score where 1=poor and 5=excellent
‡ Stem rot score where 0=no damage and 10=plant killed.
§ Number of top leaves killed by aggregate sheath spot.
* Significantly different than Calmati-202 at the 0.05 level.

Table 16. Grain dimension (mm) of milled and cooked kernels of Calmati-202, imported basmati, and Calmati-201.

Identity	Milled Kernel			Cooked Kernel	
	Length	Width	L / W	Length	Elongation
Calmati-202	7.15	1.95	3.66	14.9	2.1
Basmati import	7.22	1.72	4.19	17.4	2.4
Calmati-201	6.52	2.09	3.12	13.3	2.0

Milling quality

The milling yields of most recent California long-grain varieties represent significant improvement over their predecessors. Under proper harvest management and favorable weather conditions, these varieties are expected to produce high milling yields. 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 without losing milling quality. These may include hull cover protection, grain formation, or physicochemical properties of the grain that result in fissuring resistance. Efforts have been initiated to screen advanced breeding lines of all grain types for their resistance to grain fissuring. In 2006, nearly 200 advanced selections from long and short-grain projects, and 120 selections from medium-grain project were characterized for fissuring susceptibility. This effort will continue in conjunction with RiceCAP project currently underway at RES.

Information obtained from single kernel moisture meter is also being used at RES to evaluate the uniformity of harvest maturity among advanced experimental lines that will ultimately lead to improved head rice yields. Milling yield potential of 32 of the most advanced long-grain lines from the Statewide Yield Tests were evaluated in 2006 harvest moisture studies in two maturity groups.

RiceCAP Project

RES is participating in the RiceCAP project which is a newly established USDA initiative with the objective of applying genomic discoveries to improve milling quality and disease resistance in rice. Four breeding programs (Arkansas, California, Louisiana, and Texas) are providing phenotyping information, and several universities and research institutions are contributing genotyping and molecular research. The goal is to analyze a number of populations and develop genetic markers that are associated with components of milling yield and sheath blight resistance. The specific contribution from RES is providing extensive fissuring studies for 3 milling populations as well as providing and evaluating a California long-grain population for developing molecular markers associated with milling quality. Funding from this project is supporting one post graduate research associate, one technician, and related expenses. This project will gradually be linked with marker aided selection efforts that is being established at RES. Further information on the status of this 4 year project can be found at http://www.uark.edu/ua/ricecap/.

Disease Resistance

SR resistance originating from *Oryza rufipogon* has been transferred to a number of high yielding long-grain lines. Twenty-two entries with a range of SR resistance were tested in 2006 Statewide and Preliminary Yield Tests. Performance of a selected number of these lines is shown in Table 17. Entries 78 (03-Y-496), 112 (02-Y-565), and 151 (01-Y-501) continue to show significant improvement because they have combined low stem rot score, low blanking, early maturity, and high yield potential for the fourth year. Even though SR scores are not as low as the original germplasm line 87-Y-550, grain yields of both lines are consistently higher than susceptible variety L-205. Three selections in the intermediate preliminary yield test (Table 7) had the highest grain yield in their maturity group, indicating a significant yield advantage over susceptible lines.

Improvements in milling yield, cold tolerance, and early maturity of SR resistant lines to the levels of L-204 and L-205 varieties is being pursued through further crossing and backcrossing. A considerable number of early generation SR resistant breeding lines were selected in 2006 in cooperation with the RES plant pathologist.

Breeding efforts are also progressing to develop California long-grain lines with resistance to rice blast. Southern blast resistant varieties are donating one or two major genes conferring resistance to blast race IG-1 found in California. Cooperative efforts continued in 2006 with the UC Davis for use of genetic markers for blast resistance screening. The new RiceCAP project grant is also contributing to capacity building and use of marker aided selection at RES. ◆

Table 17. Performance of conventional long-grain entries with resistance to stem rot in 2006 yield and milling tests.

Entry	Identity	DR†	SV‡	Day§	Ht (cm)	---Yield (lb/acre) ¶-- Statewide	RES	SR#	Blanking (%)	Head (%)
Statewide										
78	03Y496	SR	4.8	83	106	10090	10660	4.8	8	65
112	02Y565	SR	4.8	80	102	10010	10220	4.5	12	58
151	01Y501	SR	4.9	78	97	8650	9730	5.0	15	61
76, 131	L-206	L	4.9	75	95	8830	9630	7.0	8	61
Preliminary										
704	05Y743	SR	4.5	85	86	--	10400	5.3	8	66
701	05Y753	SR	4.3	85	89	--	9860	4.4	35	65
709	05P2521	SR	4.6	80	97	--	9750	5.2	15	67
699	L-205	REX	4.6	78	97	--	9240	5.4	5	66

† DR=Disease resistance, SR=stem rot.
‡ SV=seedling vigor score where 1=poor and 5=excellent, § Days to 50% heading,
¶ Grain yield at 14% moisture, SR#= stem rot score where 0=no damage and 10=plant killed.

PREMIUM QUALITY & SHORT GRAINS

Junda Jiang and Kent S. McKenzie

For the past six years, this project has experienced several changes in project leadership due to administrative issues and restructuring, as well as turnover in professional staff. Breeding efforts have continued, but evaluation and selection of material in the project has slowed and not moved forward as desired. In 2006, considerable efforts by the short grain breeder were made in quality evaluations on advanced breeding material that had been accumulating in the project. Results of the quality testing has been included the tables in this section. It should be noted that small, hand- harvested, air dried samples from flooded rows frequently produce very high milling yields. These results are used for making relative comparisons in the selection process, and are not an accurate prediction of commercial milling yields.

In addition, an expanded effort was made in the premium quality short and medium grain crossing program in the past two years. This involved a large number of three-way and/or backcrosses to premium varieties with the hope of recovering the premium cooking that is so elusive. Intense selection on the material from these crosses is ready to begin in 2007. A project leader will be assuming responsibility for this part of the RES Breeding Program and will be working with staff to move forward.

