2005 RICE BREEDING PROGRESS REPORT
AND
2006 RESEARCH PROPOSAL

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

January 1, 2006

In Memory of
Sammy R. Langdon
(1948-2005)

Mr. Sammy Langdon, a member of our staff at RES for the past 25 years, passed away suddenly at home June 24, 2005. Sam worked with our field/maintenance crew handling foundation seed production and field equipment operation. The success of this organization is made possible by many people that include dedicated employees like Sam who till the land, plant the crop, rogue the seed fields, harvest, clean and process seed rice, and make our annual Rice Field Day a success. On behalf of the California Cooperative Rice Research Foundation and his coworkers, we want to recognize Sam's long service here and extend our thanks and condolences to his family and friends.

RICE EXPERIMENT STATION STAFF

Administration

Kent S. McKenzie, Ph.D. .... Director

Plant Breeding

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

Plant Breeding Support

Matthew A. Calloway ....Plant Breeder Assistant
Baldish K. Deol...Plant Breeder Assistant
Paramjit S. Deol ....Plant Breeder Assistant
Harbhajan Singh Toor ....Plant Breeder Assistant
Harry P. Wright ....Plant Breeder Assistant
Ann E. Noble (resigned 8/31/05)..............................Post-Graduate Assistant
Alexander I. Roughton..Post-Graduate Assistant

Field Operations and Maintenance

Bill W. Brandon ....Field Supervisor
Clayton E. Heineman ....Mechanic and Operator
Burtis M. Jansen ....Maintenance and Operator
Donald L. Nuchols ....Maintenance and Operator

Clerical and Accounting

Lacey R. Stogsdill ....Administrative Assistant

♦♦♦♦♦♦♦♦

TABLE OF CONTENTS

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 was expanded by approximately 100 acres in 1998 to support weed research, breeding, and foundation seed production.

Dr. Kent S. McKenzie is the station director and the scientific professional staff of CCRRF includes plant breeders Drs. Carl W. Johnson, Farman Jodari, Junda Jiang, and plant pathologist Mr. Jeffrey J. Oster. Eleven career positions consisting of five plant breeding assistants, one postgraduate assistant, a field supervisor, one mechanic and field operator, two maintenance and field operators, and an administrative assistant make up the support staff. Approximately 30 seasonal laborers are employed during crucial planting and harvest times.

Organization and Policy

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

Research Mission and Funding

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

USDA research by providing land, resources, and management for genetic, agronomic, weed, insect, disease, and other disciplinary research.

Rice variety development at RES is primarily funded by the CRRB that manages funds received from all California rice producers through California Rice Research Program assessments. The CRRB acts under the authority of the California Department of Food and Agriculture (CDFA). The CRRB finances approximately 80% of the RES annual budget and 20% is derived from the sale of foundation rice seed to seed growers, grants, and revenues from investments. RES does receive some grants from agribusiness and the RRT. The RRT is a tax-exempt trust [501(c)3] established in 1962 to receive tax deductible contributions for support of rice research. RES is not government supported, but is receiving some USDA competitive grant rice research support through the RiceCAP initiative.

Cooperative Research

Cooperative research is an integral part of rice research at RES involving USDA and UC scientists. Dr. Thomas H. Tai, USDA-ARS Research Geneticist, Department of Agronomy and Range Science, UCD, is working with all project leaders to develop improved breeding and genetics methods for rice variety improvement. Rice quality and genetic research has included studies with USDA scientists Drs. Thomas Tai, Anna McClung, Bob Feldstrom, Stephen R. Delwiche, Elaine T. Champagne and Robert Swank. Drs. Charles F. Shoemaker and Ana Maria Ibanez-Carranza are pursuing research on rice quality in the Department of Food Science and Technology, UCD and material and support are provided to that effort. Statewide performance testing of advanced experimental lines and varieties was conducted by Mr. Raymond L. Wennig, UCD staff research associate, under the direction of University of California Cooperative Extension Farm Advisors Mr. W. Michael Canevari (San Joaquin), Dr. Randall G. Mutters (Butte, Placer, Sacramento, Sutter, Yuba), and Dr. Chris Greer (Glenn, Colusa, Yolo, Tehama) and Agronomist Dr. James E. Hill, (Department of Agronomy and Range 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 2005. Dr. Albert J. Fischer, associate professor, Weed Science Program, Department of Vegetable Crops, UCD and Mr. James Eckert UCD staff research associate at RES, conducted UC rice weed research on 18 acres. Dr. Randall Mutters is coordinating the rice systems research in a 13 acre research area established at RES and he is being supported by UCD staff research associate Mr. Steve Bickley. Dr. Larry D. Godfrey, extension ento-mologist, and Mr. Richard L. Lewis, postgraduate researcher, Department of Entomology, conducted rice water weevil research. Please refer to the 2005 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 is 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 were grown at RES in 2004-5. Future research in this area by RES will depend on California's needs, market acceptance, and the development of research agreements.

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

Seed Production and Maintenance

The production and maintenance of foundation seed of California public rice varieties and new releases is an important RES activity. The foundation seed program is a cooperative program between CCRRF and Foundation Seed and Certification Services at UCD. Its purpose is to assure availability of pure, weed free and high quality seed of public rice varieties for the benefit of the California rice industry. The California public rice breeding program of CCRRF has developed 42 improved rice varieties since the accelerated research program began in 1969. Foundation seed of 17 public rice varieties and basic seed of two Japanese premium quality varieties were produced on 175 acres at RES in 2005. Although the foundation seed program is self-sustaining and not supported with CRRB funds, the cooperation of CCRRF-UC-USDA-CRRB makes the program possible and has resulted in an estimated 90 percent use of certified seed by the California rice industry.◆

RICE BREEDING PROGRAM

INTRODUCTION

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

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

RES has been working to improve rice quality evaluation capabilities in all market types. Physicochemical and grain testing for rice quality components are being expanded to support the breeding program. This has been made possible by the improvement of laboratory facilities, equipment, and the addition and training of support staff. Screening, evaluation, and research in the area 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. In 2005 limited aerial herbicide options were 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 remains 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 2005 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 grower’s fields.

BREEDING NURSERIES

Delayed and streamlined nursery preparation delayed seeding of the 2005 breeding nursery at until May 20th, and was completed the 27th. Further problems were encountered due to unleveled fields, N losses, fertilizer application errors, and record high temperatures in July resulting in some of the lowest plot yields in recent memory at RES. Statewide commercial yields were estimated to be down 16% from 2004 and the Butte County Growers Association reported the pool yield average down 17% to 7900 lb/acre from 2004.

In 2005, 1725 new crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 31,775. 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 can be grown for selection purposes in 2006, thereby accelerating the breeding process.

The 2005 RES breeding nursery occupied approximately 83 acres. Water-seeded yield tests included 4157 small plots and 3488 large plots. Small seed increase plots and cooking samples were grown on 2.5 acres and included 36 advanced breeding lines. Forty experimental lines (3316 headrows) were grown for seed increase, quality evaluations, and purification. The nursery included about 59,600 water-seeded and 12,030 drill seeded progeny rows. Selections were made for advancement, quality evaluations, and purification from approximately 10,000 progeny rows. F_2 populations from 2003 and 2004 crosses were grown in precision drill-seeded plots on 14 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 2006.

Headrows (2400) of M-401, M-402, M-206, M-207, L-205, L-206, and Calmati-202 were grown for breeder seed production in 2006. This headrow seed can be used for several years to produce breeder seed because it is stored under low temperature and proper humidity conditions.

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

After an extensive search, a new winter nursery site was identified and leased in late September 2004. A contract was reached with a new cooperator, the site cleared, and the nursery (8820 rows) planted by RES staff in November 2004. F_1 plants from 2004 crosses were transplanted into the nursery later in December under RES supervision. Bird netting was purchased and selection and harvest completed and seed returned in April, processed and planted at RES.

In July new paddies were constructed for rotation at the cleared site and 8400 progeny row nursery and planted in November by RES staff. F_1 plants from

557 new crosses were transplanted to the field in December. Selection and harvest will occur in April and seed returned for processing and planting in the 2006 RES breeding nursery.

The 2005 UCD Cold Tolerance Nursery contained 3 acres of precision drill-seeded F_2 populations and 8,800 dry-seeded progeny rows. In the UCD Rice Facility, blanking in the breeding rows and F_2 populations was at a moderate level. Unfortunately, due to a change in the irrigation system, cold water delivery severely damaged all the long grain and much of the short grain progeny rows making them unusable. Selections were made from the F_2 populations. The cool temperatures observed at UCD typically are not as low as those observed at the San Joaquin location. The UCD Cold Tolerance Nursery allows selection of materials with moderate resistance to blanking and is a valuable location for advancement, evaluation, and selection of breeding materials.

The San Joaquin Cold Tolerance Nursery was planted in cooperation with two local rice growers. The 4-acre drill seeded nursery included 10,320 rows and 3.6 acres of F_2 populations. Management and production were excellent. Blanking levels were medium providing good opportunities to select blanking resistant material. The new Hege nursery row planter was used successfully at both UCD and San Joaquin nurseries.

