2007 RICE BREEDING PROGRESS REPORT
AND
2008 RESEARCH PROPOSAL

P. O. Box 306, Biggs, CA 95917-0306
January 1, 2008

RICE EXPERIMENT STATION STAFF

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Farman Jodari, Ph.D. ....Plant Breeder
Carl W. Johnson, Ph.D. ....Plant Breeder
Jacob Lage, Ph.D. ....Plant Breeder
Jeffrey J. Oster, M.S. .... Plant Pathologist

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OVERVIEW

Kent S. McKenzie

The California Cooperative Rice Research Foundation (CCRRF) is a private nonprofit research foundation [501(c)(5)] 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, Virgilio Andaya, Jacob Lage, 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 two administrative assistants make up the support staff. Approximately 30 seasonal laborers are employed during crucial planting and harvest times.

Organization and Policy

Policy and administration of RES is the responsibility of an 11-member Board of Directors elected by the CCRRF membership. Directors serve a three-year term and represent geographical rice growing areas of California. They are rice growers and serve without compensation. CCRRF works to serve all California rice growers, and its policies generally reflect those of public institutions such as UC. CCRRF cooperates with UC and USDA under a formal memorandum of understanding. The UC and 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 Rice Research Trust (RRT). The RRT is a tax-exempt trust [501(c)3] established in 1962 to receive tax deductible contributions for support of rice research. 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 Fjellstrom, and Ming Chen. Dr. Charles F. Shoemaker and his students are pursuing research on rice quality in the Department of Food Science and Technology, UCD and material and support are provided to that effort. Statewide performance testing of advanced experimental lines and varieties was conducted by Mr. Raymond L. Wennig, UCD staff research associate, under the direction of University of California Cooperative Extension Farm Advisors Mr. W. Michael Canevari (San Joaquin), Dr. Randall G. Mutters (Butte), Dr. Chris Greer (Placer, Sacramento, Sutter, Yuba), Dr. Luis Espino (Glenn, Colusa, Yolo), and Agronomist Dr. James E. Hill, (Department of Plant 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 2007. 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. Albert Fischer, Randall Mutters, Bruce Linquist, James Thompson, Richard Plant, Chris Greer, Luis Espino, and James Hill are all doing research in a 13 acre rice systems research area. They are being supported by UCD staff research associate Mr. Steve Bickley. Dr. Larry D. Godfrey, extension entomologist, and Mr. Wade Pinkston, 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. Further testing required by the California Rice Commission of CCRRF foundation and basic seed samples for 2007 sale as well as all California commercial rice were all non-detect.

All research at RES is reviewed annually by the CCRRF Board of Directors, representatives of the University of California, and the California Rice Research Board. A Rice Breeding Program Review was conducted in August 2007 by outside panel of rice experts. They reported and gave their recommendations at meeting with the Board of Directors and representatives from the CRRB.

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 170 acres at RES in 2007. 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 (RBP) 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. Jacob Lage joined the staff in July. He is working with Dr Johnson and will lead the project after Dr. Johnson retires in July 2008. Dr. Farman Jodari is the long-grain project leader (see Long Grains). He supports the Program through data analysis for yield testing, field labor management, is the liaison to Southern U.S. breeding programs, and the RiceCAP project. Dr. Virgilio Andaya is the new project leader for premium quality, waxy, and California short grains (see Short Grains). He is providing expertise and leadership for the DNA marker lab. 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. Staff continues to work to improve rice quality evaluation and selection for all market types. Screening, evaluation, and research in the area of DNA marker technology is progressing at RES.

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

The focus of the RES rice breeding program is on developing improved rice varieties to meet the needs of California growers now and into the future. This report summarizes the general activities of the 2007 RES Rice Breeding Program, including the various breeding nurseries, selected results from large plot yield tests, disease nurseries, greenhouse, and field experiments at RES and in growers' fields.

BREEDING NURSERIES

Seeding of the 2007 breeding nursery began May 15th, and was completed the 25th. The growing season was characterized as a more normal growing season and was reflected in at statewide average yield estimate of 8220 pounds per acre. There was some cool temperature induced blanking in some later materials.

In 2007, 1253 crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 34,808. 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 2008, thereby accelerating the breeding process. In addition, a large number of backcrosses are being made to transfer disease resistance by the Pathology Project.

The 2007 RES breeding nursery occupied approximately 80 acres. Water-seeded yield tests included 3888 small plots and 3668 large plots. Small seed increase plots and cooking samples were grown on 2.5 acres and included 40 advanced breeding lines. Sixty-seven experimental lines (4520 headrows) were grown for seed increase, quality evaluations, and purification. The nursery included about 54,000 water-seeded and 4,000 drill seeded progeny rows. Selections were made for advancement, quality evaluations, and purification from approximately 10,000 progeny rows. F_2 populations from 2005 and 2006 crosses were grown in precision drill-seeded plots on 20 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 2008.

Headrows (2800) of M-104, M-205, M-206, Calmochi-101, Calmati-201, Calmati-202, and L-206 were grown for breeder seed production in 2007. 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 2006-7 winter nursery included 8460 progeny and an F_1 nursery of 550 crosses. Selection and harvest was completed and seed returned to RES and planted in May.

The 2007-8 winter nursery of 8460 rows was planted November 4th and 5th, 2007, and 570 F_1 populations were transplanted to the nursery December 6th to 8th, 2007. Selection and harvest will occur in April, and seed returned for processing and planting in the 2008 RES breeding nursery.

The 2007 UCD Cold Tolerance Nursery contained 7800 drill-seeded F_2 progeny rows. This was an observational nursery only, due to contamination concerns from adjacent UC research. Precision drill-seeded F_2 populations were grown on 4 acres in Yolo County.

The nursery suffered heavy bird damage but some 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 screening of materials for resistance blanking in that environment.

The San Joaquin Cold Tolerance Nursery was planted in cooperation with two local rice growers. The 5-acre drill seeded nursery included 11,500 rows and 3.6 acres of F_2 populations.

In addition, a large plot single replication yield test of 64 medium grain lines were grown in cooperation with the UC. Management and production were excellent. Blanking levels were very high, providing opportunities to select blanking resistant material.

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 2007 Statewide Yield Tests were conducted at seven locations in commercial fields by Mr. Raymond L. Wennig, Dr. Randall G. Mutters, Dr. James E. Hill, Dr. Chris Greer, and Dr. Luis Espino. Advanced selections were tested in one of the three maturity groups: very early, early, or intermediate to late with standard check varieties included for comparison. Each maturity group was subdivided into an advanced and preliminary experiment. The advanced entries and checks had four replications and the preliminary entries had two replications. Plots were combine-size (10 by 20ft) and the experimental designs were randomized complete blocks.

All 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 15th to 18th and May 24th to 25th, 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. Granite® and propanil were used for the first seeding date and Cerano® and propanil on the second date. One application of Mustang® was applied for rice water weevil control.

Tables 1 to 6 contain a summary of performance information from the 2007 Statewide Yield Tests. Seedling vigor scores on the second date reflected the damage from herbicide injury. Yields are reported as paddy rice in pounds per acre at 14% moisture. Yield data from the first seeding date (2 reps) was not included in the Tables 1 to 4 because of very high variability in the nursery. A new San Joaquin location in a drill-seeded system was used. In 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 2008. Complete results of the 2007 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" 2007 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 San Joaquin, Sutter, Yolo, and RES (2 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
11	05Y724	M	4.6	84	91	45	5.9	11190	9920
9	M206	M	4.6	83	93	73	6.1	11030	9750
15	07Y015	LSR	5.0	85	93	0	5.5	10880	7970
2	S102	S	4.3	79	96	89	6.5	10730	9830
5	04Y332	MPQ	4.8	87	94	70	5.6	10420	8570
13	L206	L	4.8	80	85	40	6.4	10360	9540
8	M202	M	4.6	89	98	77	6.1	10250	8590
14	04Y501	LR	4.9	87	100	0	5.9	10130	9040
17	04Y508	L	4.5	91	97	0	6.1	9870	8430
12	L205	LR	4.9	89	95	28	5.9	9550	8500
16	01Y655	LR	5.0	97	99	5	5.9	9390	9080
7	M104	M	4.7	80	93	97	6.0	8930	9040
6	05Y299	MPQ	4.4	84	99	90	6.1	8430	7960
10	04Y227	M	4.9	81	101	97	6.6	8430	8700
4	05Y196	SPQ	4.7	87	99	99	5.5	7900	8820
3	04Y177	SPQ	4.4	83	91	100	5.7	7720	8510
1	CM101	SWX	4.6	81	96	100	5.8	6740	8760
Mean			4.7	85	95	61	6.1	9520	8790
LSD(0.05)			3.3	1.6	2.9	28	0.7	1450	340
C.V. (%)			0.3	3	6	32	8.0	7	5