Research for this project is primarily focused on genetic improvement of premium quality short and medium grains. Secondary objectives include conventional short grains and waxy short grains. A much smaller effort is given to low amylose lines, bold grains (Mediterranean or Arborio types), and water weevil resistance breeding. The emphasis and breeding goals do vary for the different grain and quality types.

Premium Quality

"Premium quality" is a term used to identify the California medium-grain varieties like M-401 that have unique cooking characteristics preferred by certain ethnic groups (e.g. Japanese and Korean). Premium quality medium grains are very glossy after cooking, sticky with a smooth texture, and remain soft after cooling. Aroma and taste are also cited as important features. These types are similar to the high quality short-grain Japanese varieties like Koshihikari. Premium quality is a complex rice quality characteristic and developing improved high yielding premium quality varieties adapted to California continues to be a difficult breeding challenge.

Short Grains

Calhikari-201, a semidwarf, early maturing, premium quality short-grain variety was developed by a complex crossing and selection program to capture the cooking characteristics of the premium quality Koshihikari and agronomic advantages of California short grains. It represents the first release of an adapted premium quality short grain for California. Agronomic performance and yields of Calhikari-201 is superior to Koshihikari, however, its cooking quality is below Koshihikari and it has not been well accepted by the Japanese market. Calhikari-201 is susceptible to stem rot and cool temperature induced blanking, and does not yield as well as California conventional short grains like S-102. Breeding efforts are targeting improving these weaknesses as well as trying to achieve further quality improvements.

Sixteen advanced premium quality short-grain (SPQ) breeding lines were included in the 2006 UCCE Statewide Yield Test (Tables 1-6). Yield and quality data on these advanced breeding lines are summarized in Table 18. An additional forty preliminary SPQ breeding lines were tested in the Preliminary Yield Tests at RES. Table 19 contains yield and quality data for the best cooking lines.

Medium Grains

A parallel breeding effort is continuing to develop improved premium quality medium grains for the M-401 market. Ten advanced premium quality medium-grain (MPQ) breeding lines were included in the UCCE Statewide Yield Test (Tables 1-6). Yield and quality data on these advanced breeding lines are summarized in Table 20. Fifty-one preliminary MPQ breeding lines were tested in the Preliminary Yield Tests at RES. Table 21 contains yield and quality data for the best cooking lines. Selection emphasis in MPQ materials is toward larger kernels with M-202 grain and milling yields and M-401 cooking quality.

Premium quality selections with good yield potential, blanking and/or disease resistance will be evaluated in cooking tests. Several of the advanced lines have been grown in headrows for advancement and purification and/or are being advanced in the Hawaii winter nursery. Selected lines and new selections will undergo further quality evaluations in cooking and laboratory tests during the winter. Agronomic data including disease and blanking resistance will be combined with quality data to select entries for further testing in 2007. Superior lines will be used as parents in future crosses.

Other Activities

Conventional short grain breeding activities are directed toward making improvements in S-102, including incorporating the glabrous trait and improving disease resistance. Breeding work is continuing to develop replacements for the waxy variety Calmochi-101. Yield, disease resistance, and quality are all research objective areas for improvement. Results of the more advanced lines are included in Tables 1-7. New breeding lines advanced from small plots and progeny rows in 2006 will be evaluated further in 2007.

A small number of bold grain types, similar to the Italian varieties like Arborio, are generated and tested each year. A variety of kernel shapes and levels of chalkiness are being recovered, and most are better milling but have smaller kernel size than Arborio. Quality evaluations remain a problem and interest by marketing organizations is limited.

Calamylow-201, a low amylose short grain, was released for a small specialty market in development (See Appendix). Crossing and selection is continuing to develop improved low amylose materials.

A small amount of screening and selection for tolerance to rice water weevil is being maintained, however, efforts in this area are declining due to other priorities.

Table 18. Yields and quality results for advance premium quality short-grain experimental entries in 2006 UCCE Statewide Yield Tests.

Entry Number	Identity	Grain Yield† 2006	Grain Yield† 2005	Head/Total ‡ 2006	Head/Total ‡ 2005	Milled Score§ 2006	Milled Score§ 2005	Kernel Wt.¶ 2006	Kernel Wt.¶ 2005	Cook# C1	Cook# C2
2	S102	9170	8350	63/72	70/74	4.6	4.7	25.9	27.0	4.2	4.3
3	04Y177	9210	7090	70/72	71/72	4.9	4.9	18.0	19.1	4.7	4.7
4	03Y164	8510	8210	65/69	68/70	4.9	4.9	19.1	19.8	4.6	4.6
5	03Y166	8930	7860	65/70	66/69	4.8	4.8	19.5	20.3	4.6	4.6
6	05Y176	8620	8070	66/72	68/71	4.8	4.8	20.4	19.4	4.6	4.6
18	05Y178	8040	8320	67/73	69/73	4.7	4.9	19.8	19.8	4.6	4.4
19	05Y194	8570	7630	65/70	65/69	4.7	4.8	20.9	20.4	4.6	4.5
20	05Y196	8790	7660	67/73	64/73	4.8	4.8	22.0	21.1	4.6	4.5
21	03Y167	8980	7300	65/70	66/69	4.8	4.8	20.5	20.6	4.5	4.5
22	03Y170	8540	6780	71/74	70/74	4.8	4.9	21.3	21.9	4.5	4.3
23	05Y175	8290	7500	68/73	71/73	4.7	4.9	19.0	20.4	4.5	4.5
63	CH201	8650	7740	67/74	64/72	4.9	4.8	18.3	20.0	4.5	4.6
64	04Y165	9550	8530	71/74	71/74	4.9	4.8	19.5	20.9	4.6	4.5
65	04Y189	9270	8300	71/74	71/74	4.9	4.8	20.5	22.1	4.8	4.7
82	04Y178	8940	8710	66/72	68/73	4.8	4.9	20.4	21.3	4.4	4.4
83	05Y172	8490	8130	67/71	66/71	4.9	4.8	19.0	19.5	4.5	4.6
84	05Y192	8350	7510	67/71	66/70	4.9	4.8	18.8	19.0	4.6	4.7
123	05Y663	8540	8420	67/73	71/73	4.7	4.8	19.8	20.6	4.6	4.6