The cold tolerance nurseries remain an essential part of selecting for resistance to blanking and are used in conjunction with two refrigerated greenhouses at RES. In exceptionally cool years, the yield performance of cold tolerant varieties like Calmochi-101, M-103, 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 2005 Statewide Yield Tests were conducted at eight locations in commercial fields by Mr. Raymond L. Wennig, Mr. W. Michael Canevari, Dr. Randall G. Mutters, Dr. James E. Hill, and Dr. Chris Greer. Advanced selections were tested in one of the three maturity groups: very early, early, or intermediate to late with standard check varieties included for comparison. Each maturity group was subdivided into an advanced and preliminary experiment. The advanced entries and checks had four replications and the preliminary entries had two replications. Plots were combine-size (10 by 20ft) and the experimental designs were randomized complete blocks.

All these advanced large plot entries were also tested at RES in a randomized complete block design. The large plot seeding dates at RES were May 23 and 24 and May 25 to 27, 2005 for replications 1 & 2 and 3 & 4, respectively.

The plot size was 12 by 15 ft with the center 10 ft combine harvested (150 ft^2). Water seeding and conventional management practices were used in these experiments. Ordram® was used for grass control. Shark® and Londax® were applied for broadleaf weed control. One application of Mustang® was applied for rice water weevil control.

A number of factors contributed to the relatively low plot yields in the nursery including late planting, problems in seed bed preparation, fertilizer application errors, and high July temperatures. Tables 1 to 6 contain a summary of performance information from the 2005 Statewide Yield Tests. Yields are reported as paddy rice in pounds per acre at 14% moisture. 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 2006. Complete results of the 2005 Statewide Yield Tests are reported by UCCE in "California Rice Varieties Description and Performance Summary of 2005 and Multiyear Statewide Rice Variety Tests in California" 2005 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 locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
14	L205	L	4.7	84	94	6	5.9	8920	8390
16	99Y041	L	4.6	81	99	21	6.1	8840	8780
18	04Y508	L	4.6	81	100	1	5.6	8840	8380
17	03Y467	LR	4.8	73	93	5	8.4	8670	8260
15	99Y469	L	4.7	76	91	25	6.3	8400	8130
2	S102	S	4.9	72	95	45	6.1	8350	8690
13	L204	L	4.8	79	90	1	6.5	8140	7880
11	04Y031	M	4.5	72	102	42	6.4	8140	8220
6	04Y198	SPQ	4.7	75	91	14	5.9	8070	7690
3	04Y206	S	4.8	75	95	31	6.1	8040	8400
10	04Y010	M	4.7	73	96	48	6.6	7980	8170
5	03Y166	SPQ	4.7	74	85	1	5.1	7860	7620
4	01Y185	SPQ	4.8	72	91	60	5.7	7700	8090
12	04Y037	M	4.8	74	97	43	6.6	7620	7790
9	04Y009	M	4.9	78	98	65	6.6	7560	8010
7	04Y007	M	4.8	74	97	60	6.4	7460	7700
1	CM101	W	4.8	74	95	53	5.7	7220	7900
8	04Y008	M	4.8	69	93	53	5.7	5860	7580
Mean			4.7	75	94	31	6.0	7980	8090
LSD(0.05)			0.2	2.7	5.8	27	8.5	1010	330
C.V. (%)			2.6	2.5	4.3	60	0.8	8.9	5.9

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

Table 2. Agronomic performance means of very early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
50	01Y655	LR	4.8	86	10	2	6.1	9720	8730
46	04Y501	LR	4.8	79	105	4	6.4	8970	8610
23	03Y183	S	4.7	73	91	59	5.8	8790	8350
42	02Y565	SR	4.6	82	100	1	5.2	8770	8330
47	02Y516	L	4.7	76	104	20	5.8	8740	8360
33	04Y378	M	4.7	77	100	45	5.8	8720	8220
45	04Y492	L	4.7	79	100	2	6.1	8710	8390
48	04Y523	L	4.8	78	99	19	7.5	8430	8380
44	04Y506	L	4.8	77	89	1	5.8	8390	8460
25	04Y220	W	4.5	78	96	21	5.7	8370	8600
26	04Y332	MPQ	4.8	74	103	33	5.6	8280	8060
19	03Y164	SPQ	4.7	79	95	30	5.7	8210	7700
43	03Y454	L	4.4	79	93	2	5.9	8000	7770
38	04Y855	M	4.9	72	102	59	6.1	7890	8280
32	04Y286	M	4.7	74	96	56	6.3	7890	7850
41	04Y999	M	4.8	73	95	5	6.2	7890	7660
37	04Y837	M	4.8	72	103	57	6.2	7830	8450
35	04Y817	M	4.9	69	97	46	6.2	7680	7940
36	04Y827	M	4.9	73	101	31	5.5	7670	7830
34	04Y816	M	4.9	73	101	6	5.6	7620	8030
24	04Y213	W	4.7	78	87	51	5.9	7610	8190
39	04Y857	M	4.8	74	99	34	6.3	7610	7650
31	04Y252	M	4.3	75	98	33	5.8	7520	7650
40	04Y926	M	4.9	71	97	54	6.3	7510	7680
30	04Y247	M	4.6	73	91	25	5.9	7460	7580
21	03Y167	SPQ	4.9	75	91	4	5.1	7300	7270
20	04Y177	SPQ	4.6	74	88	51	5.5	7090	8040
28	04Y227	M	4.7	69	102	65	5.8	7000	7990
27	03Y308	MPQ	4.6	77	95	64	5.2	6930	7800
49	03Y485	BA	4.9	77	98	1	6.6	6790	6570
22	03Y170	SPQ	4.9	77	86	75	5.8	6780	7400
29	04Y234	M	4.7	70	94	28	5.2	6610	7490
Mean			4.7	75	96	30	6.0	7900	7970
LSD(0.05)			0.2	2.6	5	27	8.5	910	470
C.V. (%)			3.5	2.4	3.7	65	0.8	8.2	6.6

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

Table 3. Agronomic performance means of early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Butte, Colusa, Yuba, and RES locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
81	01Y655	LR	4.8	88	101	2	6.3	8820	8490
76	L205	LR	4.6	87	96	1	6.4	8760	8270
79	99Y041	L	4.7	83	98	5	6.6	8620	8300
80	99Y529	L	4.6	81	99	1	6.2	8450	8420
78	99Y469	L	4.6	77	88	9	6.9	8250	8130
71	04Y071	M	4.7	80	95	8	5.8	7980	8490
62	S102	S	4.7	75	97	34	6.4	7950	7520
68	04Y068	M	4.9	73	98	35	6.7	7890	7910
65	01Y327	SPQ	4.8	78	91	9	6.8	7810	7680
75	L204	L	4.7	80	89	1	6.9	7810	7840
63	CH201	SPQ	4.9	79	90	44	8.2	7740	7600
64	03Y316	SPQ	4.7	86	96	2	5.1	7710	7690
70	04Y070	M	4.8	79	96	10	6.4	7560	8120
72	04Y072	M	4.8	73	95	39	7.5	7540	7490
74	04Y144	M	4.8	78	94	3	5.5	7520	7740
73	04Y012	M	4.6	79	101	50	6.8	7450	7780
69	04Y069	M	4.8	77	96	48	7.0	7350	7500
67	03Y308	MPQ	4.8	77	97	60	5.8	7290	7720
66	01Y185	SPQ	4.6	74	96	45	5.8	7220	7230
77	CT201	BA	4.9	81	109	5	6.3	6900	7110
61	CM101	W	4.5	77	97	51	6.2	6830	6830
Mean			4.7	79	96	22	6.4	7780	7800
LSD(0.05)			0.2	2.6	6	25	8.2	950	520
C.V. (%)			3.2	2.4	4.4	82	0.8	8.6	8.2

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

Table 4. Agronomic performance means of early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Butte, Colusa, Yuba, and RES locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
108	03Y496	SR	4.8	84	104	1	6.0	9410	8920
105	04Y105	LR	4.9	84	96	1	6.2	8960	8120
97	04Y460	M	4.7	81	97	13	5.6	8700	8400
104	03Y151	LR	4.7	84	97	1	7.1	8620	8560
83	04Y165	SPQ	4.6	82	92	38	6.9	8530	7900
106	04Y564	L	4.9	85	99	2	5.8	8510	8200
109	01Y502	SR	4.5	83	97	1	6.0	8400	8580
82	04Y189	SPQ	4.8	83	94	63	6.6	8300	7760
110	04Y524	L	4.9	84	102	1	5.4	8290	7780
89	04Y314	MPQ	4.8	77	101	64	6.1	8240	7600
102	04Y928	M	4.8	75	96	10	6.8	8160	7410
98	04Y656	M	4.7	80	99	19	6.2	8070	8230
95	04Y405	M	4.7	79	93	3	5.4	7920	8030
99	04Y687	M	4.7	82	98	4	6.0	7900	8220
91	04Y274	M	4.8	76	94	4	5.4	7840	7910
88	04Y330	MPQ	4.9	72	91	19	6.2	7790	7600
92	04Y280	M	4.7	77	96	9	5.9	7650	7500
93	04Y294	M	4.8	75	97	9	5.5	7640	7560
101	04Y905	M	4.8	77	105	28	6.5	7600	7400
84	04Y173	SPQ	4.7	74	89	5	5.8	7590	7220
87	03Y559	MPQ	4.5	77	100	36	6.7	7560	7450
100	04Y228	M	4.8	72	96	43	6.1	7540	8010
94	04Y387	M	4.8	77	98	30	6.2	7520	7330
103	04Y1006	M	4.9	74	95	14	6.2	7330	7240
90	03Y324	S	4.3	77	96	28	6.2	7270	7470
96	04Y428	M	4.7	79	102	15	5.8	7250	7540
85	04Y181	SPQ	4.4	79	93	40	5.9	7130	6620
86	03Y295	MPQ	4.7	79	95	21	6.4	7060	7140
111	04Y537	BA	4.8	79	101	1	7.4	6860	6710
107	04P3220	BA	4.9	86	111	69	7.2	6240	5790
Mean			4.7	79	97	19	6.4	7860	7720
LSD(0.05)			0.3	2.3	3.9	26	8.2	570	440
C.V. (%)			4.7	2.1	2.9	97	0.8	5.2	5.8