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

Table 2. Agronomic performance means of very early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES (2 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
30	06Y436	M	4.8	82	94	75	6.4	10370	9630
35	06Y265	M	4.9	77	95	70	6.2	10370	8850
45	06Y506	L	4.9	83	93	3	5.8	10340	8350
42	06Y510	LR	4.9	86	96	0	6.0	10240	9060
25	06Y349	SWX	4.8	80	94	90	6.0	10150	9360
37	06Y385	M	4.9	81	98	88	6.1	10130	9380
29	06Y239	M	4.9	80	96	50	6.6	10090	9680
43	06Y485	LWX	5.0	94	94	3	6.1	10050	9230
50	05Y552	LJ	4.6	80	94	10	6.3	9870	8940
28	05Y471	M	5.0	78	100	78	6.5	9830	9360
47	06Y513	L	5.0	87	92	3	6.1	9810	8960
51	99Y529	L	4.8	84	92	5	5.4	9760	8960
48	06Y518	L	4.6	91	94	3	5.6	9740	8420
40	06Y889	M	4.8	83	92	50	6.4	9720	9660
33	06Y288	M	4.7	80	94	80	6.1	9550	9380
46	05Y547	LR	5.0	82	94	5	6.2	9550	8150
41	06Y928	M	4.8	80	96	63	7.2	9530	8780
31	06Y236	M	4.6	82	95	83	6.3	9530	9340
27	06Y367	SWX	4.7	87	97	60	5.8	9520	9150
21	03Y167	SPQ	4.8	88	90	0	5.2	9430	8370
39	06Y843	M	4.8	81	91	80	6.8	9350	8930
36	06Y274	M	4.8	83	94	85	5.8	9180	8840
38	06Y832	M	4.6	84	99	84	5.5	9170	9260
34	06Y230	M	27	81	95	65	6.3	9120	9050
22	04Y330	MPQ	4.8	81	90	80	5.6	9050	8050
44	05Y490	L	5.0	88	92	13	6.4	8840	8020
26	06Y223	SWX	4.7	84	94	80	6.1	8840	9520
32	06Y240	M	4.7	81	97	93	5.7	8680	8810
18	06Y199	SPQ	4.8	80	90	100	5.6	8390	8630
23	06Y175	MPQ	5.0	81	102	95	5.9	8370	7830
19	06Y207	SPQ	4.8	77	93	97	6.9	8270	8270
24	06Y184	MPQ	4.9	81	102	50	6.3	7900	7780
20	06Y208	SPQ	4.8	86	94	93	7.8	7040	7940
49	03Y151	LR	4.9	96	91	0	5.8	5090	4590
Mean			5.4	83	94	54	6.1	9260	8720
LSD(0.05)			98	2.4	3.9	26	0.7	1780	600
C.V. (%)			NS	4	7	28	8	9	7

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

Table 3. Agronomic performance means of early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (2 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
72	05Y698	M	4.8	90	93	25	5.9	9550	8510
74	L206	L	4.7	77	83	28	7.3	9540	8520
67	M206	M	4.8	79	94	85	6.2	9430	8850
78	01Y655	LR	4.7	90	95	3	5.8	9270	8450
64	03Y559	MPQ	4.8	83	87	75	6.1	9070	8560
77	99Y529	L	4.8	84	85	0	5.9	8960	8710
69	M205	M	4.9	88	93	35	6.3	8920	8590
76	06Y599	MPQ	4.8	88	91	20	5.9	8230	8310
71	06Y1072	M	5.0	88	110	88	6.3	8770	8350
62	S102	S	4.7	76	86	99	6.1	8730	8130
70	M208	M	4.9	86	90	30	6.1	8490	8230
73	L205	LR	4.8	85	91	30	5.8	8420	8130
66	04Y308	MPQ	4.8	87	89	8	5.9	8260	8240
63	06Y333	MPQ	4.7	87	94	68	5.8	8880	8240
65	05Y300	MPQ	4.7	89	95	85	6.2	7800	8110
61	CM101	SWX	4.8	76	92	99	6.5	6990	7390
68	M202	M	4.8	91	92	53	5.9	6940	7660
75	03Y151	LR	5.0	96	87	0	6.2	5380	6330
Mean			4.8	85	91	46	6.1	8420	8150
LSD(0.05)			3.1	2.3	3.6	38	0.7	1360	440
C.V. (%)			NS	4	7	38	7	8	7

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

Table 4. Agronomic performance means of early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (2 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
81	05Y165	SPQ	4.9	84	89	70	5.5	10200	8450
113	06Y701	LSR	4.6	89	87	0	5.1	9660	8180
105	03Y496	LR	4.4	87	95	0	5.3	9530	8650
92	06Y445	M	4.8	82	96	97	6.3	9370	9020
112	01Y501	LSR	4.8	83	92	0	5.6	9300	8580
109	06Y589	L	4.8	86	82	0	5.5	9140	8190
102	06Y965	M	4.9	79	89	8	6.3	9130	8560
90	06Y395	M	4.6	79	97	93	6.0	9030	8690
97	06Y685	M	4.9	85	92	45	5.8	8940	8540
101	06Y950	M	4.9	79	89	94	5.6	8910	8680
106	06Y575	LR	5	86	95	0	5.6	8880	8750
96	06Y675	M	4.7	89	92	25	5.8	8880	8710
100	06Y916	M	4.8	78	89	95	6.0	8870	8960
94	06Y475	M	4.8	79	97	73	6.2	8870	8460
98	06Y857	M	4.8	85	88	18	6.6	8810	7960
91	06Y400	M	4.7	83	93	65	5.7	8770	8760
108	05Y566	L	4.8	85	87	0	5.5	8710	8130
107	05Y625	L	4.9	87	87	0	5.6	8420	7990
95	06Y667	M	4.8	86	93	20	6.0	8080	8490
111	06Y545	LB	5	84	84	0	5.9	8050	7160
93	06Y467	M	4.8	83	91	80	6.7	8030	8590
85	06Y322	MPQ	4.8	84	92	94	6.1	8000	8110
88	06Y629	MPQ	4.9	87	93	93	5.7	7670	7690
83	05Y346	SPQ	4.9	82	93	100	5.9	7560	7350
80	06Y356	SPQ	4.9	81	86	88	6.4	7490	7880
82	06Y202	SPQ	4.9	83	100	98	6.1	7330	7520
99	06Y881	M	4.7	85	91	30	6.4	7320	7850
84	05Y352	MPQ	4.8	78	94	80	6.6	7080	7540
89	07Y089	M	4.7	87	96	80	6.8	6840	7800
87	06Y334	MPQ	4.9	87	94	65	5.7	6750	7550
103	CT201	LB	5	84	85	0	5.9	6640	6750
86	05Y202	MPQ	4.8	85	89	35	6.4	6500	7440
110	07Y110	LIM	4.8	86	90	0	7.1	6420	7390
79	CH201	SPQ	5	86	92	98	6.1	6230	6960
104	CT202	LB	4.9	84	84	68	6.5	6080	6320
114	06Y707	LJ	4.3	92	90	94	7.3	5160	6460
Mean			4.8	84	91	50	6.1	8073	8000
LSD(0.05)			2.4	2.9	4.1	22	0.7	1460	570
C.V. (%)			0.2	5	8	22	8	9	7

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

Table 5. Agronomic performance means of intermediate to late advanced entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (4 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days §	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
124	05Y657	SSR	4.7	91	95	5	5.5	11120	10410
130	L206	L	4.6	81	79	6	8.2	10390	9880
125	05Y343	SWX	4.7	89	92	63	5.9	10200	10130
131	99Y529	L	4.8	87	91	4	5.6	10160	10260
126	M205	M	4.9	92	94	43	6.3	10080	10270
133	04Y706	L	4.8	89	91	3	5.6	9930	9630
128	05Y386	M	4.9	86	90	50	6.0	9700	9540
129	L205	LR	4.9	89	90	9	6.5	9430	9530
122	04Y625	MPQ	5	89	97	36	6.6	9290	9450
127	M202	M	4.9	90	98	57	6.7	8960	9290
121	M402	MPQ	5	101	96	1	5.7	8940	8970
123	05Y328	MPQ	4.9	86	100	82	6.1	8710	9170
132	03Y151	LR	4.9	95	86	1	5.7	7000	7440
Mean			4.8	90	92	28	6.3	9530	9540
LSD(0.05)			3.2	2.4	3.8	78	1.0	890	420
C.V. (%)			0.2	3	5	31	10	7	5