† Paddy rice yield in lb/acre at 14% moisture in large plots at RES.
‡ %Head and total milled rice averages of two rows harvested at two harvest moistures.
§ Visual appearance score (1 to 5) of head rice.
¶ 1000 grain weight (g) of milled rice.
# Subjective taste/texture score of cook rice (1 to 5) for C1 is hot and C2 cold in 2005.

Table 19. Yields and quality results for premium quality short-grain experimental entries in 2006 RES Preliminary Yield Tests.

Entry	Identity	Yield†	Head/Total ‡		Milled Score§		Wt.¶	Cook#	
Number		2006	2006	2005	2006	2005	2006	C1	C2
186	S102	9070	61/72	65/74	4.8	4.7	25.9	--	--
189	AKITA	5990	66/71	71/73	4.9	4.9	17.8	4.6	4.6
197	06Y197	8500	65/71	68/70	4.7	4.9	18.4	4.6	4.6
198	06Y198	8450	66/70	63/70	4.8	4.8	18.9	4.3	4.6
199	06Y199	8910	68/71	72/73	4.8	4.9	17.4	4.6	4.6
201	06Y201	8560	64/69	68/71	4.7	4.8	19.0	4.5	4.5
204	06Y204	7510	60/69	71/73	4.8	4.8	18.9	4.4	4.6
205	06Y205	8790	66/70	66/74	4.8	4.8	17.6	4.4	4.7
207	06Y207	7700	60/67	71/72	4.8	5.0	18.1	4.8	4.7
208	06Y208	8320	62/71	71/72	4.9	4.9	17.6	4.8	4.8
210	06Y210	8630	65/70	68/70	4.9	4.7	19.8	4.5	4.5
212	06Y212	8450	65/71	69/70	4.8	4.8	18.9	4.5	4.6
352	06Y352	7830	67/70	69/70	5.0	4.8	19.3	4.5	4.5
354	06Y354	8450	68/72	70/73	4.9	4.9	19.1	4.6	4.5
357	06Y357	8340	67/73	63/73	4.9	4.9	19.0	4.5	4.5
359	06Y359	7730	65/71	71/73	5.0	4.9	18.6	4.6	4.7
634	KOSH	5790	61/70	68/71	4.7	5.0	18.5	4.7	4.6
636	CH201	7930	65/72	66/72	4.9	4.8	18.5	4.7	4.6
638	06Y638	9030	70/73	72/74	4.8	4.8	18.8	4.6	4.7
630	06Y640	8000	65/70	69/70	4.9	4.9	17.0	4.5	4.6

† Paddy rice yield in lb/acre at 14% moisture in large plots at RES.
‡ %Head and total milled rice averages of two rows harvested at two harvest moistures.
§ Visual appearance score (1 to 5) of head rice.
¶ 1000 grain weight (g) of milled rice.
# Subjective taste/texture score of cook rice (1 to 5) for C1 is hot and C2 cold in 2005.

Table 20. Yields and quality results for advance premium quality medium-grain experimental entries in 2006 UCCE Statewide Yield Tests.

Entry Number	Identity	Grain Yield† 2006	Grain Yield† 2005	Head/Total ‡ 2006	Head/Total ‡ 2005	Milled Score§ 2006	Milled Score§ 2005	Kernel Wt.¶ 2006	Kernel Wt.¶ 2005	Cook# C1	Cook# C2
8	M202	8960	8700	68/70	68/70	4.8	4.8	20.8	--	4.5	4.5
25	05Y330	8950	7700	64/69	63/67	4.8	4.9	21.5	22.9	4.6	4.5
26	04Y332	9030	8280	69/71	69/71	4.8	4.8	22.9	23.5	4.1	4.1
27	05Y299	8740	7460	68/72	67/71	4.8	4.8	22.8	23.0	4.4	4.5
66	04Y308	9130	7610	70/72	70/72	4.8	4.8	20.5	22.3	4.5	4.5
67	05Y300	8850	7610	70/72	65/73	4.7	4.9	23.0	24.1	4.6	4.6
86	05Y202	7700	7660	68/72	70/73	4.9	4.9	22.3	23.1	4.5	4.5
87	03Y559	7960	9140	70/73	67/71	4.8	4.8	21.9	21.5	4.5	4.6
88	04Y314	8260	8240	71/73	67/72	4.7	4.8	21.5	23.0	4.3	4.4
121	M402	8280	8570	66/72	67/79	4.7	4.8	20.8	21.3	4.4	4.4
135	05Y301	8590	7440	71/72	66/70	4.9	4.8	22.8	23.9	4.7	4.6
136	04Y625	8180	9170	67/71	63/68	4.9	4.9	21.8	23.1	4.0	4.3

† Paddy rice yield in lb/acre at 14% moisture in large plots at RES.
‡ %Head and total milled rice averages of two rows harvested at two harvest moistures.
§ Visual appearance score (1 to 5) of head rice.
¶ 1000 grain weight (g) of milled rice.
# Subjective taste/texture score of cook rice (1 to 5) for C1 is hot and C2 cold.

Table 21. Yields and quality results for premium quality medium-grain experimental entries in 2006 RES Preliminary Yield Tests.