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

Table 5. Agronomic performance means of intermediate to late advanced entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
133	03Y151	LR	4.8	91	98	4	7.6	10630	9470
134	04Y706	L	4.7	88	101	4	6.3	10530	9260
132	01Y501	SR	4.8	89	103	4	6.2	10340	9320
126	03Y576	SR	4.7	97	96	1	5.5	9940	9000
124	04Y622	MPQ	4.8	84	96	15	6.8	9270	8480
129	04Y100	M	4.8	87	99	65	6.6	9230	8930
123	03Y559	MPQ	4.8	83	105	83	6.3	9140	8740
130	L205	LR	4.9	94	98	13	6.6	9110	8730
127	04Y127	M	4.9	90	101	28	5.8	9110	9120
128	04Y128	M	4.9	86	109	93	7.0	8610	8850
121	M402	MPQ	4.9	106	106	4	5.6	8570	8380
125	03Y324	S	4.9	82	102	25	5.8	8570	8820
131	CT201	BA	4.9	87	108	28	6.2	7690	7330
122	CH201	SPQ	4.9	83	95	97	8.7	7590	7980
Mean			4.8	89	101	33	6.1	9170	8660
LSD(0.05)			0.1	1.3	7.5	14	6.8	1740	410
C.V. (%)			0.9	0.7	3.4	20	0.8	8.8	5.3

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

Table 6. Agronomic performance means of intermediate to late preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES locations in 2005.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
139	04Y404	M	4.8	86	104	25	6.5	9980	9330
154	04Y704	SR	4.7	94	93	1	5.4	9860	8510
137	04Y638	SR	4.7	97	90	2	5.2	9520	8580
152	99Y041	L	4.8	96	104	5	6.3	9380	8800
138	04Y208	SR	4.7	85	92	4	6.2	9230	8400
149	99Y529	L	4.7	86	104	10	7.0	9180	9090
136	04Y625	MPQ	4.8	87	103	13	6.2	9170	8470
146	04Y842	M	5.0	80	108	63	6.0	9140	9120
140	04Y413	M	4.8	88	105	15	6.6	9110	9030
142	04Y660	M	4.9	87	99	9	5.8	9110	8650
147	04Y997	M	4.9	82	107	18	5.8	8660	8140
150	99Y494	LW	4.9	96	96	4	7.3	8650	8880
143	04Y662	M	4.8	87	101	25	5.8	8630	8790
135	02Y321	MPQ	4.9	87	107	60	7.2	8080	8040
144	04Y683	M	4.9	87	99	28	6.6	7990	8600
151	99Y469	L	4.7	82	97	35	6.6	7910	8420
148	04Y1007	M	5.0	79	102	15	5.9	7640	7600
141	04Y419	M	5.0	84	102	20	5.3	7470	7890
153	04Y153	BA	4.8	84	98	70	6.0	6860	6120
145	04Y823	M	4.9	77	108	70	6.2	6550	8140
Mean			4.8	86	101	24	6.1	8600	8430
LSD(0.05)			0.1	4.6	6.6	20	6.8	1630	700
C.V. (%)			1.3	2.5	3.1	39	0.8	9.1	7.1

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

PRELIMINARY YIELD TESTS

Preliminary Yield Tests are the initial step of replicated large plot testing for experimental lines. The experimental design, plot size, and production practices are identical to the Statewide Yield Tests grown at RES. A summary of the yields of 2005 Preliminary Yield Tests is presented in Table 7. These tests included 984 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 2006 Statewide Yield Tests. ◆

Table 7. Summary of Preliminary Yield Tests at RES in 2005.

Test	Number of Entries	All	Highest	Top 5	Check
		Average Yield (lb/acre)†			
Very early					
Short grains	60	7620	9030	8850	8290
Medium grains (A)	16	6010	6420	6230	6400
Medium grains (B)	54	6690	7730	7440	7160
Long grains	81	9240	10270	10150	9050
Early					
Short grains	83	7030	8340	8080	7340
Medium grains (A)	57	6860	7560	7450	7030
Medium grains (B)	50	8430	9580	9270	9060
Long grains	81	8390	10390	10310	6660
Intermediate-Late					
Short grains	45	8420	10530	9960	9090
Medium grains	50	8270	9420	9240	8770
Long grains	45	8130	9740	9510	9060
Special Blast (1 rep)					
Medium grains A	244	7790	11140	10380	9210
Medium grains B	60	7780	9570	9410	8200
Medium grains C	58	7270	8710	8290	7700

† Paddy rice yield at 14% moisture.

CALROSE MEDIUM GRAINS

Carl W. Johnson

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

Efforts to incorporate blast resistance into CRMG's began in 1996 with crosses involving various cultivars (Southern and foreign) with various genes resistant to the California IG-1 race. In every greenhouse crossing season (summer and winter) resistant material from original crosses plus new sources continue to be back-crossed to adapted germplasm. The Hawaii winter nursery, winter greenhouse, and modified breeding procedures were utilized to advance resistant lines. These efforts have resulted in M-207 being released for those areas in Glenn and Colusa counties that have blast damage every year. In addition, experimental line 02-Y-816 with *Pi-z* blast resistant gene is anticipated to be released as 'M-208' in the spring of 2006.

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

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

Calrose Medium Grain Quality

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

Experimental 02-Y-816

02-Y-816 is being proposed as a varietal release in 2006 as M-208. Its anticipated final confirmation will occur in early February. The following describes in summary form the background, agronomic characters, and proposed area of adaptation.

02-Y-816 (03-Y-32, 04-Y-12 and 05-Y-73) is an early, smooth, high yielding semidwarf, Calrose quality medium-grain rice with resistance to the California blast race IG-1 derived from the *Pi-z* gene. Its pedigree is M-401/3/Mercury//Mercury/Koshihikari (97 row 17126)/4/M-204 and this cross, R23324 was made in 1997-1998 winter greenhouse. 97 row 17126 was derived from the cross R19610 made in 1993-1994 winter greenhouse. The male parent of cross 19610 was later released as the medium grain Lafitte (PI593690) by Louisiana State University and was the source for *Pi-z* blast resistance gene.

Table 8. Summary of Agronomic Characteristics in 2003-2005 UCCE Very Early and Early Statewide Yield Test for M-206, 02-Y-816, M-207, and M-202.

Character	M-206	02-Y-816	M-207	M-202
Seedling Vigor Score)	4.9	5.0	4.8	4.9
Days to 50% Heading	80	86*	82	85
Plant Height (cm)	98	100	98	98
Lodging (%)	33	33	42	32
Greenhouse Blanking (%)	8	9	11	12
Blanking at Davis (%)	9	15	25	17
Blanking at San Joaquin (%)	7	10	11	13
Overall Blanking (%)	8	11	16	14
Stem Rot Score	6.4	6.6	7.5	6.3
Harvest Moisture (%)	20.9	19.7	18.9	20.9
Yield lbs/acre @ 14 %	8812	8641	8334	8465
Total Milled Rice (%)	68.4	67.9	66.7	68.2
Whole Grain Milled Rice (%)	64.7	63.8	61.3	63.1
1000 Brown Rice Kernel Weight (g)	23.8	24.4	21.6	23.2
Brown Rice Kernel Length (mm)	6.26	6.60	6.42	6.24
BR Brown Rice Kernel Width (mm)	2.82	2.85	2.71	2.85
Brown rice Length/Width Ratio	2.22	2.32	2.36	2.19
Apparent Amylose Content (%)	16.8	17.3	15.3	15.6
Alkali Spreading Score(1.7% KOH)	6.0	6.7	6.2	6.6

* Significantly different than M-206 and M-207 at 0.05 level.