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

Table 6. Agronomic performance means of intermediate to late preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (2 reps) locations in 2007.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
143	06Y444	M	4.9	88	94	49	6.2	9490	9470
144	06Y664	M	4.9	90	90	11	6.2	9240	9820
140	06Y293	M	5.0	80	94	61	6.1	9120	8980
146	06Y696	M	4.9	88	92	31	6.1	9030	9480
141	06Y390	M	4.9	86	95	45	5.6	8980	9140
145	06Y668	M	4.9	85	85	11	6.4	8900	9490
137	06Y620	SPQ	4.8	92	94	10	6.2	8760	9150
147	06Y984	M	4.8	89	92	24	6.5	8660	8820
151	07Y151	LIM	4.9	91	94	1	6.5	8610	8960
138	05Y346	SBG	4.8	86	96	62	6.8	8590	9070
139	06Y290	M	4.9	81	89	53	6.5	8580	8980
142	06Y438	M	5.0	88	90	43	6.5	8330	9030
148	06Y1024	M	4.9	84	93	45	7.1	8070	9100
136	06Y313	SPQ	4.9	85	93	61	6.4	7870	8080
134	CH201	SPQ	5.0	86	88	81	7.0	7830	8200
135	CA201	SPQ	4.8	83	88	64	7.0	7560	7340
150	CT202	LB	5.0	84	83	11	6.4	7500	7160
149	CT201	LB	4.9	91	85	1	6.0	7350	8320
153	05Y744	LJ	4.5	97	96	29	6.2	6950	7940
155	07Y155	LB	4.9	93	90	12	5.5	6730	7110
154	07Y154	LB	4.8	93	89	1	6.2	6470	6700
152	07Y152	LB	4.8	93	93	1	5.7	5370	5500
Mean			4.9	88	91	32	6.3	8090	8360
LSD(0.05)			2	2.6	3.6	58	1.0	900	580
C.V. (%)			0.1	3	5	26	8	8	8

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

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 2007 Preliminary Yield Tests is presented in Table 7. These tests included 966 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 2008 Statewide Yield Tests. ◆

Table 7. Summary of Preliminary Yield Tests at RES in 2007

Test	Type	Number of Entries	All	Highest	Top 5	Check	Standard Check
			----------Average Yield (lb/acre)†----------				
Very Early							
Short grains	Specialty rice	59	9088	11373	10811	10267	S-102
Medium grains	Group A	16	10020	10820	10500	9303	M-104
	Group B	54	10270	11320	11090	10440	M-206
Long grains	Conventional	61	9930	10680	10570	10430	L-206
	Specialty rice	16	8760	10960	10220	7950	CT-201
Early							
Short grains	Conventional	11	9121	10352	9883	8170	M-202
	Specialty rice	70	7906	9905	9496	7580	CH-201
Medium grains	Group A	56	9490	10690	10330	10750	M-206
	Group B	52	9610	10860	11430	9920	M-206
Long grains	Conventional	66	9810	11100	10850	10870	L-206
	Specialty rice	13	8430	1071	9800	7910	CT-201
Intermediate-Late							
Short grains	Conventional	24	9217	10793	10338	8568	S-301
	Specialty rice	20	7887	9710	9091	7829	M-401
Medium grains		50	9940	10630	1580	10440	M-205
Long grains	Conventional	23	8860	10030	9880	8450	L-205
	Specialty rice	18	6770	9810	8430	7030	CT-201
Medium Grains (Blast 1 rep)							
	Group A	240	9100	11720	11630	8990	Avg.(20)
	Group B	60	8470	10980	9910	8690	Avg.(6)
	Group C	57	9110	12170	11330	9710	Avg.(6)

† Paddy rice yield at 14% moisture.

PREMIUM QUALITY & SHORT GRAINS

Virgilio C. Andaya

The short grain and premium quality rice (SGPQ) breeding project is in a transition. Significant changes in focus and priorities for the project are being instituted with the assumption of a new project leader in 2007. Plans are formulated and gradually being carried out to consolidate all the information and breeding materials generated by previous project leaders and to streamline breeding efforts to steer the project back on a competitive tract.

The SGPQ is charged with the development of improved rice varieties for the following grain types and specialty rices: 1) conventional short grains, 2) premium quality short grains, 3) premium quality medium grains, 4) waxy short grains, 5) low amylose short grains, and 6) bold grains (Arborio-type). The last three components are considered specialty rice because of their unique grain quality attributes. Efforts to incorporate stem rot and blast resistance in collaboration with the station plant pathologist is continuing. Water weevil resistant materials are still being maintained under the project.

Though breeding goals do vary for the different grain quality and specialty types, great efforts are being exerted to meet the challenge of producing superior rice varieties that combine, among others, premium grain quality, high yield potential, disease resistance, and adaptation to cold environments. These goals can be achieved by incorporating innovative tools like the DNA marker technology into the breeding program.

Standard Varieties

The market for short grain and premium quality rice remains an important component of the California rice industry. Agronomic, grain yield, and grain quality improvements of existing short grains, premium quality types and specialty rices would be of significant value to the industry. Table 8 summarizes the yields of standard varieties derived from the project and served as checks in the UCCE Statewide Yield Tests.

Table 8. Five-year average grain yield performance of check entries for the short grain premium quality project in the UCCE Statewide Yield Tests.

Year	---Grain Yield#---			
	M-402	S-102	CH-201	CM-101
2003	8280	9190	7500	8270
2004	9530	9670	8530	9380
2005	8378	8688	7471	7897
2006	7850	9230	8040	8250
2007	8973	9828	6960	8758
Average	8602	9321	7700	8511

Paddy rice yield in lb/acre at 14% grain moisture content

Conventional Short Grains

Approximately 20% of all breeding lines in the project are conventional short grains, comparatively lower because of increased emphasis on the development of premium quality and specialty rices.

S-102 is still the dominant short grain variety in commercial production in California because of its very high yield potential in combination with very early maturity, resistance to cold-induced blanking, and large kernel size. However, S-102 is very susceptible to stem rot and has a pubescent hull which is undesirable during seed processing. The primary goal for the conventional short grain breeding is to capture the agronomic characteristics of S-102, and incorporate stem rot resistance and smooth hulls. The development of smooth-hulled, stem rot resistant derivatives of this variety remains a big challenge.

S-102 has been a consistent high yielding check variety in the very early group of the UCCE Statewide Yield Test. For the past two years, no conventional short grains were entered in the Statewide Test. A vigorous crossing work is underway and new strategies in progeny selections are being devised to successfully meet breeding challenges

In 2007, twelve lines were tested in the Preliminary Yield Tests at RES. Agronomic performance and milling data of selected lines that out yielded the check varieties are summarized in Table 9. These lines may be entered in Statewide Yield Test pending the results of a rigorous grain quality evaluation and taste tests.

Table 9. Agronomic performance and milling averages of selected 2007 conventional short grain entries in the RES Preliminary Yield Tests.

Entry No.	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*
Very Early							
07Y210	11349	4.9	78	90	60.0	5.9	65/68
07Y213	10542	4.8	78	89	60.0	5.7	59/71
S102	10267	4.8	76	94	100.0	6.2	68/71
Early							
07Y350	10221	4.9	84	89	0.0	5.6	68/72
07Y349	9973	4.9	86	96	0.0	4.9	55/69
07Y348	9144	4.9	82	94	0.0	5.5	65/70
Intermediate Late							
07Y665	9109	4.9	81	94	97.5	5.8	72/74
07Y661	9083	4.9	80	93	50.0	6.0	66/71
S301	8568	4.9	98	101	25.0	5.5	67/71

Paddy rice yield in lb/acre at 14% moisture
†SV=seedling vigor score where 1=poor and 5=excellent
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage and 10=plant killed
* H/T= Head and total milled rice averages from milling rows and plots

Premium Quality

The development of premium quality short and medium grain rice varieties is the primary focus of this project and received approximately 60% of the total efforts and resources. A working definition of premium quality rice is the type of rice that cooks very glossy and slightly sticky, with a smooth texture, tastes tender and slightly sweet, with subtle aroma, and remains soft after cooling. These cooking characteristics are exemplified by the California medium-grain cultivar M-401 and the Japanese premium short grain varieties Koshihikari and Akitakomachi. Grain quality is mainly cultural in nature and varies depending on taste preferences by consumer or ethnic groups. Thus, breeding for locally-adapted, high-yielding premium quality rice that takes into account these consumer preferences continues to be a difficult challenge.

Premium Quality Short Grains (SPQ)

The premium short grain rice variety Calhikari-201 (CH-201) is the first SPQ variety released in California. CH-201 was derived from a cross involving Koshihikari, a premium quality Japanese variety, and S-101. Released in 1999, this variety is high yielding, early maturing, has good seedling vigor, and lodging resistant. However, it has a rough hull, susceptible to stem rot, susceptible to blanking, and its grain quality did not quite equal Koshihikari, making it less acceptable for the Japanese market.

CH-201 is being extensively used in the breeding program to further improve its grain quality and agronomic attributes. Crosses involving parents with known grain quality characteristics are being used extensively to capture their excellent grain qualities.

In 2007, twelve premium quality short grains were tested in the UCCE Statewide Yield Tests Four of the 12 entries in the Statewide trials were tested for more than one year. The average yields, agronomic attributes, and milling yields of selected entries in the Statewide Tests are presented in Table 10. On average, these selected entries out-yielded CH-201 upwards of 5%, have better stem rot resistance scores, and comparable milling yields. The experimental lines 04Y177 and 05Y196 are being closely monitored as potential lines for seed increase for 2008. These lines are being purified in headrows and will be further evaluated for their milling and cooking qualities.

A total of 44 advanced lines were entered in the Preliminary Yield Tests at RES. Agronomic performance and milling data of selected entries are summarized in Table 11. These lines will undergo further grain quality evaluations and cooking tests before they are entered for the Statewide Tests in 2008.