Entry	Identity	Yield†	Head/Total ‡		Milled Score§		Wt.¶	Cook#	
Number		2006	2006	2005	2006	2005	2006	C1	C2
161	M104	7920	62/69	70/72	4.7	4.8	23.5	4.3	4.3
162	M206	8470	70/71	71/72	4.8	4.9	21.8	--	--
168	05Y318	7744	70/73	70/73	4.8	5.0	21.6	4.6	4.5
169	05Y329	8504	66/70	64/68	4.9	4.8	22.4	4.6	4.6
171	06Y171	7800	70/71	71/72	4.8	4.9	19.5	4.6	4.6
172	06Y172	7820	69/71	69/70	4.9	4.8	19.6	4.6	4.6
174	06Y174	7710	68/71	71/72	4.9	4.8	20.9	4.5	4.6
175	06Y175	7760	68/70	70/71	4.9	4.8	21.6	4.7	4.7
177	06Y177	8020	70/71	70/71	4.9	4.7	20.3	4.6	4.5
321	06Y321	8120	70/71	71/72	4.9	4.8	19.6	4.6	4.6
322	06Y322	8180	71/72	71/73	5.0	4.9	21.4	4.7	4.7
323	06Y323	7750	69/71	68/71	5.0	4.9	22.4	4.7	4.7
325	06Y325	7590	70/72	71/73	5.0	4.8	22.1	4.7	4.7
326	06Y326	8040	69/71	68/72	5.0	4.8	20.0	4.4	4.6
327	06Y327	7480	69/70	69/71	5.0	4.9	19.8	4.7	4.7
331	06Y331	7940	70/72	70/72	4.9	4.9	21.0	4.7	4.7
335	06Y335	7190	69/71	71/72	4.8	4.7	20.9	4.8	4.8
338	06Y338	7420	69/70	72/73	4.9	4.8	20.0	4.6	4.6
339	06Y339	7410	68/70	69/71	4.8	4.9	19.8	4.7	4.8
340	06Y340	7510	67/70	70/71	4.8	4.8	18.9	4.7	4.7
619	M202	8090	68/70	67/71	4.9	4.9	20.5	4.5	4.5
622	M-401	5340	57/66	57/66	4.7	4.8	23.8	4.6	4.7
623	M-402	8090	64/69	66/70	4.8	4.8	20.4	4.6	4.6
624	KOKR	4650	54/70	68/71	4.7	4.7	18.1	4.7	4.7
627	06Y627	8180	68/69	72/72	4.9	4.9	20.6	4.6	4.6
629	06Y629	8170	69/71	68/73	4.9	4.9	22.6	4.6	4.6

† Paddy rice yield in lb/acre at 14% moisture in large plots at RES.
‡ %Head and total milled rice averages of two rows harvested at two harvest moistures.
§ Visual appearance score (1 to 5) of head rice.
¶ 1000 grain weight (g) of milled rice.
# Subjective taste/texture score of cook rice (1 to 5) for C1 is hot and C2 cold in 2005.

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 (over 800 crosses last year in a rapid backcrossing program), and screens statewide and preliminary trial breeding lines and varieties (about 2500 rows per year) for stem rot and sheath spot resistance in the field. In the greenhouse, screening is conducted for sheath spot resistance (about 450 entries per year), blast (5000-10,000 entries for major gene resistance), and bakanae (400 entries). The rapid backcross program involves screening about 2800 seedlings for blast, and 24,000 seedlings each for stem rot and sheath spot resistance per year. In addition, early generation materials derived from breeder's crosses are cycled through the disease nursery to identify and verify disease resistant lines (about 6000 rows). Intense selection pressure is applied for important agronomic traits because sources of disease resistance have a number of undesirable characteristics. The objective is to transfer an improved level of disease resistance into future varieties. A major effort is directed toward resistance to blast, but SR continues to receive significant attention. The source of SR resistance also confers aggregate and bordered sheath spot (SS) resistance.

Bakanae disease was recently introduced into California, and work has been completed to determine damage and develop detection and control techniques. Disease screening continues on all statewide yield trial entries.

False smut was found by farm advisor Dr. Chris Greer this past summer. This disease has been a problem in certain areas in the southern United States, and should be watched closely in California.

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 fraction of a percent of the lines screened show higher levels of SR resistance than current varieties. There were about 6000 rows in the 2006 SR nursery.

This year, 3510 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 grain and short grain resistant lines are emerging, but progress has been slow with the medium grains.

Several current varieties and stem rot resistant lines were evaluated for yield in an inoculated disease nursery. The intent is to determine the yield loss associated with a given stem rot score, and at what disease level resistant lines show a yield advantage. This work is possible since resistant lines now have yield potentials approaching current varieties.

The following table summarizes 2004-6 results (only for lines tested in 2006).

		2004		2005		2006	
Variety		SR	Yield	SR	Yield	SR	Yield
L205	L	6.7	8584	5.8	8165	6.5	7444
01Y501	L	5.5	9323	4.7	8684	5.7	7927
01Y502	L	4.7	9126	4.4	8140	5.1	7123
02Y565	L	5.1	8770			5.6	8786
03Y496	L	4.8	9222	4.0	9906	5.2	9010
04Y702	L			3.7	8540	4.7	8454
05Y751	L					5.1	7890
05Y753	L					5.2	7988
05Y754	L					5.1	7989
06Y491	L					5.1	7941
M206	M			5.7	7181	5.9	8321
S102	S	5.8	8152	5.8	8028	7.2	8438
03Y576	S			4.7	8474	5.1	8420
04Y634	S					4.8	8478
04Y638	S			4.6	8362	4.7	8504
04Y641	S					4.9	8537
05Y338	S					5.8	8878
05Y654	S					4.4	8217
05Y657	S					5.3	8102
87Y550	L	3.8	7651	3.8	7811	4.9	8037
$LSD_{0.05}$		0.6	1436	0.6	552	0.4	830

The long grain line 03-Y-496 has out yielded L-205 by an average of 16.6% percent. It has performed well in off-station trials, also. No short grain lines out yielded S-102, but many were comparable. 87-Y-550 is an old resistant line. Some resistance has been lost in materials developed after 87-Y-550, but yield gains have been large.