02-Y-816 is essentially an M-202 agronomic type CRMG that is an improvement over the other blast resistant variety M-207. 02-Y-816 compared to M-207 is 4 days later, lodges 9% less, has improved whole head rice (2.5 points), and 4 percent higher seed weight (Table 8, 9, and 10). 02-Y-816, will be the second CRMG with resistance to race IG1 of blast found in California. Resistance has been confirmed by multiple greenhouse and molecular marker tests. The *Pi-z* gene presence has been confirmed and rated fixed by two different labs using different markers. 02-Y-816 can be commingled with other CRMG's with similar size, shape and weight; has similar chemical kernel starch characters; and judged very similar to M-206, M-207 and M-202 in visual, cooking, and taste evaluations by various milling and marketing organizations and individual evaluations.

Table 9. Statewide Yield Test over location yield averages of M-206, 02-Y-816, M-207 and M-202 for 2003 to 2005. †

Year	Test	M-206	02-Y-816	M-207	M-202
2003	VE SWYT	8680	9020	8460	8340
2004	VE SWYT	9850	9120	9050	9560
2005	E SWYT	7905	7783	7491	7496
2005	Strip Trial	7713	7767	7600	7950
Mean		8537	8423	8150	8337

†pounds/acre at 14.0% moisture.

Table 10. 2005 Strip Trial Yields at 14% moisture and milling yield of M-206, 02-Y-816, M-207 and M-202.

Entry	Yield	Harvest H_20	Total	Head
M-206	7713	16.2	71.6	57.0
02-Y-816	7767	17.4	69.3	56.8
M-207	7600	15.7	67.8	48.5
M-202	7950	17.0	70.3	49.9

02-Y-816 is adapted to the majority of M-202 growing areas. 02-Y-816 has improvements for lodging and whole grain milling quality over M-207. Although it has specific application in those areas in Glenn and Colusa counties that have fields with varying degrees of blast damage every year that reduces yield and milling quality, it also has the potential as to be grown in combination with other CRMG's. 02-Y-816 can be best described as an M-202 type with blast resistance. Fertilization requirements will be similar to M-202.

Promising Medium-Grain Entries

Medium-grain experimental entries in the very early group of the Statewide Yield Tests ranged from M-103 to M-202 in maturity (Table 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.

A number of CRMG lines in the Statewide Yield Tests, very early and early groups, 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. Selection for improved lodging resistance, seedling vigor and milling yield is continuing. Increased emphasis in developing rice varieties with blast resistance has produced a large volume of breeding materials. Twenty-one CRMG blast resistant entries were evaluated (9 in VE, 6 in E, and 5 in I-L). In general as new generated blast materials are brought on line for statewide testing they are improving in the overall yield stability and whole grain head rice required by California medium-grain varieties. Pending final review of 2005 data and quality tests, only 1 or 2 CRMG blast resistant entries will be re-tested in 2006.

03-Y-254 is a very early, smooth, high-yielding, semidwarf CRMG in the second year of Very Early Statewide Tests. Compared to M-104, it has improved yield (3.5%) and stable whole grain head rice (1-2 points). Its maturity and seedling vigor are similar to M-104. It will again be retested in 2006.

Preliminary Yield Test Entries in Hawaii

There are 26 CRMG entries from 2005 yield tests being grown in the Hawaii Winter Nursery for purification, seed increase, and additional agronomic evaluation (Table 11). Maturities of these entries range from M-103 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 quality is equal to or better than M-202. Overall, these entries are 1 inch taller than M-205. There are 13 regular CRMG's without blast resistance and 13 CRMG's with blast resistance.

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. Forty-nine percent (219 of 446) of the CRMG crosses were for blast resistance. Thirty-nine percent of CRMG 2005-06 Hawaii rows (1081 rows) were for IG-1 blast resistance and included 78 pedigrees.

A special test of blast resistant entries was conducted at RES (Table 7). Breeding efforts have overcome the 30% yield drag, higher blanking levels, and lower milling yields, and have produced improved experimental lines with blast resistance. There are 13 entries with blast resistance that yielded more (up to 17%) than highest CRMG check. The 79% discard rate of experimental lines attests to the challenges of developing adapted blast resistant lines in the CRMG. The saved entries range from M-104 to M-202 maturities. Each generation of blast materials show increases in resistance to blanking and improved head rice. Thirteen of the blast resistant lines have sufficient agronomic merit and are being advanced in Hawaii for testing in 2006.

Another yield test with selected entries from 541 rows is planned for 2006. 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 11. Preliminary Yield Test Calrose medium-grain entries selected and advanced in the 2004-05 Hawaii Winter Nursery.

Source	No. of Entries	No. Selected	No. in Hawaii
All entries	589	145	26
Stem rot	5	3	1
Seedling vigor	2	1	1
Blast resistance	362	74	13

Herbicide Resistance

Several crosses made onto herbicide resistant Clearfield® rice germplasm were advanced. Visual evaluation of the plant growth characteristics indicate that it may take a long time to transfer this non-transgenic characteristic into a high yielding CRMG. The remaining lines from the cold San Joaquin location were screened by the herbicide, leaving 7 lines which will be advanced in 2006. In addition, weeds resistant to this herbicide are already present in California. No breeding research was conducted on transgenic herbicide resistant M-202 in 2005 by RES.

Milling Quality

Selection for grain quality factors continues to be an integral part of the RES medium-grain breeding effort. Increased emphasis has been placed on identifying experimental lines with improved milling yields. Head rice yield is one of the important criteria for advancing a breeding line. New techniques and procedures are being used as they are developed. 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 589 entries at this stage in 2005. Forty-nine of the 145 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. Forty-nine of 74 advancing blast entries had head rice equal to respective CRMG and 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. Progress is being made to improve and maintain high head rice yield.

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 average head and total milled rice at 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 test headed in a 10 day period. No particular trends were noted. In previous years the dry down rate in VESW test (particularly San Joaquin) has proven to be a useful tool. In 2005 only the San Joaquin location proved to be a useful tool. The other cool VESW locations were all cut at low moistures. Unlike 2004, a faster dry down rates in majority of blast entries was not observed in 2005.

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.

There appears to be a barrier to recovery of high yield, blanking resistance, and earliness in combination with high SR resistance in CRMGs. 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).

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-103 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). An observed genetic trait is being studied for its application to deep water during stand establishment.

2005 Project Summary

1. M-207 (00-Y-805) was released in the spring of 2005. It is a very early to early CRMG with IG-1 blast resistance, adapted to all CRMG growing areas, but was released as a CRMG alternative for those areas with rice blast disease problems serving as an intern variety.
2. 02-Y-816 is being proposed for release in 2006 as M-208. It is an early CRMG with IG-1 blast resistance and is adapted to the majority of M-202 production areas. It is best described as a M-202 type with blast resistance and has the potential to be grown in combination with other CRMG's.
3. Fast track efforts to develop other CRMG blast resistant varieties continue with other lines being advanced in Hawaii. These lines, along with other blast material, continue to have yield increases.
4. Other CRMG breeding and research activities were continued. The amount of effort for the various objectives was dependent on time, resources and genetic variation available. The search for significantly lower SR scores in high yielding CRMG remains a priority.

2006 Research Direction

1. Tentative strip trial for 03-Y-254 will be compared to M-104 and M-206 located the coldest rice production areas to evaluate yield performance and milling quality.
2. Continue fast track development of CRMG varietal development with blast resistance to include yield, head rice and cooking evaluation. Special blast yield trial results indicate there could be another 5-7% yield increase. Plan for the use of DNA markers in early generation blast selection if feasible.
3. Incorporate new germplasm for SR and sheath spot resistance from other RES projects and using a combination of low SR score and stay green types as selection criterion.
4. Small and large plot yield tests will begin for Chinese introduction backcross material to evaluate its potential.
5. CRMG variety development will continue evaluating CRMG materials that are in the breeding pipeline that do not have blast resistance but have significant improvements for beneficial agronomic and quality traits.

PREMIUM QUALITY & SHORT GRAINS

Junda Jiang and Kent S. McKenzie

Project research for short grains and premium quality rice breeding is focused on genetic improvement of six different grain and quality types that include 1) premium quality short and medium grains, 2) conventional short grains, 3) waxy short grains, 4) low amylose lines, 5) large seeded (Arborio type) grains, 6) disease resistance, and 7) water weevil resistance breeding. The emphasis and breeding goals do vary for the different grain and quality types. The 2005 season research highlights from each research area are discussed below.

Premium Quality

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

Short Grains

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

Fourteen advanced premium quality short-grain (SPQ) breeding lines were included in the 2005 UCCE Statewide Yield Test (Tables 1-6). Thirty-seven preliminary SPQ breeding lines were tested in the Preliminary Yield Tests at RES. Agronomic performance and milling data on eight of the fourteen advanced breeding lines and eight preliminary lines are summarized in Table 12. These sixteen experimental lines were selected because of earlier maturity, smooth hull, better lodging or blanking resistance, different parentage, kernel size, better cooking quality or yield potential than the check variety Calhikari-201. Entries 004 and 020 showed good yield potential in the Very Early Statewide group. Preliminary Yield

Test entries 165, 176, 178, and 663 advanced breeding lines, Entries 019 and 022 were identified having more tender texture than the check variety Calihikari-201, but they are still not up to the premium quality of Koshihikari. These lines and others will undergo further quality evaluations in cooking and showed higher yield at RES. Two laboratory tests during the winter. Agronomic data including disease and blanking resistance will be combined with quality data to select entries for further testing in 2006. Superior lines will be used as a parent in future crosses.