Table 10. Agronomic performance and milling yields of selected 2007 premium quality short grain (SPQ) entries in the UCCE Statewide Yield Tests.

Entry No.	ID	Mat. ‡	Years in Test	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*
4	05Y196	VE	2	8820 (8795)	4.9	93	93	29	5.5	65/70
81	05Y165	E	2	8448 (8447)	4.9	88	90	19	5.5	65/69
3	04Y177	VE	3	8510 (8356)	4.8	90	88	27	5.7	68/70
21	03Y167	VE	4	8365 (8172)	4.9	92	123	1	5.2	65/69
18	06Y199	VE	1	8635 (-----)	4.9	89	123	29	5.6	68/70
79	CH-201	E	5	6960 (7700)	5.0	87	88	28	6.1	67/70

‡ Maturity, VE=very early, E=early, IL=intermediate late
# Paddy rice yield in lb/acre at 14% moisture. Value in parenthesis is the average yield from all years tested
†SV=seedling vigor score where 1=poor and 5=excellent
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage and 10=plant killed
* H/T= Head and total milled rice averages from milling rows and plots

Table 11. Agronomic performance and milling averages of selected 2007 premium quality short grain (SPQ) entries in the RES Preliminary Yield Tests.

Entry No.	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*
Very Early							
07Y182	11373	4.9	82	90	35.0	5.8	68/71
07Y183	10394	4.9	77	92	80.0	5.4	70/71
07Y167	10258	5.0	77	91	100.0	5.3	66/70
07Y176	10054	5.0	75	88	60.0	5.8	68/71
AKITA	6833	4.7	78	90	100.0	6.8	70/71
Early							
07Y300	9511	4.9	87	89	0.0	5.4	63/70
07Y299	9340	4.9	88	83	0.0	5.3	66/71
07Y293	9034	4.9	86	91	0.0	5.5	67/70
07Y294	8930	4.9	86	91	0.0	6.3	68/70
CH-201	6169	5.0	86	92	0.0	6.8	66/71
Intermediate late							
07Y656	8608	4.9	93	96	82.5	5.7	68/72
07Y651	8246	5.0	90	92	0.0	5.3	66/70
07Y650	8152	4.9	86	86	100.0	5.6	64/68
Hitomebore	6764	4.9	89	99	100.0	6.1	69/72

Paddy rice yield in lb/acre at 14% moisture
†SV=seedling vigor score where 1=poor and 5=excellent
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage and 10=plant killed
* H/T= Head and total milled rice averages from milling rows and plots

Premium Quality Medium Grains

Breeding for premium quality medium grain types (MPQ) is focused on capturing the excellent grain and cooking characteristics of M-401. This variety is a late maturing premium quality medium grain released in California in 1981 and was derived through mutation breeding. In 1999, the rice variety M-402 was released as an alternative to M-401. It is late maturing, has more translucent grains and higher milling yields. These varieties together with some proprietary medium grain varieties are being using in crosses to capture their excellent grain quality. Progeny lines are selected based on yield potential, early maturity, high seedling vigor, resistance to blanking and lodging, synchronous flowering, and milling yields. Cooking tests are given heavy emphasis in the selection process.

In 2007, a total of sixteen MPQ entries were tested in the Statewide Yield Test. Eight of the entries are in the yield tests for more than one year while the rest were new entries. At least two years of statewide yield and agronomic data are needed to identify promising lines for seed increase. Table 12 summarized the agronomic performance and milling yields of selected MPQ entries in the Statewide Yield Tests. Compared to M-402, entry 04Y625 has a 5% yield advantage in 2007 but the overall yield advantage is not dramatic. The level of milling yields and blanking tolerance of the MPQ still needs to be addressed.

Table 12. Agronomic performance and milling yields of selected 2007 premium quality medium grain (MPQ) entries in the UCCE Statewide Yield Tests.

Entry No.	ID	Mat. ‡	Years in Test	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*
122	04Y625	IL	3	9447 (8716)	5.0	91	100	15	6.6	63/69
66	04Y308	E	3	8238 (8683)	5.0	89	92	5	5.9	65/70
64	03Y559	E	4	8558 (8584)	5.0	88	92	20	6.1	65/70
5	04Y332	VE	3	8570 (8434)	5.0	95	92	18	5.6	63/68
65	05Y300	E	2	8115 (8368)	4.9	91	92	32	6.2	65/70
6	05Y299	VE	2	7955 (8288)	4.9	92	95	26	6.1	63/68
22	04Y330	VE	3	8050 (7822)	5.0	92	122	21	5.6	65/68
86	05Y202	E	2	7443 (7576)	5.0	88	91	19	6.4	65/70
123	05Y328	IL	1	9173 (------)	5.0	86	102	48	6.1	69/71
121	M402	IL	5	8973 (8602)	4.9	102	103	1	5.7	64/72

‡ Maturity, VE=very early, E=early, IL=intermediate late
# Paddy rice yield in lb/acre at 14% moisture. Value in parenthesis is the average yield from all years tested
†SV=seedling vigor score where 1=poor and 5=excellent
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage and 10=plant killed
* H/T= Head and total milled rice averages from milling rows and plots

Table 13. Agronomic performance and milling averages of selected 2007 premium quality medium grain (MPQ) entries in the RES Preliminary Yield Tests.

Entry No.	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*
Very Early							
07Y199	10165	4.8	80	87	30	5.7	64/69
07Y204	9647	5.0	82	91	43	5.6	69/71
07Y186	9385	4.9	77	90	18	6.2	69/70
M104	9383	4.9	74	94	95	7.6	66/69
Early							
07Y331	9025	4.9	86	95	0	5.6	67/70
07Y320	8961	4.7	84	100	0	6.1	71/72
07Y326	8936	4.9	85	94	0	5.8	70/71
07Y343	8842	4.8	86	94	0	5.6	69/71
07Y322	8706	5.0	83	96	0	5.7	70/71
M203	7001	4.9	84	100	0	6.1	68/70
Intermediate late							
07Y646	8930	4.9	88	96	45	7.3	67/71
07Y647	8625	4.9	86	91	75	6.9	69/71
07Y645	7860	4.9	92	92	0	5.4	69/71
M401	7829	4.9	102	107	0	5.1	64/71

Paddy rice yield in lb/acre at 14% moisture
†SV=seedling vigor score where 1=poor and 5=excellent
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage and 10=plant killed
* H/T= Head and total milled rice averages from milling rows and plots

Sixty eight preliminary MPQ breeding lines were tested in the Preliminary Yield Tests at RES. The agronomic performance and milling characteristics of eleven selected advanced lines are summarized in Table 13. The eleven experimental lines were selected based on higher average yields compared to the check varieties, milling yields and overall agronomic performance. The blanking in San Joaquin for the MPQ are generally heavy compared to tests conducted in Davis and in the greenhouse. Blanking tolerance will be addressed in future crosses. Likewise, rigorous grain quality evaluation and cooking tests will be made on these selections before they are advanced for the Statewide Tests in 2008.

Specialty Rice

Specialty short grain rice is divided into three groups: a) waxy short grains, b) low amylose short grains, and c) bold grains (Arborio-type). Breeding for specialty rice varieties presents unique challenges often attributed to poorly defined grain and cooking quality attributes. These make quality evaluation and selection difficult. Current project allocation is about 20% of the project.

Calmochi-101 (CM-101) is the latest waxy short grain rice released for California in 1985. It has a high yield potential, excellent blanking tolerance in cold locations, has large kernels but has rough hulls. Emphasis is given in breeding for smooth hulls, larger kernels, and improved agronomic attributes. The rice variety Calamylow-201 (CA-201) is the first and only low-amylose (~7% amylose content) variety developed for California and is a mutant derived from Calhikari-201. This variety was released in 2006 as a new product for the California rice industry. To a lesser extent, breeding for improved low amylose short grain is being continued. Breeding for bold grain types similar to the Italian variety Arborio and Carnaroli is also being continued in this project. A major objective is to improve milling yields and agronomic performance while retaining the grain appearance and quality.

A total of 11 waxy short grains, 7 bold grains, and 5 low amylose short grains were entered either in the Statewide or Preliminary Yield Tests in 2007. The agronomic and yield performance of selected lines in the Statewide Yield Tests and in the RES Preliminary Yield Tests are summarized in Tables 14 and 15, respectively.

Table 14. Agronomic performance and milling yields of selected 2007 specialty rice entries in the UCCE Statewide Yield Tests.