Because progress in the medium grain has been difficult, an immediate backcross program has been started. Two long grain and two medium grain lines with high yield and resistance from *O. rufipogon* and two lines with resistance from *O. nivara* have been backcrossed with 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. Two hundred eighteen crosses were made this year for this purpose. The mode of inheritance of resistance from *O. nivara* will be determined in 2007. So far, most crosses are at the BC_2F_1 stage, and a few at BC_3F_1. Backcrossing will continue until BC_6 has been made, and material will enter the normal yield-testing program. In addition, progeny from each backcross will be allowed to segregate, and screening will be done through F_4, when the breeders will be able to evaluate progress, and use advancing lines in their crossing programs.

In addition, 161 lines resulting from a cross of M-202 with *O. officinalis* made at the International Rice Research Institute (IRRI) were brought through quarantine. *O. officinalis* has much higher stem rot resistance than *O. rufipogon*, but has a different genetic structure than cultivated rice. Normally, crosses of *O. officinalis* with cultivated rice are sterile. IRRI used embryo rescue to get fertile plants, but dropped the program when they could not get fertile backcross plants. No stem rot resistance was found in these lines. *O. officinalis* was also found to be susceptible to blast. Further crossing of resistant material will be attempted. A recent report of a successful very wide cross of *Zizania* with *Oryza sativa* has been reported, using a special crossing technique. This technique was used in additional crosses of M-206 with *O. officinalis*. One plant (0.2% frequency) was found with resistance equivalent to *O. officinalis.* However, it was sterile both with itself and when used in crosses. Further crossing will continue directly with *O. officinalis*.

Marker research by the USDA at UCD has not identified any markers useful in identifying SR resistance genes so far.

Sheath Spot

O. rufipogon-derived resistance also confers protection against SS. Researchers in the South have found resistance to sheath blight (caused by a similar fungus) in this wild species accession, also.

A greenhouse screening program has been set up to test statewide yield entries (other than those with wild species resistance) for sheath spot resistance. This is especially important for the medium grains, which do not yet benefit from sheath spot resistance derived from *O. rufipogon*. The test revealed large differences in sheath spot resistance among these materials. Correlations between yearly results are about $r^2=0.5$. Sheath spot is more widespread than stem rot, and can cause significant damage. Field tests in the stem rot nursery are inadequate because of interference from stem rot and because of field conditions unfavorable to sheath spot development in many years.

In addition, an immediate backcross program has been started to transfer sheath blight resistance genes from Teqing, Jasmine 85, and MCR10277 to M-206 and L-205 (270 crosses this year). Most crosses are at the BC_2F_1 (and a few at the BC_3F_1) level. Screening strategy will parallel that used for the SR immediate backcross program. Rice CAP researchers are currently developing molecular markers to aid in transfer of this resistance.

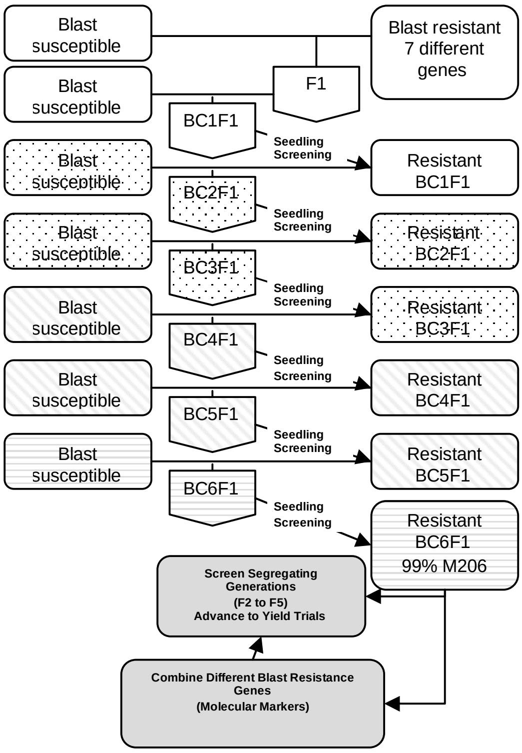
Blast

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 2006, 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. However, more blast was found in 2003 than in any year since 1998. Due to late planting, more M-104 was grown than usual in 2003. 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.

Major resistance genes limit blast symptom expression to small brown flecks at most, but different races of the blast fungus can overcome this resistance in several years after variety release. The low disease pressure in California may delay this expected breakdown. 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. Almost all material presently advancing through the medium grain program possesses only this gene. About 7500 lines were screened for major gene resistance in the greenhouse this past year.

IRRI recently 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 to introduce these genes into M-206.

The following diagram illustrates this program.



Only genes with a wide spectrum of blast resistance in worldwide tests were chosen (Pi-b, Pi-1, Pi-k^h, Pi-k^m, Pi-z^5, Pi-ta^2, and Pi-9). The third backcross has been made and screened for blast resistance (314 crosses this year). The fourth backcross will be made this winter, and the program will continue though six backcrosses. This should take 1-2 more years. By that time, 99.2% of genes in this material will be from M-206. Different blast resistance genes can then be combined using marker assisted selection. These pyramided genes should greatly slow or eliminate the breakdown of major gene resistance. Lines with different single resistance genes can simultaneously be advanced to yield testing.

A cooperative project with the USDA laboratory at Davis to develop molecular marker screening for these resistance genes is continuing.

Markers would allow detection of multiple resistance genes in the same variety or breeding line without actually screening against the races necessary to differentiate these genes. These races cannot be used in California due to fear of introducing them into growers' fields.