Table 12. Agronomic performance and milling averages of selected 2005 premium quality short grain (SPQ) entries in the UCCE Statewide and RES Preliminary Yield Tests.

2005 Entry	Identity	Grain Type	Harv Moist (%)	Yield (lb/acre at 14%)	SV†	Days to 50% Heading	Height (cm)	Lodge (%)	H_20 (%) ‡	H/T (%)
Very Early Statewide										
004	01Y185	SPQ	13.0	8090	4.8	72	91	60	19.0	68/71
005	03Y166	SPQ	15.3	7620	4.7	74	85	0	22.0	66/69
019	03Y164	SPQ	14.0	7700	4.7	79	95	30	17.1	68/70
020	04Y177	SPQ	13.8	8040	4.6	74	88	50	19.9	71/72
021	03Y167	SPQ	14.6	7270	4.9	75	91	0	21.2	66/69
022	03Y170	SPQ	14.6	7400	4.9	77	86	80	16.7	70/75
002	S-102	S	12.6	8690	4.9	72	95	50	16.6	70/74
Early Statewide										
082	04Y189	SPQ	16.4	7760	4.8	83	94	60	19.2	71/74
083	04Y165	SPQ	15.5	7900	4.6	82	92	40	18.5	71/74
063	CH-201	SPQ	13.4	7600	4.9	79	90	40	16.6	64/72
Very Early Preliminary										
165	05Y165	SPQ	15.6	9030	4.8	80	98	0	17.9	68/71
171	05Y171	SPQ	14.5	7830	4.8	75	94	70	18.1	67/71
176	05Y176	SPQ	12.9	8070	4.8	73	85	0	18.0	68/71
178	05Y178	SPQ	15.6	8320	4.9	72	90	0	19.2	69/73
196	05Y196	SPQ	14.8	7660	4.8	75	92	60	18.2	64/73
197	05Y197	SPQ	15.0	7960	4.8	81	100	80	17.7	68/72
161	AKITA	SPQ	16.8	6090	4.7	77	101	100	18.5	71/73
Intermediate/Late Preliminary										
662	05Y662	SPQ	12.6	7880	5.0	78	92	50	17.3	65/72
663	05Y663	SPQ	13.0	8420	4.9	83	86	20	19.5	71/73
664	CH201	SPQ	12.2	7010	4.9	79	93	50	15.6	66/72
646	KOSH	SPQ	16.9	5610	4.8	92	116	80	19.6	68/71

† Seedling vigor score where 1=poor, 5= excellent.
‡ H_20 = Average harvest moisture of milling row samples.
H/T= Head and total milled rice averages of two rows harvested at two harvest moistures.

Medium Grains

A parallel breeding effort is continuing to develop improved premium quality medium grains for the M-401 market. Eleven advanced premium quality medium-grain (MPQ) breeding lines were included in the UCCE Statewide Yield Test (Tables 1-6). Forty-seven preliminary MPQ breeding lines were tested in the Preliminary Yield Tests at RES. As a group, MPQ entries showed excellent seedling vigor, but susceptibility to blanking, lodging and asynchronous flowering weaknesses. Agronomic performance and milling data for seven advanced breeding lines and twelve preliminary breeding lines are summarized in Table 13. These nineteen experimental lines were selected because of earlier maturity, blanking resistance, or better yield potential than the check variety M-401. Most of selected lines yielded similar to the Calrose medium grain checks. Selection emphasis in MPQ materials is toward larger kernels with M-202 grain and milling yields and M-401 cooking quality. Cooking tests are being conducted on these and other breeding lines in an effort to identify premium quality selections with an improvement in yield, blanking and/or disease resistance. Two advanced MPQ breeding lines, Entries 089 and 123, and several Preliminary MPQ lines including Entries 200 and 300, have been identified possessing M-401 type cooking quality with earlier maturity, blanking resistance, or high grain and milling yield. These selections will be used in future crosses and further testing in 2006. Earlier generation premium quality material was also harvested from small plots and progeny rows in 2005 for cooking evaluation and further testing in 2006.

Conventional Short Grains

S-102, released by CCRRF in 1996, is the predominant California short-grain in commercial production and has been a high yielding entry in the very early advanced group of the Statewide Yield Test for many years. In combination with its very early maturity, blanking resistance, and very large kernel, it has been hard to develop lines with those traits that out performs it. However, S-102 has pubescent leaves and hulls and is susceptible to stem rot disease. Developing a glabrous “S-102” with better stem rot resistance and yield potential is a breeding goal.

In 2005, three advanced short grain lines were tested in the UCCE Statewide Yield Test and ten preliminary lines in the RES Preliminary Yield Tests. Agronomic performance and milling data for two Very Early Statewide and two Very Early Preliminary breeding lines are summarized in Table 14. All four entries were selected for smooth hulls. Entry 23 has large kernels like S-102 but yielded less. Entries 207 and 208 out yielded S-102, but have smaller kernel size and a few days later maturing than S-102. These breeding lines fall short of breeding goals, but are being used as parents in crosses. New short-grain breeding lines advanced from small plots and progeny rows in 2005 will be evaluated further in 2006.

Table 13. Agronomic performance and milling averages of selected 2005 Premium quality medium grain entries (MPQ) in the UCCE Statewide and RES Preliminary Yield Tests.

2005 Entry	Identity	Grain Type	Harv. Moist (%)	Yield (lb/acre at 14%)	SV†	Days to 50% Heading	Height (cm)	Lodge (%)	H_20‡ (%)	H/T (%)
Very Early Statewide										
026	04Y332	MPQ	16.4	8060	4.8	74	103	30	20.7	69/71
027	03Y308	MPQ	17.1	7800	4.6	77	95	60	20.0	71/72
008	M-104	M	14.2	7580	4.8	69	93	50	18.0	70/72
Early Statewide										
086	03Y295	MPQ	15.3	7140	4.7	79	95	20	20.3	67/72
088	04Y330	MPQ	15.4	7600	4.9	72	91	20	20.2	65/69
089	04Y314	MPQ	15.9	7600	4.8	77	101	60	18.8	67/72
069	M-202	M	14.4	7500	4.8	77	96	50	22.4	64/66
068	M-206	M	15.8	7910	4.9	73	98	40	21.3	71/72
Intermediate/Late Statewide										
123	03Y559	MPQ	16.1	8740	4.8	83	105	80	19.2	67/71
135	02Y321	MPQ	15.5	8040	4.9	87	107	60	20.9	68/72
121	M-402	MPQ	20.8	8380	4.9	106	106	0	25.9	67/69
Very Early Preliminary										
199	05Y199	MPQ	15.3	7770	4.9	75	102	70	18.5	71/72
200	05Y200	MPQ	13.7	7230	4.9	74	95	0	16.3	62/71
201	05Y201	MPQ	14.2	7470	4.8	72	94	30	19.3	65/70
202	05Y202	MPQ	16.0	7660	4.9	76	98	50	20.6	70/73
198	M-104	M	14.0	7980	4.8	71	91	50	18.0	70/72
Early Preliminary										
294	04Y308	MPQ	16.1	7610	4.8	76	94	40	22.1	70/72
299	05Y299	MPQ	15.1	7460	4.8	73	97	80	19.5	67/71
300	05Y300	MPQ	16.1	7610	4.8	78	99	60	18.7	65/73
308	05Y308	MPQ	15.3	7070	4.9	73	98	80	17.9	70/72
313	05Y313	MPQ	15.3	7620	4.9	74	97	50	17.8	66/72
328	05Y328	MPQ	14.5	7500	4.8	76	102	80	17.7	71/73
329	05Y329	MPQ	14.9	7880	4.8	73	93	30	19.2	64/68
291	M-202	M	15.7	7370	4.8	75	99	100	19.4	67/71
Intermediate/Late Preliminary										
666	05Y666	MPQ	14.7	8220	4.9	79	98	30	18.7	64/71
643	M-401	MPQ	25.3	7070	5.0	112	101	0	22.9	57/66
644	M-402	MPQ	20.7	9090	5.0	106	100	0	23.1	66/70

† Seedling vigor score where 1=poor, 5= excellent.
‡ H_20 = Average harvest moisture of milling row samples.
H/T= Head and total milled rice averages of two rows harvested at two harvest moistures.

Table 14. Agronomic performance and milling averages of selected 2005 short grain entries (S) in the UCCE Statewide and RES Preliminary Yield Tests.

2005 Entry	Identity	Grain Type	Harv. Moist (%)	Yield (lb/acre at 14%)	SV†	Days to 50% Heading	Height (cm)	Lodge (%)	H_20‡ (%)	H/T (%)
Very Early Statewide										
003	04Y206	S	13.7	8400	4.8	75	95	30	17.8	66/74
023	03Y183	S	14.1	8350	4.7	73	91	60	17.6	66/72
002	S-102	S	12.6	8690	4.9	72	95	50	16.6	70/74
Very Early Preliminary										
207	04Y196	S	14.5	8930	4.8	75	95	40	19.7	61/69
208	05Y208	S	14.2	8590	4.9	77	97	0	18.9	65/70
206	S-102	S	13.8	8290	4.9	73	98	90	14.7	65/74

† Seedling vigor score where 1=poor, 5= excellent.
‡ H_20 = Average harvest moisture of milling row samples.
H/T= Head and total milled rice averages of two rows harvested at two harvest moistures.