Entry No.	ID	Mat. ‡	Years in Test	Grain Yield#	SV†	Days §	Ht. (cm)	Lodge (%)	SR ¶	H/T*
125	05Y343	IL (WX)	2	10130 (9320)	4.9	88	97	25	5.9	62/70
138	05Y346	IL (BG)	2	9067 (9067)	4.9	86	101	32	6.8	45/69
25	06Y349	VE (WX)	1	9360 (----)	5.0	90	126	23	6.0	61/70
26	06Y223	VE (WX)	1	9520 (----)	4.9	91	135	21	6.1	62/70
27	06Y367	VE (WX)	1	9145 (----)	4.9	93	135	18	5.8	62/69
1	CM101	VE (WX)	5	8758 (8511)	4.9	90	91	26	5.8	66/70

‡ Maturity, VE=very early, E=early, IL=intermediate late
# Paddy rice yield in lb/acre at 14% moisture
†SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage,10=plant killed.
* H/T= Head and total milled rice averages from milling rows and plots
WX=waxy, BG=bold grain

Table 15. Agronomic performance and milling averages of selected 2007 specialty rice entries in the RES Preliminary Yield Tests.

Entry No.	Grain Yield#	SV†	Days§	Ht. (cm)	Lodge (%)	SR¶	H/T*	Grain Type
Very Early								
07Y217	10284	4.8	73	91	98	5.6	63/67	WX
07Y219	9951	4.9	75	88	70	6.1	68/71	WX
07Y216	9229	4.9	79	94	0	5.9	69/70	WX
CM-101	7192	4.8	78	89	100	6.0	66/71	WX
Early								
07Y365	9462	5.0	84	89	0	6.1	64/72	BG
CA-201	7580	4.8	84	90	0	7.0	64/69	LA

Paddy rice yield in lb/acre at 14% moisture
†SV=seedling vigor score where 1=poor and 5=excellent.
§ Days to 50% heading
¶ SR=stem rot score where 0=no damage, 10=plant killed.
* H/T= Head and total milled rice averages from milling rows and plots
WX=waxy, BG=bold grain, LA=low amylose.

Breeding for Water Weevil, Stem Rot and Blast Resistance

Breeding for rice water weevil tolerance has been an integral part of the project for a long time. However, breeding progress in this area is very slow because of several factors such as non-uniform insect distribution in the experimental plots, erratic insect infestation on a yearly basis, and unclear genetics of insect resistance. Likewise, the lack of screening methods under controlled environments makes it difficult to confirm the resistance of selected lines. Thus, work in this area is momentarily discontinued.

Breeding for stem rot resistance remains an important component of the short grains project. Efforts in this area are vigorous in the collaboration with the RES plant pathologist. Progress has been slow in recovering the level of resistance of the donor parents while maintaining the agronomic and grain quality attributes of the target parents. Though some stem rot advanced lines registered some of the highest yields in the Statewide and Preliminary Yield Tests, their milling yields, cooking scores and overall grain quality remained poor. A backcross scheme is being planned to address this recurring issue.

Breeding for blast resistance to California race IG-1 continues in the project but will receive a lesser attention in the coming years.

DNA Marker Lab

The DNA marker lab at RES is up and running. The use of markers for marker-assisted selection is now increasingly feasible with the cost of equipment and laboratory supplies going down significantly.

For the past couple of years, advanced lines have been routinely screened with a microsatellite marker RM190 for the *Waxy* gene which allows accurate classification of lines to specific grain quality groups. A marker, AP5930, for the blast resistance gene *Pi-z* derived from the donor variety 'Lafitte' was also developed and validated using advanced lines from the medium grain breeding project. Efforts are now underway to develop similar markers for other blast resistance genes.

As a long term goal, the DNA marker lab will formulate procedures to efficiently identify and develop markers for traits such as stem rot resistance, cold tolerance, semidwarfing genes, and other important plant characteristics as they are discovered, and devise ways to efficiently implement a marker-assisted selection scheme for all projects at the station.

LONG GRAINS

Farman Jodari

The long-grain breeding project continues its research and breeding efforts to develop superior long-grain varieties of four major quality types for California, including 1) Conventional long grain, 2) Jasmine, 3) Basmati, and 4) aromatic types. Milling and cooking quality improvements of conventional 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 variety L-204, does have a typical amylose content, gel type, and viscogram profile. However, a subtle difference still exists in softness of cooked rice of L-204 and Southern long grain varieties. Extensive quality screening and selection efforts have eliminated the majority of texture softness from the long grain breeding material. In addition, higher amylose lines have been developed that show lower hardness of cooked grain texture when compared to Rexmont type varieties such as L-205.

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. 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. Similar to Southern long grain types, L-206 has intermediate amylose and gelatinization temperature types.

Grain Yield of L-206 averaged over eight seasons (2000-2007) has been significantly higher than M-202 at the RES location and similar to L-205 and M-202 at Sutter-East test location. Average yields were 8890 lb/acre in cooler location of Sutter-east and 10,170 lb/acre at RES (Table 16). Yields at colder locations of Yolo and San Joaquin have not been as competitive as M-202.

In 2007, however, in the drill seeded test in San Joaquin, L-206 yield was second highest after S-102, at 9850 lb/acre. With the exception of the Butte location, grain Yields tested for 3 years in additional locations during 2005 through 2007 were not significantly different from L-205 or M-202. Three year average yields at Butte location were 8770 for L-206 and 7810 for 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. Growing season in 2007 had significantly lower overall degree days as compared to 7 previous years. In spite of this, L-206 yield was very competitive with other varieties including medium grains (Tables 1–6). Average head rice yield of L-206 during 2001 – 2007 seasons was 63 % 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 long-grains that are being evaluated in detail in advanced generations include 06Y513, 04Y706, which possess improved agronomic and quality traits. Performance results of a selected number of conventional long grains entries with intermediate (L) or high (LR) amylose contents are listed in Table 17. California grown high amylose long grains such as L-205 tend to have softer cooked grain texture than those grown in Southern US. Therefore they can be used as conventional long-grain type. Certain high amylose long-grain types such as 06Y599 (Table 17) have shown an even softer cooked grain texture than L-205 and further quality testing of this group is underway.

Table 16. Yield performance of L-206 compared to L-205 and M-202 averaged over 8 or 3 years at RES and 8 other UCCE Statewide Yield Test locations.

Maturity- Location	L-206	L-205	M-202	Years tested*
Very early				
RES	10170	9900	9080	8
Sutter	9140	8890	9170	8
Yolo	8250	8450	8910	8
San Joaquin	8190	7450	7510	8
Early				
RES	9277	8820	7760	3
Butte	8770	8520	7810	3
Colusa	9120	8890	9180	3
Yuba	7220	6930	7070	3
Intermediate/Late				
RES	9170	9150	8730	3
Sutter	9390	9210	9020	3
Glenn	7980	7730	8120	3

† Grain yield 10 lb/acre at 14% moisture.

*Very early locations were tested during 2000 – 2007 and all other locations were tested during 2005 – 2007.

Table 17. Performance of selected conventional long-grain entries with intermediate (L) or high (LR) amylose content in 2007 yield and milling tests.

Entry	Amylose Group	Identity	-----Yield†-----		Blanking	Head Rice
			Statewide	RES	(%)	(%)
Very Early Statewide						
47	L	06Y513	8960	9810	18	64
51	L	99Y529	8960	9760	15	63
48	L	06Y518	8420	9740	18	63
13	L	L-206	9540	10360	15	63
16	LR	01Y655	9080	9390	18	60
14	LR	04Y501	9040	10130	18	61
12	LR	L-205	8500	9550	8	65
Early Statewide						
109	L	06Y589	8190	9140	12	--
77	L	99Y529	8710	8960	15	63
74	L	L-206	8520	9540	15	63
78	LR	01Y655	8450	9270	18	62
76	LR	06Y599	8240	8880	12	61
73	LR	L-205	8130	8420	8	63
Intermediate Statewide						
131	L	99Y529	10260	10160	12	-
133	L	04Y706	9630	9930	25	-
130	L	L-206	9880	10390	15	-
Very Early Preliminary						
533	L	06P2742	--	10540	35	62
515	L	06P2705	--	10440	15	63
480	L	L-206	--	10430	15	63
Early Preliminary						
575	L	06P2694	--	11100	25	63
576	L	06P2751	--	10930	25	63
561	L	L-206	--	10870	15	63
Intermediate Preliminary						
761	L	06P2413	--	10030	25	60
752	L	06P2388	--	9980	35	63
735	LR	L-205	--	8550	15	65

† Grain yield in lb/acre at 14% moisture.

DNA markers were successfully used in 2007 to determine the type of amylose synthesis gene in 1200 long grain breeding lines. This effort was in cooperation with USDA rice genetics lab at UCD and the RiceCAP project post-graduate researcher at RES. RiceCAP project has made significant contribution since 2005, in the initial setup of the DNA analysis system at RES. This capacity is a valuable tool for breeding programs at RES, especially with the development and availability of new genetic markers. Currently 2 DNA markers are being routinely used at RES to determine amylose type and blast resistance.

Specialty Long Grains

Breeding efforts were increased in specialty long grain area in 2007. Specialty types include Jasmine, Basmati, and conventional aromatics such as A-201. Agronomic and milling quality of selected specialty lines is shown in Table 18.

Calmati-202 was released in 2006 as a true basmati variety. It is an early maturing, semi-dwarf, pubescent, aromatic, elongating, long-grain. 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, the yield potential of Calmati-202 is 10% lower than Calmati-201. Calmati-202 is not intended as a replacement for a higher yielding conventional aromatic variety such as A-201.