Due to sometimes erratic screening results, a series of experiments was designed to increase conventional screening accuracy. California's low humidity environment along with the dry environment in the new greenhouse apparently causes screening problems not faced in the southern U.S. High humidity, temperatures below 80F, the correct amount of nitrogen applied before inoculation, and proper soil dry down increase infection efficiency, whereas high humidity after inoculation increases lesion size. These results were used to revise screening techniques.

Bakanae Disease

Bakanae disease, caused by the fungus *Gibberella fujikuroi* (=*Fusarium fujikuroi*), was found for the first time in Butte and Colusa Counties in 1999. Research at the station established the identity of the disease. It was also found in Yuba and Sutter Counties in 2000 and throughout most of the rice growing region in 2001-2. Incidence was low in 2003 and subsequent years, when seed treatment with 1-5% bleach (6% NaOCl) was widespread. Currently, seed growers should treat with 5% bleach for 2 hours followed by replacement of the treatment solution with plain water. Other growers should treat with 2.5% bleach (no replacement required).

The seed treatment research been concluded. Backup chemicals have been identified in case bleach is no longer available. These treatments are: 1) 5% of a H2O2 (30% solution), 2) 0.5% phosphorous acid (also 0.5% Phosgard or Nutramix which contain 60% phosphorous acid), and 3) 1.75% Perasan (peroxyacetic acid).

Screening breeding lines for bakanae resistance continues. All statewide entries are screened in the greenhouse, and all current varieties are screened in the field as 4x6 plots as well. Correlations between the two types of test have not been very high—further work is necessary. Statewide entries may be screened as rows in the field in the future.

Quarantine Introductions

The building blocks for any breeding program are varieties with traits desirable in commercial production. This past year, one hundred sixty-one more entries were brought through quarantine (representing crosses made at IRRI of M-202 with *O. officinalis* for stem rot resistance).

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 enables 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

D. MARLIN BRANDON RICE RESEARCH FELLOWSHIP

Dr. Marlin Brandon began his career in 1966 as the Rice Farm Advisor in Colusa, Glenn, and Yolo Counties, 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 2006, fellowships of $2,500 were awarded to Rebecca Bart and Louis Boddy, both graduate students at UCD. A total of 12 fellowships have awarded.

CALIFORNIA COOPERATIVE RICE RESEARCH FOUNDATION, INC.

RICE EXPERIMENT STATION
BIGGS, CALIFORNIA 95917-0306
and
CALIFORNIA AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF CALIFORNIA
OAKLAND, CALIFORNIA 94612
and
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, DC 20250

Notice of naming and release of rice cultivar

'CALMATI-202'

Calmati-202 is an early maturing, pubescent, basmati type long-grain selection from the cross R22053 made at the Rice Experiment Station (RES), Biggs, CA in 1996. Its pedigree is 'A-201'/9543483. A-201 is an early maturing aromatic semidwarf long-grain cultivar released by CCRRF in 1996. The male parent, 9543483 is a sister line of 'Calmati-201' with a higher cooked kernel elongation ratio. Calmati-201 is a basmati-type variety release by CCRRF in 1999, and has two basmati plant introductions in its pedigree. They include PI373938, named 'Dehraduni' and PI475918, an introduction from Pakistan which is a semidwarf mutant of 'Basmati 370'. Calmati-202 was tested in the University of California Cooperative Extension (UCCE) Statewide Yield Tests in 2003 as experimental 03-Y-152 and in 2004 through 2005 tests as 04-Y-153.

Calmati-202 is being released for its improved basmati-type kernel and cooking characteristics that approach those of imported basmati rice. Milled rice kernels of Calmati-202 were significantly longer than Calmati-201, and slightly shorter than imported basmati available in the US market. Grain width of Calmati-202 is more slender than Calmati-201 but not as slender as imported basmati rice. Length/width ratio of the Calmati-202 shows a significant improvement over Calmati-201. Apparent amylose content of Calmati-202 is 24 percent which is slightly higher than Calmati-201 based on analysis provided by the USDA-ARS Rice Research Unit, Beaumont, TX. Cooked kernel length of Calmati-202 is also slightly longer than Calmati-201 and subjective texture scores indicate a slightly drier cooked grain texture than Calmati-201. Cooked rice of Calmati-202 that was aged nearly one year was preferred by taste panelists over Calmati-201. Cohesiveness of the cooked grains as well as grain shape and texture of Calmati-202 are clearly distinguishable improvements over Calmati-201.

Seedling vigor of Calmati-202 is similar to L-205 and M-202. Days to 50% heading is 6 days later than L-205 and 4 days later than M-202. Plant height is the same as L-205 and 8 cm shorter than M-202. Calmati-202 has shown significantly lower yield potential than L-205 and M-202 in 2003 to 2005 testing. Greenhouse tests indicate it is susceptible to cold induced blanking, and like Calmati-201, it is adapted only to warmer rice growing areas of California.

Milling tests from 2003 to 2005 have shown an average % head rice milling yield of 59.4, 61.0, 63.4, and 64.5 for Calmati-202, Calmati-201, L-205 and 'L-204', respectively. Grain fissuring studies have shown that like Calmati-201, Calmati-202 is susceptible to fissuring at low harvest moistures. Timely harvest at harvest moisture of 17% and proper handling is recommended to preserve milling and 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.

Application is being made to protect Calmati-202 under the U.S. Plant Variety Protection Act, Title V option, and for utility patents. Breeder and Foundation seed of these cultivars will be maintained by California Cooperative Rice Research Foundation, P.O. Box 306, Biggs, CA 95917-0306.