Table 15. Agronomic performance and milling averages of selected 2005 stem rot resistant (SR) entries in the UCCE Statewide and RES Preliminary Yield Tests.

2005 Entry	Identity	Grain Type	SR† Score	Yield (lb/acre at 14%)	SV‡	Days to 50% Heading	Height (cm)	Lodge (%)	H_20§ (%)	H/T (%)
Intermediate/Late Statewide										
126	03Y576	SR	5.5	9000	4.7	97	96	0	22.7	69/71
137	04Y638	SR	5.2	8580	4.7	97	90	0	21.0	63/71
122	CH-201	SPQ	8.7	7980	4.9	83	95	100	16.5	65/71
Early Preliminary										
338	05Y338	SR	5.2	7750	4.8	74	86	0	16.3	62/72
363	CH-201	SPQ	6.9	7340	4.8	77	93	50	14.3	65/73
Intermediate/Late Preliminary										
651	04Y641	SR	5.1	9970	4.8	81	79	0	17.3	64/72
653	05Y653	SR	4.2	9160	4.8	88	91	10	19.9	64/72
654	05Y654	SR	4.7	9690	4.7	86	90	0	20.2	63/73
657	05Y657	SR	5.6	10530	4.8	88	97	10	21.3	65/73
648	S-301	S	6.8	9360	4.9	91	101	0	24.2	70/71

† SR score=stem rot score where 0=no damage and 10=plant killed.
‡ Seedling vigor score where 1=poor, 5= excellent.
§ H_20 = Average harvest moisture of milling row samples.
H/T= Head and total milled rice averages of two rows harvested at two harvest moistures.

Disease Resistance

Because of their high yield potential and less demand on cooking characteristics in the conventional short grains, breeding efforts have focused on improving disease resistance with support of the Pathology Project. Breeding for stem rot (SR) resistance remains an important long-term objective of this breeding program. Progress has been slow, however new lines are starting to appear in yield tests that show clear improvement in stem rot scores and high yield potential.

Agronomic performance and milling data for two advanced SR breeding lines and five preliminary breeding lines are summarized in Table 15. As a group, SR entries have excellent yield potential and resistance to lodging, but tend to be late-maturing, with inferior grain and cooking quality compared to premium quality short grains. The donor germplasm “94-Y-559” for SR resistance has come from the long-grain project. It is hoped that this material may in turn provide useful stem rot resistant germplasm for the medium-grain project as well as the premium quality types.

Crossing, screening, and selection for blast resistance to California race IG-1 continues in the project. The pathology project is screening early generation and advanced selections in the greenhouse to identify resistant lines. Several early-maturing and high-yielding blast resistant lines have been recovered from short grain and premium quality medium grain crosses. Sources included a Korean short grain introduction, “Daegwanbyeo”, and the southern US medium grain cultivar, “Lafitte”, as blast resistance donors. However, kernel physical and cooking characteristics, milling quality, and cold induced blanking resistance are areas requiring continued evaluation and improvement. In some cases it appears that improved blast resistance is accompanied by increased stem rot scores.

Development and application of DNA marker technology for selection of disease resistant lines is underway in the RES Breeding Program with the support and cooperation from the USDA-ARS. This tool should expedite the development of improved disease resistant varieties

Special Purpose Types

The special purpose varieties often have unique or undefined cooking characteristics that make quality evaluation and selection difficult. It is also very common to find the special purpose quality strongly associated with poor adaptation, low yield potential or low head rice yield. As with premium quality varieties, differences in adapted experimental lines are expected from the quality found in the old and/or imported target rice variety.

Waxy

Improvement of the short-grain waxy (mochi, glutinous, or sweet) rice, Calmochi-101, is focusing on improving agronomic and quality characteristics. In 2005, two waxy experimental lines were tested in the very early Statewide Yield Test and eight waxy lines were tested in the RES Preliminary Yield Tests (Tables 1 and 16). Evaluation of these materials was focused on recovering high yield potential, blanking resistance, early maturity, and glabrous hulls. Entry 025, an advanced breeding line showed significant yield advantage with glabrous hulls, larger kernels, and erect plant type over Calmochi-101, but it was 4 days later than Calmochi-101 and susceptible to blanking (Table 20). Two very early, glabrous preliminary lines, Entries 215 and 216, showed significant agronomic advantages over CM-101, with larger kernels, blanking resistance and better stem rot resistance. These breeding lines will be advanced to the Statewide Yield Test for further testing and used in future crosses in 2006. Quality evaluations on these lines with the input from marketing organizations will be critical to help RES to develop new improved waxy varieties in order to meet the needs of the market and industry.

Low Amylose

Amylose content in endosperm starch is recognized as a major determinant of eating, cooking, and processing quality of rice. Japanese rice breeders have been working for many years and developed rice cultivars with low amylose contents to improve eating quality and for new products for the rice industry. Induced mutation has been used to develop dull endosperm mutants that have 6 to 10% apparent amylose. These varieties are not available and probably not well adapted to California.

A special project was initiated in 1999 to recover endosperm mutants in adapted germplasm at RES. Two low amylose lines were successfully developed from the California premium quality short-grain cultivar Calhikari-201 through induced mutation, designated as BL-1 and BL-2. Both mutants had reduced grain weight and panicle size, yielded 11-15 % lower than their parent Calhikari-201, but possess amylose content (~7%) and stickiness values similar to the Japanese low amylose varieties. Recently, BL-1 has been approved to release as a new variety named "Calamylow-201" for a small specialty market in development.

Eight new low amylose entries recovered from cross breeding were included in the 2005 Preliminary Yield Test at RES. Agronomic performance and milling data for three selected entries are summarized in Table 16. These three new entries yielded slightly more than BL-1 but still lower than the check Calhikari-201. Breeding efforts are continuing to address the agronomic problems associated with the current low amylose lines through crosses with adapted California germplasm. The breeding program is currently evaluating new low amylose materials in small plots and progeny rows for higher yield potential, larger grain size, and other desirable characteristics such as glabrous hulls.

Other Activities

Breeding for bold grain types, similar to the Italian varieties like Arborio, continues in this breeding project. Agronomic and milling performances of lines in preliminary yield tests are far superior to Arborio. A variety of kernel shapes and levels of chalkiness is being recovered and most are better milling but have smaller kernel size than Arborio. Quality evaluations remain a problem and interest by marketing organizations limited.

One of the additional project objectives is to transfer rice water weevil (RWW) tolerance to adapted California varieties. Breeding activities are continuing in the RWW nursery at RES.

Rice breeding is a continuous process in pursuit of a better variety. Besides the above-mentioned Statewide Yield Test and Preliminary Yield Test, over 700 new breeding lines selected from progeny rows were tested in small plots (4 by 6 ft) for selection and generation advance. More than 12,000 progeny rows and 154 F_2 populations were grown at RES, Davis and San Joaquin breeding nursery for selection. Two hundred of new crosses and backcross between current varieties, promising breeding lines, and new germplasm were made in the summer of 2005. Rice breeding is also a team activity at RES. Collaboration with other breeders, plant pathologists, UC scientists, USDA scientists, rice growers and customers is imperative to success of this project. To enhance breeding efficiency, we are making best use of Hawaii winter nursery, San Joaquin and Davis Cold Tolerance Nurseries, refrigerated greenhouse facility. Efforts are also being made in collaboration with USDA geneticist Dr. Tom Tai at UC-Davis to use marker-assisted selection in this breeding program.

Table 16. Agronomic performance and milling averages of selected 2005 waxy (W) and low amylose (LA) entries in the UCCE Statewide and RES Preliminary Yield Tests.

2005 Entry	Identity	Grain Type	Harv. Moist (%)	Yield (lb/acre at 14%)	SV†	Days to 50% Heading	Height (cm)	Lodge (%)	H_20‡ (%)	H/T (%)
Very Early Statewide										
001	CM-101	W	14.9	7900	4.8	74	95	50	18.8	69/73
024	04Y213	W	14.8	8190	4.7	78	87	50	17.9	60/72
025	04Y220	W	17.3	8600	4.5	78	96	20	23.5	69/72
Very Early Preliminary										
198	M-104	M	14.0	7980	4.8	71	91	50	18.0	70/72
215	04Y218	W	16.4	7410	4.8	74	92	0	22.2	66/71
216	05Y216	W	14.9	7220	4.9	73	96	70	21.7	69/73
219	05Y219	W	14.1	7710	4.8	77	88	10	17.7	61/72
220	CM-101	W	14.7	6680	4.8	75	98	60	19.4	70/73
Early Preliminary										
343	05Y343	W	16.7	7970	4.8	80	98	30	20.2	70/73
291	M-202	M	15.7	7370	4.8	75	99	100	19.4	67/71
Early Preliminary										
353	BL-1	LA	12.9	6290	4.9	75	89	60	16.4	69/72
355	04Y340	LA	15.1	6670	4.8	76	97	90	18.5	68/70
357	05Y357	LA	13.6	7110	4.8	76	90	10	16.7	68/72
360	05Y360	LA	14.0	6760	4.8	76	92	40	16.9	69/72
363	CH-201	SPQ	12.8	7340	4.8	77	93	50	14.3	65/73

† Seedling vigor score where 1=poor, 5= excellent.
‡ H_20 = Average harvest moisture of milling row samples.
H/T= Head and total milled rice averages of two rows harvested at two harvest moistures.