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

A new series of basmati type selections were tested in 2007 statewide trials that have shown a significant cooking quality advantage over Calmati-201 and Calmati-202. Entries 06Y152 and 06Y154 posses true basmati qualities that are nearly indistinguishable from imported basmati types. Their primary features include higher elongation, more flaky texture, and minimal curving of the cooked grain. Both grain yield and milling yield of these lines, however, are lower than Calmati-202. Further testing is underway to determine their suitability for commercial production. Efforts are also already underway to improve both their yield and milling quality. Emphasis in basmati type breeding continues to be placed on recovering slender and flaky-cooking kernels with higher elongation ratios.

Efforts continued in 2007 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 02Y710 and 02Y712, were obtained. These early mutants are serving as valuable germplasm source for further agronomic improvements. Twenty-four advanced jasmine type selections were tested in 2007.

Table 18. Performance of specialty long-grain entries in 2007 yield and milling tests.

Entry	Identity	Specialty Type	---Yield †--- Statewide	RES	Blanking (%)	Head Rice (%)
Very Early Statewide						
50	05Y552	Jasmine	8940	9870	40	61
13	L-206		9540	10360	15	62
Early Statewide						
111	06Y545	Basmati	7160	8050	40	53
103	CT-201	Basmati	6750	6640	45	61
104	CT-202	Basmati	6320	6080	18	58
74	L-206		8520	9540	12	63
Intermediate/Late Statewide						
153	05Y744	Jasmine	7940	6950	45	48
154	07Y154	Basmati	6700	6470	35	48
152	07Y152	Basmati	5500	5370	40	44
149	CT-201	Basmati	8320	7350	35	61
150	CT-202	Basmati	7160	7500	18	58
130	L-206		9880	10390	12	63
Preliminary						
569	06Y614	Aromatic	--	10090	45	64
603	06P3058	Aromatic	--	9240	45	62
599	06P2950	Jasmine	--	8830	45	62
606	06P3201	Basmati	--	7810	40	55
748	06P3177	Basmati	--	7240	45	50
767	06P3110	Basmati	--	6110	30	54
530	06P3134	Basmati	--	7770	40	53
487	06Y547	Basmati	--	7650	40	57
562,736	CT201	Basmati	--	7470	45	62
563,737	CT202	Basmati	--	7240	25	58

† Grain yield in lb/acre at 14% moisture.

Milling quality

Continued improvement in milling yield and milling stability of new long-grain varieties to the level of medium grains remains a major objective. Grain characteristics are being evaluated and selected that will lend milling yield stability to long-grain lines under adverse weather conditions and allow a wider harvest window. These may include hull cover protection, grain formation, or physicochemical properties of the grain that result in fissuring resistance. Efforts have been initiated to screen advanced breeding lines of all grain types for their resistance to grain fissuring. This effort will continue in conjunction with RiceCAP project currently underway at RES.

Information obtained from single kernel moisture meter is also being used to evaluate the uniformity of harvest maturity among advanced experimental lines that will ultimately lead to improved head rice yields. Milling yield potential of 30 of the most advanced long-grain lines from the Statewide Yield Tests were evaluated in 2007 harvest moisture studies in two maturity groups.

RiceCAP Project

RES is participating in the RiceCAP project which is a 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 specific contribution from RES is providing extensive fissuring studies for 3 milling populations as well as evaluating a California long-grain population for developing molecular markers associated with milling quality. The 3rd year of the project was completed in 2007. The California milling population, MY3, was advanced to F_7 generation, and 257 RILs were planted at RES in 2 replications. The results of milling yield phenotyping (Table 19 and Figure 1), is indicating clear and consistent differences among progeny and parents of this population. Genotyping of this population is planned to be carried out at USDA genomics facility at Stoneville, MS. This project has been linked with marker aided selection efforts that is underway 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. Thirty-five entries with a range of SR resistance were tested in 2007 Statewide and Preliminary Yield Tests. Performance of a selected number of these lines is shown in Table 20. Entries 105 (03Y496) and 112 (01Y501) 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 87Y550, grain yields of both lines are consistently higher than susceptible variety L-205. The 2007 growing season with cooler than normal temperatures provided favorable condition to select for stem rot resistant lines with tolerance to cooler temperatures.

Improvements in milling yield, cold tolerance, and early maturity of SR resistant lines to the levels of L-205 and L-206 varieties is being pursued through further crossing and backcrossing. A considerable number of early generation SR resistant breeding lines were advanced in 2007 in cooperation with the RES plant pathologist.

Table 19. Characteristics of parental lines of MY3 population shown among individual observations grown at RES in 2007, indicating the consistency of HR yield differences between the two varieties.

Entry	Replication	Days to Head	Harv. Date	Harv. H2O	Head Rice	Variety
07MY3-040	1	78	9/26	16.3	57.3	01Y110
07MY3-040	2	80	9/26	16.6	56.6	01Y110
07MY3-095	1	81	9/28	19.5	56.7	01Y110
07MY3-095	2	77	9/26	16.6	57.4	01Y110
07MY3-145	1	77	9/26	16.8	56.4	01Y110
07MY3-145	2	77	9/26	17.4	59.1	01Y110
07MY3-223	1	86	9/26	17.1	57.1	01Y110
07MY3-223	2	82	9/26	16.2	59.0	01Y110
07MY3-264	1	85	9/26	16.7	58.0	01y110
07MY3-264	2	85	9/26	16.9	58.4	01y110
07MY3-065	1	81	9/26	16.9	66.6	L204
07MY3-065	2	83	9/26	15.4	65.8	L204
07MY3-173	1	82	9/26	15.1	63.5	L204
07MY3-173	2	83	9/26	15.4	65.0	L204
07MY3-248	1	86	9/28	16.7	63.8	L204
07MY3-248	2	85	9/26	17.1	65.1	L204
07MY3-258	1	81	9/26	18.6	62.6	L204
07MY3-258	2	82	9/26	16.5	65.5	L204
07MY3-259	1	81	9/26	14.5	63.7	L204
07MY3-259	2	78	9/26	15.1	63.2	L204

Figure 1. Frequency distribution of MY3 random inbred lines (RILs) and parental lines for head rice yields during 2007 at RES.

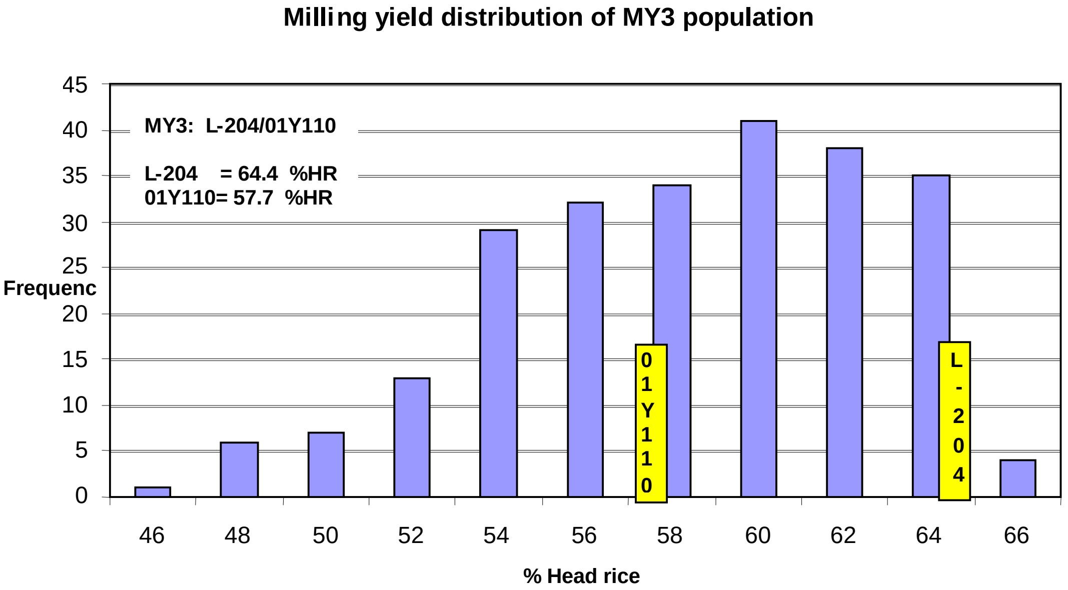


Table 20. Performance of conventional long-grain entries with resistance to stem rot in 2007 yield and milling tests.

Entry	Identity	DR†	SV‡	Day§	Ht (cm)	---Yield (lb/acre) ¶-- Statewide	RES	SR#	Blanking (%)	Head Rice (%)
Statewide										
105	03Y496	SR	4.4	87	95	8650	9530	5.3	25	54
112	01Y501	SR	4.8	83	92	8580	9300	5.6	18	59
73	L205		4.8	85	91	8130	8420	5.8	8	65
74	L206		4.7	77	83	8520	9540	7.3	15	63
Preliminary										
534	06P2345	SR	4.8	81	95	--	10680	5.5	18	58
629	06P2420	SR	4.7	79	93	--	10480	5.3	18	64
516	06P2326	SR	4.6	82	93	--	10450	5.4	12	63
482,564	01Y501	SR	4.7	81	91	--	10360	5.5	18	59
479,560	L205		4.8	83	92	--	10270	6.6	8	65
480,561	L206		4.7	78	87	--	10650	6.1	12	63

† DR=Disease resistance
‡ 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.