'M-208'

M-208 is an early, glabrous, high yielding semidwarf, Calrose quality medium-grain (CRMG) rice with blast (*Pyricularia grisea*) resistance (*Pi-z* gene) to the California race IG-1. It is an early selection from the Rice Experiment Station (RES) 1998 cross R23324 and has the pedigree 'M-401'/3/'Mercury'//Mercury/'Koshihikari'/4/'M-204'. The male parent was a breeding line found to be resistant to IG-1, selected from RES cross R19610 made in 1994. M-401, developed at RES, is a late maturing premium quality medium-grain currently grown in California. The male parent of cross R19610 was later released as the medium grain cultivar 'Lafitte' (PI593690) by Louisiana State University Ag Center's Rice Research Station and was the source of the *Pi-z* blast resistance. M-204, also developed at RES, is an early CRMG still in production in California. M-208 is the product of modified pedigree breeding utilizing the Hawaii winter and RES nurseries for generation advance and purification. M-208 has been tested in the University of California Cooperative Extension (UCCE) Statewide Yield Tests 2003 through 2005 under the experimental designation 02-Y-816.

M-208 is the second California rice cultivar released with resistance to blast race IG-1 that is present in California. Blast resistance to IG-1 has been confirmed by multiple greenhouse tests and the utilization of DNA molecular analysis by the USDA-ARS Rice Research Unit, Beaumont, TX and the USDA-ARS Crops Pathology Genetics Research Unit, Davis, CA using different markers.

M-208 was compared to 'M-206', 'M-207' and 'M-202'. M-208 1,000 kernel weight averaged 5% heavier than the other CMRG varieties. Brown rice kernel lengths, widths, and length/width ratios of M-208 are similar to CMRG varieties. M-208 total and whole kernel milling yields are 1 to 2 points higher than M-207. M-208 total milled rice is similar to M-206 and M-202. M-208 whole kernel milled rice is less than M-206 but better than M-202. Laboratory analysis for physicochemical characters (apparent amylose content, alkali score, RVA viscosity, and gelatinization temperature) by the USDA-ARS Research Unit, Beaumont, TX indicate that it fits CRMG standards. Milled rice samples of M-206, M-208, M-207 and M-202 were distributed to various California rice marketing organizations and individual rice quality evaluators in 2004 and 2005. Responses indicated M-208 may have minor quality improvements over M-206 and M-202. M-208 can be commingled with other CRMGs.

M-208 has improvements for lodging, total and whole kernel milling yield over M-207. M-208 is adapted to the majority of M-202 growing areas. Although it has specific application in those areas in Glenn and Colusa counties that have fields with varying degrees of blast damage every year, it also has the potential to be grown in combination with other CRMGs in other areas. M-208 can be best described as an M-202 type with blast resistance. Fertilization requirements will be similar to M-202.

Application is being made to protect M-208 under the U.S. Plant Variety Protection Act, Title V option, and for utility patents. Breeder and Foundation seed of these cultivars will be maintained by California Cooperative Rice Research Foundation, P.O. Box 306, Biggs, CA 95917-0306.

‘L-206’

The California Cooperative Rice Research Foundation, Inc. (CCRRF), the California Agricultural Experiment Station (CAES), and the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), announce the naming and release of a new rice cultivar L-206.

L-206 is a very early to early maturing, glabrous, long-grain selection from the cross R17864 made at the Rice Experiment Station (RES), Biggs, CA in 1992. Its pedigree is ‘L-203’/9039614. L-203 is an early maturing semidwarf long-grain cultivar released by CCRRF in 1992. The male parent, 9039614 is an F_6 selection from the cross ‘Lemont’/3/R1588/ ‘L-201’//R1588/‘Labelle’. Lemont is a semidwarf long-grain cultivar developed by the USDA-ARS, Beaumont, TX. R1588 is a selection of a cross between an unknown introduction, PI321161, and a long-grain selection from RES. L-201 is an intermediate height variety released by CCRRF in 1979. Labelle is a very early long-grain variety with good cooking and milling qualities released by USDA-ARS, Beaumont, TX in 1973. L-206 was tested in the University of California Cooperative Extension (UCCE) Statewide Yield Tests 2000 through 2005 under the experimental designation 99-Y-469.

Seedling vigor of L-206 is similar to ‘L-205’ and slightly lower than ‘M-202’. Days to 50% heading is an average of 4 days earlier than both L-205 and M-202. L-206 is 6 cm shorter than L-205 and 11 cm shorter than M-202. Lodging potential is not significantly higher than L-205, however, due to earlier maturity plants may lean due to excessive dryness after harvest maturity. Susceptibility to cold induced blanking (greenhouse blanking score), and reactions to stem rot and aggregate sheath spot pathogens of L-206 was not significantly different from L-205 and M-202**.**

L-206 has shown significantly higher yield potential than M-202 at RES location and equal yield potential to L-205 and M-202 at the Sutter-East test location in 2000 to 2005 tests. Yields at colder locations of Yolo and San Joaquin counties and the warmest location of Glenn county were not as competitive as M-202. Grain Yields of L-206 tested in additional locations during 2005 were not significantly different from L-205 or M-202.

Milled rice kernels of L-206 are slightly longer than ‘Cypress’, a predominant Southern US variety. Milled kernels of L-206 are slightly longer than L-205 and shorter than ‘L-204’. Average % head rice of L-206, L-205, and L-204 were 62.8, 63.4 and 63.6% respectively, in 2001 to 2005 milling studies. Recommended harvest moisture is 17 percent.

Analysis provided by the USDA-ARS Rice Research Unit, Beaumont, TX, indicated that L-206 is the same as L-204 averaging 22.8 percent apparent amylose content with intermediate type alkali spreading values, and is similar to the traditional southern long-grain varieties,. The primary difference in the cooking qualities of L-206 and L-204 is the amylographic profile shown by RVA values. Cool paste viscosity and setback values of L-206 are slightly higher than L-204, which seems to be associated with lower stickiness exhibited by the cooked grains of L-206. Cooked rice of L-206 was preferred by taste panelists over L-204 and L-205.

L-206 should be adapted to all but the coolest rice growing areas of Yolo and San Joaquin counties. Greenhouse tests indicate that L-206 has slightly higher resistance to cold induced blanking than L-204. In the warmest areas of California's rice production region, growing season for very early varieties such as L-206 may not be long enough for maximum production.