LONG GRAINS

Farman Jodari

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

Conventional Long Grain

The long-grain rice market in US is based on quality characteristics of Southern US varieties. Cooking quality of conventional long grain types are characterized, for the most part, by intermediate amylose content (21 to 23%), intermediate gelatinization temperature (alkali spreading value of 3 to 5), and a moderate viscogram profile. California long-grain varieties have improved considerably in recent years in cooking quality components. L-204, has an intermediate amylose and gel type and moderate viscogram profile. A subtle difference still exists in softness of cooked rice of L-204 and Southern long grain. Extensive quality research and breeding efforts are underway to address this issue in future long-grain varieties.

Conventional California long-grain varieties possess superior agronomic traits. They have excellent plant type, lodging resistance, grain yield, and seedling vigor. Improvements in milling qualities and cold tolerance are getting major emphasis in the long-grain project. Research is underway for evaluation and improvement of cooking quality of conventional long grains types. This includes use of amylose, gel temperature, viscogram, and sensory information in addition to grain physical characteristics.

Use of DNA marker to determine the type of amylose synthesis gene has been successfully tested in this program and is being gradually merged with the current wet chemistry methods. This effort is in cooperation with UC Davis rice genetics lab and depends on the use of high capacity instruments for DNA analysis. A smaller capacity and less expensive system is being considered for use in breeding lab at RES. Availability of on-site DNA analysis system can be a valuable tool for breeding programs at RES, especially with the development and availability of new genetic markers.
During the 2005 season, a total of 102 advanced conventional long-grain selections were tested in statewide and preliminary yield tests. Performance results of a selected number of these entries are listed in Table 17. The overall yields in 2005 were lower than expected due to late planting season. Several long-grain entries including 03-Y-496, 99-Y-529, and 04-Y-706 yielded significantly higher than L-204. Experimental lines 01-Y-502 and 03-Y-496 are conventional types with Stem Rot (SR) resistance that have also shown very high yield potential, although milling yield of these lines have been somewhat lower than L-204. A selected number of

long-grain germplasm lines from southern US breeding programs and indica introductions from USDA National Rice Research Center were used in 2005 in a crossing program for blast resistance, cooking quality, and milling quality improvements.

Release of L-206

Conventional long-grain experimental line 99-Y-469 was approved for release by the California Crop Improvement Association in Feb. 2006 as 'L-206'. 99-Y-469 is a very early to early maturing semidwarf selection (Table18). Average heading date is 5 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 of 99-Y-469 were not significantly different from L-205 and M-202. Plants of 99-Y-469 are glabrous and anthocyanin pigmentation occurs only in apiculi. 99-Y-469 has slightly stronger amylographic profile, as shown by higher cool paste viscosity and RVA setback values. Consequently cooked grain texture of it is less sticky than L-204. Similar to Southern long grain types, 99-Y-469 has intermediate amylose and gelatinization temperature types.

Grain yields of 99-Y-469 compares favorably with L-205 and M-202 (Table 18 and 19). It is adapted to most of the rice growing region of California except the coldest locations of Yolo and San Joaquin Counties and the warmest locations of Glenn County. Average head rice yield of 99-Y-469 during 2001 to 2005 seasons was 62.8 % which is 0.6% lower than L-205 (Table 18). Kernels of 99-Y-469 are shorter than L-204 and slightly larger than L-205. About 150 cwt of 99-Y-469 foundation seed was produced in 2005.

Newrex Type

Newrex is special quality rice that has 2 to 3% higher amylose content and a stronger viscogram profile than conventional long grains. Because of these characteristics, Newrex types cook dry, exhibit minimal solids loss during the cooking, and are a superior type for canned soups, parboiling, and noodle making. The dry cooking characteristics of a Newrex type variety may help address the soft cooking tendency of California grown conventional long-grain rice. The Newrex type variety L-205 has shown superior processing qualities and excellent agronomic characteristics. Milling yield reductions in post harvest handling have been reported. Modifications in milling and storage procedures are expected to alleviate this problem. Fissuring studies are also underway in the long grain project to monitor fissure developments of advanced breeding lines during a period of time and storage condition that simulates commercial storage.

Performance of selected Newrex type entries in 2005 yield tests are shown in Table 20. Several experimental lines performed well in statewide trials, with grain yields, averaged over location, ranging between 8610 and 9470 lb/acre compared 8560 for L-205. Several entries have also shown similar or higher head rice yields as compared with L-205.

Table 17. Performance of conventional long-grain entries in 2005 yield and milling tests.

Entry†	Identity	-----Yield (lb/acre) ‡-----		Blanking	Head Rice
		Statewide	RES	(%)	(%)
Very Early Statewide					
16	99Y041	8780	8840	15	63
18	04Y508	8380	8840	10	60
15	99Y469	8130	8400	15	60
13	L-204	7880	8140	15	64
Early Statewide					
108	03Y496	8920	9410	30	60
80	99Y529	8420	8450	10	63
79	99Y041	8300	8620	15	61
78	99Y469	8130	8250	15	60
75	L-204	7840	7810	15	63
Intermediate Statewide					
134	04Y706	9260	10530	35	61
149	99Y529	9090	9180	10	61
151	99Y469	8420	7900	15	60
130	L-205	8730	9110	8	63
Very Early Preliminary					
531	04P2811	--	10270	10	62
528	04P2780	--	10140	10	62
481	L-204	--	8760	15	64
Early Preliminary					
570	04Y591	--	10390	35	60
566	04Y588	--	10350	10	64
562	L-205	--	6660	8	64
Intermediate Preliminary					
747	94Y633	--	9740	40	60
757	04P2701	--	9360	10	64
738	L-205	--	9060	8	64

† Entry 108 is stem rot resistant line.
‡ Grain yield at 14% moisture.

Table 18. Agronomic characteristics of 99-Y-469, L-205 and M-202 averaged over Sutter-East and RES locations during 2000 to 2005.

Character	99-Y-469	L-205	M-202
Seedling Vigor Score†	4.5	4.6	4.8*
Days to 50% Heading	82	86*	86*
Plant Height (cm)	86	92*	97*
Lodging (%)	24	11	41*
Harvest Moisture (%)	14	16	19*
Head Rice Yield (%)	62.8	63.4	--
Greenhouse Blanking (%)	8	5	15
Stem Rot Score‡	5.5	5.6	5.2
Aggregate Sheath Spot Score§	2.4	2.6	2.2

†Seedling Vigor visual score where 1= poor and 5=excellent.
‡Stem rot score where0=no damage and 10=plant killed.
§Number of top leaves killed by aggregate sheath spot.
*Significantly different from 99-Y-469 at 0.05 probability level

Table 19. Yield performance of Experimental 99-Y-469 as compared to L-205 and M-202 at Sutter-East and RES locations during 2000 to 2005 UCCE Statewide Yield Test.

	Sutter-East			RES		
Year	99Y469	L-205	M-202	99Y469	L-205	M-202
2005	7300	7440	7210	8400	8920	7560
2004	10650	10400	11090	10930	10350	9050*
2003	8240	8610	8250	9340	9370	7760*
2002	9100	9050	8940	10670	10910	9710*
2001	8770	8250*	8590	10740	10220	9950
2000	9540	9370	9940	10930	10500	9380*
Mean	8930	8850	9000	10170	10050	8900*

*Yields were not significantly different at any location.

Table 20. Performance of Newrex type long-grain entries in 2005 yield and milling tests.

Entry	Identity	----Yield (lb/acre)†--- Statewide	RES	Blanking (%)	Head Rice (%)
Statewide					
133	03Y151	9470	10630	8	60
50	01Y655	8730	9720	15	59
46	04Y501	8610	8970	8	62
14, 130	L205	8560	9020	8	63
Preliminary					
510	04P2558		9920	15	
487	04Y484	--	9880	35	63
519	04P2617	--	9870	20	64
518	04P2607	--	9870	15	
482	L205	--	9050	8	61

†Grain yield at 14% moisture.

Specialty Long Grains

Calmati-201 is a true basmati type aromatic long-grain variety. It possesses cooked kernel elongation and cooking qualities that approach those of imported basmati rice, with slightly less flakiness. Calmati-201 is susceptible to cold induced blanking and is not recommended for cooler regions. In spite of cold sensitivity, Calmati-201 is expected to perform well in warmer regions in California especially for a basmati class of rice. Basmati rice yield levels are inherently lower than standard varieties even in their country of origin, primarily due to their small and slender kernels.