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 are utilized to advance resistant lines. A modified backcrossing scheme is used 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 continuing process that involves evaluation of genetic variation and requires time, new techniques, elimination of undesirable genotypes, and identification of superior ones for California's unique environment. 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. Over the last 30 years, Calrose kernel weight and size has increased while improving translucency. M-206, M-205 and M-208 have 5% more kernel weight than M-202.

M-208 Released

M-208 was released in the spring of 2006. M-208 is an early, smooth, high yielding semidwarf, Calrose quality medium-grain rice with resistance to California rice blast race IG-1.

In 2007, M-208 was grown on approximately 600 acres in the west side in Colusa County where blast is present in varying degrees, primarily on alkali soils. Growers reported M-208 had:

1. Yields equal to M-202 (88-92 cwt) but less than M-205 in non-blast fields.
2. Lodging was less than M-202.
3. No blast disease was observed.
4. Milling was equal or slightly superior to M-202.
5. Most growers would plant it again and/or increase their M-208 acreage.

Milled rice samples of M-208, M-206 and M-202 were distributed to various California rice marketing organizations and individual evaluators for 2 years indicate M-208 is similar to M-206 and M-202 with improvements noted in taste and texture for M-208. M-208 can be comingled with other Calrose medium grain. The 1/8 parentage of M-401 and Koshihikari involved in the M-208 cross appears to have made contributions in kernel size and weight, and cooking quality.

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 in non-blast areas.

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 2007, 97% of 37 first time entries (2 replications) showed 1-2% lower harvest moistures but their heading dates were in the range of regular CRMG. Selection for improved lodging resistance, seedling vigor and milling yield is continuing. Fifteen of 37 new entries (2 replications) had 1-2 points more head rice than the high performing checks, M-206 and M-205. Over the last 3 years, improved head and total milled rice have been observed in the preliminary groups of the Statewide Yield Tests. These improvement are not restricted only to lines with M-206 and M-205 parentage.

05Y724 (07Y11) and 05Y471 (07Y28) are two very early, smooth, high yielding, semidwarf CRMG in the second year of Very Early Statewide Group. 05- Y-724 yield ranked 1st over last 2 years (10 percent more than M-104). Based on its days to head and harvest moistures at various locations, it appears to be more adapted to warmer rice growing areas. 05Y471 is more adapted to the Delta as indicated by days to head and harvest moistures equal to M-104 from San Joaquin location. It has yielded 3% more compared to M-104 in the Delta and its head rice is 2 points better than M-206 and 5 points more than M-104. Also, seedling vigor may be superior to M-104. The very early entries 06Y239 (07Y29) and 06Y889 (07Y40) will be considered for further testing as the yield is 7-10% higher and have shown M-206 head rice yields. 04Y227 (07Y10) yield was more erratic in 2007 and it had variable maturity. These responses will cause it to be dropped from future yield testing.

Preliminary Yield Test Entries in Hawaii

There are 49 CRMG entries from 2007 yield tests being grown in the Hawaii Winter Nursery for purification, seed increase, and additional agronomic evaluation (Table 21). 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 head rice is 1-2 points higher. Overall, these entries are 1-2 inches taller than M-205.

Grain and head rice yields continue to improve for regular CRMG, CRMG with California IG-1 blast resistance, and CRMG Chinese introgression entries. Blast entries (07Y832, 07Y1088, and 07Y1127) have yielded 11-30% more than respective checks, M-206 and/or M-205. CRMG Chinese introgression crosses (07Y227, 07Y250 and 07Y254) have produces excellent yield compared to CRMG checks.

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.

Increased emphasis in developing rice varieties with blast resistance has produced a large volume of breeding materials. Eleven CRMG blast resistant entries were evaluated (4 in VE, 5 in E, and 2 in I-L). As new blast resistant materials are brought on line for statewide testing they have been selected for improvements in the overall yield stability and head rice potential. Pending final review of 2007 data and quality tests, one or two CRMG blast resistant entries will be re-tested in 2008.

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 51 entries with blast resistance that yielded more (up to 31%) than the average of all checks. The 83% 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. Realistically these yield advantages will conservatively translate to 4-6% on a field basis. The head rice is 1 point better than M-208 which is similar to M-202. An early M-208 (07Y89) was essentially the same maturity as M-208 in 2007 and will be dropped.

Another yield test with selected entries from 2007 rows is planned for 2008. 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 21. Preliminary Yield Test Calrose medium-grain entries selected and advanced in the 2007-08 Hawaii Winter Nursery.

Source	No. of Entries	No. Selected	No. in Hawaii
All entries	585	185	49
Stem rot	9	7	5
Chinese Introgression	15	12	8
Blast resistance	357	63	15

Herbicide Resistance

No breeding research was conducted on transgenic herbicide resistant M-202 in 2007 or Clearfield® rice germplasm by the CRMG program.

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 585 entries at this stage in 2007. Sixty-one of the 185 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. Twenty-one of 63 advancing blast entries had head rice equal or better than 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 the Very Early Statewide Yield Test has proven to be a useful tool.

Two items are worthy to note about M-206. Five years of milling data from sequential moisture harvest of M-206 foundation fields and milling plots indicate someplace between 20 and 23% field M-206 moisture will stay stable for 4-5 days before continuing to dry down. Studies in 2007 by Dr. Jim Thompson showed that M-206 maintained head rice at low harvest moistures. This is only one year of testing and will need to be confirmed with more data. If this is verified, head rice improvements in certain CRMG varieties may allow growers to harvest at lower moisture and give some reduction in drying costs in the future.

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).

Current SR resistant entries (07Y232, 07Y255 and 07Y381) have excellent yields compared with M-206, however the SR resistance scores are only slightly better than M-206. The yields are 20 to 32% better than the long SR resistance check, 87Y550. These entries represent improvements in earlier maturity, milling yield, and adaptation. Early generation material from different CRMG crosses that are in Hawaii that may have some SR score improvement.

Plant Height 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. This natural mutant was recovered form M-206 and designated 'DW-206'. Tests in 2006 (yield, milling, emergence and observations) were encouraging and in 2007 expanded studies to included a special UC weed control tests and entry in the Early Statewide Yield. In the deep (8") continuous water the DW-206 was significantly better in emergence than M-206, but slightly less than M-202. Early Statewide DW-206 (07Y71) yielded 500 lb/acre less than M-206, but 600 #'s more than M-202. Head rice of DW-206 was equivalent to M-202, but 1 point less than M-206. Genetic studies by Dr. Lage established that the plant height discovery (phd) trait in DW-206 (6" taller than M-206) is a simply inherited recessive trait to semidwarf height. DW-206 has been crossed and backcrossed to current CRMG's that are now in the breeding pipeline. A utility patent for this trait has been submitted. In addition, new germplasm that is 3" taller than M-206 is also being evaluated. The phd trait is not related to tropical submergence tolerance. This germplasm will continue to be incorporated into standard varieties, evaluated for inheritance, and for any positive/negative effects on agronomic characters.

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).

Special CRMG San Joaquin Yield Nursery

A single replication 64 (5 checks) large plot yield test was drill seeded adjacent to the San Joaquin UCCE Statewide Yield Test. The 59 experimental entries represented CRMG's from SR, blast, and CRMG Chinese introgressions lines and were also tested at Biggs. Breeding material will have to be tested at an earlier generation to identify those of particular value to cold environments like the Delta.

Transition and Retirement

A 1-year CRMG breeder overlap is progressing for a successful program transfer that will be completed by July 14, 2008 when Dr. C.W. Johnson will retire. This will allow the CRMG objectives, activities, germplasm, breeding methodologies, past history, and future direction to be experienced while progressing through a complete breeding cycle.

2007 Project Summary

1. M-208 grower survey indicates that it performs well in areas where blast is present with yields comparable to M-202 and good head rice.
2. M-206 harvest moistures remain constant for 4 to 5 days in the moisture range of 20-23 percent.
3. 05Y724 and 05Y471 (VE CRMG's) have shown improved yield and stable head rice (4-5 points) when compared to M-104 after 2 years of testing. 05Y724 appears best adapted to the warm M-104 in the delta.
4. Progeny lines derived from CRMG/Chinese introgression have produced excellent yields and head rice.
5. Studies of line DW-206 showed improved emergence through continuous 8" deep water and will continued to be investigated as another tool in weed control. Further improvements may come from progeny from crosses to current CRMG's.
6. Yields, head, and total rice continues to improve for entries evolving thru the statewide and preliminary CRMG yield tests.