Application is being made to protect L-206 under the U.S. Plant Variety Protection Act, Title V option, and for utility patents. Breeder and Foundation seed of these cultivars will be maintained by California Cooperative Rice Research Foundation, P.O. Box 306, Biggs, CA 95917-0306.

'CALAMYLOW-201'

The California Cooperative Rice Research Foundation, Inc. (CCRRF), the California Agricultural Experiment Station (CAES), and the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), announce the naming and release of a new rice cultivar Calamylow-201.

Calamylow-201 is a low amylose, semidwarf, early maturing, pubescent, premium quality short-grain cultivar. It is a pure line selection of a low amylose mutant identified in an X_2 population of Calhikari-201 irradiated with ~25kR of ^{60}Co made in 2000 at the Rice Experiment Station (RES), Biggs, CA. Calhikari-201, developed at RES, has the pedigree 'Koshihikari'/(91-Y-157)*2. Koshihikari is a tall, pubescent, late maturing, lodging susceptible, premium quality Japanese short-grain cultivar recognized for its high milling and cooking quality. 91-Y-157 was an RES advanced short-grain breeding line with the pedigree Koshihikari/'S-101'. S-101 is a very early maturing, semidwarf short-grain cultivar developed and released CCRRF that is no longer in production. Calamylow-201 was tested in the University of California Cooperative Extension (UCCE) Statewide Yield Tests from 2002 to 2004 under the experimental designation BL-1.

Calamylow-201 is being released as a special purpose low amylose rice for a new developing rice market. Low amylose (6-10%) rice has been found to be more resistant to staling and this trait has been incorporated into Japanese cultivars for use in chilled or frozen rice products. This will be the first of this quality type to be developed and produced in the United States. It is being released to supply this small new specialty market. The cooking and grain quality have been evaluated during development by the Nissui Corporation. They are encouraging its release and production in California; they hold a US patent on use of low amylose rice in chilled rice products; and have been test marketing this experimental line for the past two years.

Agronomic performance and adaptation is below improved California rice cultivars, however, it is being released because of its special cooking and processing characteristics. Calamylow-201 is very similar to Calhikari-201, but averages one day earlier heading, significantly lower grain yield (13%), higher whole kernel milling yields, and higher stem rot scores. Calamylow-201 kernels have low apparent amylose content (6% vs. 17%), an opaque endosperm, and smaller kernel size than Calhikari-201. Laboratory analysis for physicochemical characters (apparent amylose content, protein content, alkali score, RVA viscosity profile, and gelatinization temperature) was also provided by the USDA-ARS Rice Research Unit, Beaumont, TX.

Calamylow-201 has shown cool temperature induced sterility (blanking) in greenhouse and cold nursery tests and is not recommended for the cool or especially the cold rice producing regions of California. 2004 UCCE nitrogen fertilizer rate tests at RES indicated that high rates of nitrogen fertility induced severe lodging without increasing grain yield and should be avoided. Calamylow-201 has been approved and classified as a variety of commercial impact (tier 1) under the California Rice Variety Certification Act.

Application is being made to protect Calamylow-201 under the U.S. Plant Variety Protection Act, Title V option. Breeder and Foundation seed of these cultivars will be maintained by California Cooperative Rice Research Foundation, P.O. Box 306, Biggs, CA 95917-0306.

Each agency will make such news releases and other publicity as it considers appropriate on or after the release date of April 15, 2006.

Rice Research Proposal

Rice research at RES in 2007 will continue toward the primary objective of developing improved rice varieties for California. The search, interview, and selection process for a medium grain breeder to overlap and transition with Dr. Johnson's anticipated retirement in 2008 is continuing, as it is to fill the vacant short grain breeding position. We are planning to fill both positions this season. Considerable time and effort is being devoted to recruitment of staff.

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 be working to 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 2007.

Quality

Efforts to identify, select, and improve culinary and milling quality in all grain types will continue to receive major emphasis. Improved techniques for cooking evaluations are being used and screening for cooking quality expanded. 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 have been implemented and greenhouse screening for resistance is continuing. M-208, an improved medium grain with resistance to blast race IG-1, was released in 2006 and efforts to develop improved blast resistant varieties will continue. The Pathology Project is proceeding forward on large scale backcrossing efforts to transfer disease resistance into selected varieties, primarily medium grain. Marker-aided selection will be a part of this effort as will the use of new sources of resistance. 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, minimum delay in maturity, and uniform grain maturity. Selection at UCD may be discontinued due to concerns about adjacent UC research activities. Expanded large plot yield testing is being considered at the San Joaquin nursery site. Cold tolerance data will include two seeding dates of advanced material at RES, UCCE Statewide Yield Tests, refrigerated greenhouse tests, and data from the UCD, San Joaquin, and Hawaii 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.

Seedling Vigor

Selection and evaluation for seedling vigor will continue on all breeding material.

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 2007. 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 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

- Develop premium quality short-grain Japanese type rice varieties
- Improve premium quality M-401 type medium grains
- Improve California short grains
- Improve waxy (sweet) rice varieties
- Improvement of low amylose rice
- Develop bold grain Arborio type rice
- Rice water weevil resistance

Calrose Type Medium-Grains

- Improve conventional medium grains
- Improve blast resistant medium grains
- Increase genetic diversity
- Utilize DNA markers for blast resistance genes with USDA researchers
- Evaluate deep water germplasm

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
- Improve SR and blast resistance

Rice Pathology

- Screening and evaluation of advanced breeding lines for blast, stem rot, sheath spot, and bakanae.
- 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 in conjunction with USDA Rice Geneticist and UCD researchers
- Facilitate transfer of wide spectrum blast resistance genes to adapted medium grains using accelerated backcrossing, screening, and selection for resistance.

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