2008 Research Direction

1. The very early experimental lines 05Y724 and 05Y471 will be thoroughly evaluated for adaptation to rice production areas favoring very early maturity varieties. The possibility of conducting strip trials will be investigated.
2. Initiate an increased and streamlined effort in stem rot resistance breeding in close collaboration with RES Pathologist Jeff Oster.
3. Screening of foreign germplasm for new sources of cold tolerance.
4. Modification of breeding methodology for rapid generation advance, reduction in cost, and efficient incorporation of molecular marker assisted selection.
5. Continue the transition from Excel-based data-handling and –storage to full incorporation of the relational database system 'Agrobase'.
6. Experiment with alternative yield testing methods including the possibility of expansion of yield testing in the Delta area.
7. Continued development of tall CRMG using the phd-trait. Also, further experimentation in collaboration with UC Davis at RES and possibly collaborative on-farm trials in organic production fields.

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 660 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 (5000-10000 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 6200 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 Chris Greer in 2006. 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 6200 rows in the 2007 SR nursery.

This year, 3955 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 2005-7 results (only for lines tested in 2007).

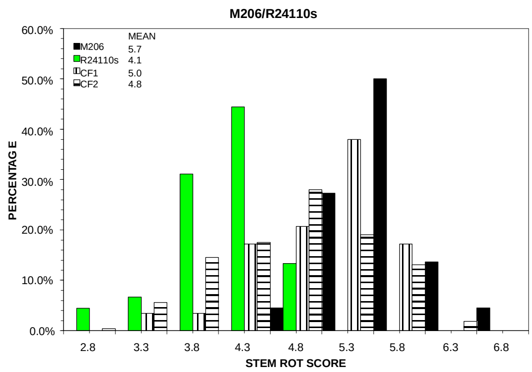
		2005		2006		2007	
Variety		SR	Yield	SR	Yield	SR	Yield
L205	L	5.8	8165	6.5	7444	6.0	8298
L206	L					5.8	9457
01Y501	L	4.7	8684	5.7	7927	5.1	8562
03Y496	L	4.0	9906	5.2	9010	4.5	8938
05Y753	L			5.2	7988	3.7	10231
06Y561	L					5.7	9200
06Y703	L					3.7	6942
M202	M					5.4	8165
M205	M					5.2	8540
M206	M	5.7	7181	5.9	8321	5.4	9263
07Y229	M					6.2	9830
07Y232	M					5.2	9322
07Y255	M					5.5	9899
07Y256	M					5.4	9458
07Y381	M					5.1	8756
S102	S	5.8	8028	7.2	8438	6.2	8703
87Y550	L	3.8	7811	4.9	8037	4.1	6499

The long-grain line 03Y496 has out yielded L-205 by an average of 16.5% percent. 05Y573 has out yielded L-205 by 15.7%. Medium grain entries yielded well, but did not have the desired level of resistance. No short grain lines were entered in the trial this year. 87Y550 is an old resistant line. Some resistance has been lost in materials developed after 87Y550, but yield gains have been large.

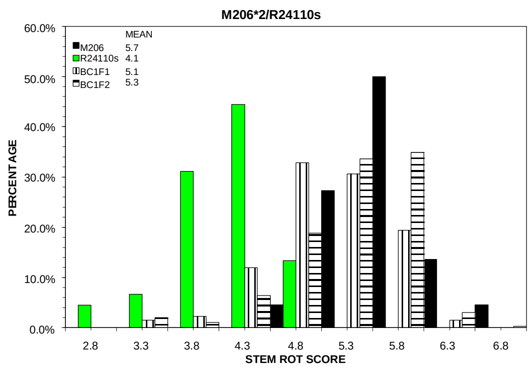
Because progress in the medium grain has been difficult, an immediate backcross program has been started. Two long grain and two medium grain lines with resistance from *O. rufipogon* and two lines with resistance from *O. nivara* have been backcrossed with M-206. Because inheritance of SR resistance from *O. rufipogon* is due to more than one gene, and the error associated with single plant selection, large populations must be used. One hundred crosses were made this year for this purpose.

The mode of inheritance of resistance from *O. nivara* was studied in 3500 transplants this year and is shown in the figures below.

Cross



Backcross



So far, inheritance appears to be additive and polygenic. It may be different than resistance from *O. rufipogon*, so the resistances may be combined in the future. Heritability estimates will be obtained in 2008.

Crosses are now at BC_3F_1. Backcrossing will continue until $BC_{5 \text{ or } 6}$ 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 done through F_5, when the breeders will evaluate progress, and use advancing lines in their crossing programs.

Marker research by Dr. Tom Tai's laboratory has not identified any markers useful in identifying SR resistance genes. Previously tested materials have been gathered and an attempt made at RES to obtain better markers for this disease.

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.

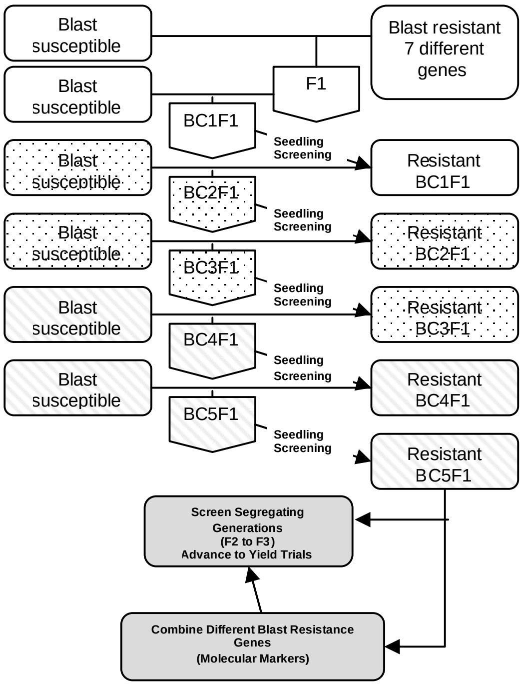
In addition, an immediate backcross program has been started to transfer sheath blight resistance genes from Teqing, Jasmine 85, and MCR10277 to M-206 and L-205 (66 crosses this year). BC_3F_1 has been made. Screening strategy will parallel that used for the SR immediate backcross program. Rice CAP researchers 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 2007, 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. 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 within 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-2, Pi-z^5, Pi-9, Pi-38, and Pi-ta^2). The fifth backcross has been made and screened for blast resistance (501 crosses this year). Theoretically, 98.4% of genes in this material are from M206. In 2008, BC_5F_2 will be screened and resistant lines selected. BC_5F_3 will be grown, and homozygous resistant lines selected. These lines will be evaluated for agronomic traits in the field, and the best material can then be used to pyramid resistance genes using marker assisted selection. 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. 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 project to develop molecular marker screening for pyramiding is in progress at RES. So far, Dr. Andaya has identified marker A5930P as the best for identifying the *Pi-z* gene.

Bakanae Disease

Seed treatment research for control of this disease has been concluded. Backup chemicals have been identified in case bleach is no longer available.

Screening breeding lines for bakanae resistance continues. All statewide entries are screened in the field. The goal is to prevent releasing excessively susceptible varieties. This should enhance the effectiveness of seed treatments in controlling the disease.

Quarantine Introductions

The building blocks for any breeding program are varieties with traits desirable in commercial production. One introduction was brought through quarantine this past year.

All introductions were grown under procedures developed and approved by USDA and CDFA to prevent introduction of exotic pests and rice diseases. This expedited process 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
2007 - Lance Tennis

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 2007, fellowships of $2,500 were awarded to Jennifer Williams and Mark Lundy. A total of fourteen fellowships have been awarded.

Rice Research Proposal

Rice research at RES in 2008 will continue toward the primary objective of developing improved rice varieties for California. Two new breeders joined the Rice Breeding Program in 2007 and considerable time and effort is being devoted to their integration in to the program, incorporating their new skills and ideas, and the transitioning with the retirement of Dr. Johnson in July 2008.

Project leaders will concentrate efforts on developing rice varieties for the traditional medium, short, and long-grain market classes. Research efforts will continue to improve and develop specialty rice such as waxy (mochi or sweet) rice, aromatic rice, and others as an adjunct breeding effort. Major breeding emphasis will continue on improving grain quality, yield and disease resistance. Efforts will be made to effectively use new as well as proven breeding, genetic, and analytical techniques. RES staff will expand DNA marker screening capabilities. Following are the major research areas of the RES Rice Breeding Program planned for short, medium, and long-grain types in 2008.

Quality

Efforts to identify, select, and improve culinary and milling quality in all grain types will continue to receive major emphasis. The RiceCAP project is cooperating with RES to develop genetic markers for milling quality. Improved techniques for cooking evaluations are being used that include use for DNA markers for amylose content, gelatinization temperature, and RVA types. 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 2008. 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
- Consolidate DNA marker development and utilization efforts for disease resistance and quality

Calrose Type Medium-Grains

- Improve conventional medium grains
- Improve stem rot resistant in medium grains
- Increase genetic diversity
- Utilize DNA markers for selection for blast resistance genes
- 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
- Facilitate transfer of wide spectrum blast resistance genes to adapted medium grains using accelerated backcrossing, screening, and selection for resistance.

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