A considerable number of basmati lines were evaluated in 2005 tests for their agronomic and cooking quality characteristics (Table 21). Thirty eight advanced selections with improved cooking qualities were tested in statewide and preliminary yield tests. A number of basmati lines with considerably more slender grain and softer grain texture are currently being advanced in the Hawaii Winter Nursery and will be tested for yield performance in 2006. Emphasis in basmati selections is being placed on recovering slender and flaky-cooking kernels with higher elongation ratios.

Efforts continued in 2005 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 Kao-Dak-Mali 105 (KDM) has been a significant barrier. KDM was irradiated with gamma ray and a number of early mutants, including 02-Y-710 and 02-Y-712, were obtained. These early mutants are serving as valuable germplasm source for further agronomic improvements.

One waxy long-grain line 99-Y-494 was tested in 2005 Statewide Yield Tests (Table 5). This line has significantly out performed L-204 and L-205 and possesses excellent agronomic and milling characteristics. Waxy lines are being used as donor parents in cold tolerance and yield improvement efforts.

Resulting waxy selections can also be developed into a waxy long-grain variety if needed.

Table 21. Performance of specialty long-grain entries in 2005 yield and milling tests.

Entry	Identity	Specialty Type	---Yield (lb/acre)†--- Statewide	RES	Blanking (%)	Head Rice (%)
Early Statewide						
110	04Y524	Jasmine	7780	8290	35	54
111	04Y537	Basmati	6710	6860	25	52
77	CT-201	Basmati	7110	6900	35	58
Intermediate Statewide						
150	99Y494	L. Waxy	8880	8650	15	61
130	L-205	Rexmont	8730	9110	8	62
153	04Y153	Basmati	6120	6860	35	54
131	CT-201	Basmati	7330	7690	35	58
Preliminary						
554	04P3134	Jasmine	--	10150	8	55
626	04P3122	Jasmine	--	10320	18	64
557	04P3271	Basmati		8490	40	52
563	CT-201	Basmati	--	6760	25	62

†Grain yield at 14% moisture.

Release of Calmati-202

Basmati type long-grain experimental line 04-Y-153 was approved for release by the California Crop Improvement Association in Feb. 2006 as 'Calmati-202'. 04-Y-153 is an early maturing, semi-dwarf, pubescent, basmati type, long-grain cultivar. Seedling vigor of 04-Y-153 is similar to L-205 and M-202 (Table 22). 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. 04-Y-153 has shown significantly lower yield potential than L-205 and M-202 at the statewide yield trials during 2003 to 2005 (Tables 22 and 23). Average yield of 03-Y-153 was 6740 lb/acre, which is 73% of L-205 and 74% of M-202 yield potentials.

Milled rice kernels of 04-Y-153 are longer than Calmati-201 and slightly shorter than imported basmati available in the US market (Table 22). Grain width of 04-Y-153 is more slender than Calmati-201 but not as slender as imported basmati rice. L/W ratio of the 04-Y-153 shows a significant improvement over Calmati-201(Table 24). Cooked kernel length of 04-Y-153 is also slightly longer than Calmati-201. The overall appearance of cooked basmati type rice is an important quality feature among basmati rice consumers. Coherence of the cooked grains as well as grain shape and texture of 04-Y-153 are distinguishable improvements over Calmati-201. Cooked rice of 04-Y-153 that was aged nearly one year was preferred by taste panelists over Calmati-201. Grain fissuring studies have shown that both Calmati-201 and 04-Y-153 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 17 percent.

Table 22. Agronomic characteristics of 04-Y-153, L-205, and M-202 averaged over 3 of the UCCE Intermediate/late Statewide Yield Tests during 2003 to 2005.

Character	04-Y-153	L-205	M-202
Seedling Vigor Score†	4.9	4.8	4.9
Days to 50% Heading	91	85*	87*
Plant Height (cm)	94	94	102*
Lodging (%)	21	36	76*
Harvest Moisture (%)	16	16	17
Head Rice Yield (%)	58	63	63
Greenhouse Blanking (%)	30	5*	18*

†Seedling Vigor visual score where 1= poor and 5=excellent.
*Significantly different from 04-Y-153 at 0.05 probability level.

Table 23. Yield performance of 04-Y-153, L-205, and M-202 over 3 locations of the UCCE Intermediate/late Statewide Yield Tests during 2003 to 2005.

	Cultivar		
Year	04-Y-153	L-205	M-202
2005	6120	8720*	8850*
2004	7440	10080*	9890*
2003	6650	8880*	8730*
Mean	6740	9230*	9040*

*Significantly different from 04-Y-153 at 0.05 probability level.

Table 24. Grain dimensions (mm) of milled and cooked kernels of 04-Y-153, imported basmati, and Calmati-201.

				Cooked Rice	
Identity	Length	Width	L/W	Length	Elongation
04-Y-153	7.15	1.95	3.66	14.9	2.1
Basmati import	7.22	1.72	4.19	17.4	2.4
CT-201	6.52	2.09	3.12	13.3	2.0

Milling quality

The milling yields of L-204, L-205, and Calmati-201 represent significant improvement over their predecessors. This was evident from 2005 results of head rice yields for these varieties (Tables 17, 20, and 21). Under proper harvest management and favorable weather conditions, these varieties are expected to produce high milling yields. Continued improvement in milling yield and milling stability of new long-grain varieties, particularly the Rexmont types, to the level of medium grains remains a major objective. Grain characteristics are being evaluated and selected that will lend milling yield stability to long-grain lines under adverse weather conditions and allow a wider harvest window without losing milling quality. These may include hull cover protection, grain formation, or physicochemical properties of the grain that result in fissuring resistance. Efforts have been initiated to screen advanced breeding lines of all grain types for their resistance to grain fissuring.

Information obtained from single kernel moisture meter is also being used at RES to evaluate the uniformity of harvest maturity among advanced experimental lines that will ultimately lead to improved head rice yields. Milling yield potential of 32 of the most advanced long-grain lines from the Statewide Yield Tests were evaluated in 2005 harvest moisture studies in two maturity groups.

RiceCAP Project

RES is participating in the 'RiceCAP' project which is a newly established USDA initiative with the objective of applying genomic discoveries to improve milling quality and disease resistance in rice. Four breeding programs of Arkansas, California, Louisiana, and Texas are providing phenotyping information and several universities and research institutions are contributing genotyping and molecular research. The goal is to analyze a number of populations and develop genetic markers that are associated with components of milling yield and sheath blight resistance. The specific contribution from RES is providing extensive fissuring studies for 3 milling populations as well as providing and evaluating a California long grain population for developing molecular markers associated with milling quality. Funding from this project is supporting one post graduate research associate, one technician, and related expenses. This project will gradually be linked with marker aided selections efforts that are being established at RES. Further information and updates on the status of this 4 year project can be obtained 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 seven entries with a range of SR resistance were tested in 2005 Statewide and preliminary yield tests. Performance of a selected number of these lines is shown in Table 25. Entries 132 (01-Y-501), 109 (01-Y-502), and 108 (03-Y-496) continue to show significant improvement because they have combined low stem rot score, low blanking, early maturity, and high yield potential for the fourth year. Even though SR scores are not as low as the original germplasm line 87-Y-550, grain yields of both lines are consistently higher than susceptible variety L-205.

Improvements in milling yield, cold tolerance, and early maturity of SR resistant lines to the levels of L-204 and L-205 varieties is being pursued through further crossing and backcrossing. A considerable number of early generation SR resistant breeding lines were selected in 2005 in cooperation with the RES plant pathologist.

Breeding efforts are also progressing to develop California long-grain lines with resistance to rice blast. Performance of 2 blast resistant entries 528 and 520 are shown in Table 25. Southern blast resistant varieties are donating one or two major genes conferring resistance to blast race IG-1 found in California. Cooperative efforts continued in 2005 with the USDA scientists at Beaumont, TX, and UC Davis for the development and use of genetic markers for blast resistance. The new RiceCAP project grant is also contributing to capacity building for marker aided selection at RES and other public rice breeding programs as well as developing better markers for Blast resistance and other traits.◆

Table 25. Performance of conventional long-grain entries with resistance to stem rot or the blast race IG-1 in 2005 yield and milling tests.

Entry	Identity	DR†	SV‡	Day§	Ht (cm)	---Yield (lb/acre) ¶-- Statewide	RES	SR#	Blanking (%)	Head Rice (%)
Statewide										
132	01Y501	SR	4.8	89	103	9320	10340	6.2	15	61
109	01Y502	SR	4.5	83	97	8580	8400	6.0	20	59
108	03Y496	SR	4.8	84	104	8920	9410	6.0	30	59
076	L-205	L	4.6	87	96	8270	8760	6.6	8	61
Preliminary										
528	04P2780	Blast	4.6	77	100	--	10140	6.1	10	62
493	04P2331	SR	4.7	77	97	--	10030	6.0	15	59
482	L205	Rex	4.6	83	95	--	9050	6.9	8	61

† 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.

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, and screens statewide and preliminary trial breeding lines and varieties (about 2000 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). In addition, early generation materials derived from crosses with resistant parents are cycled through the disease nursery to identify and verify disease resistant lines (about 6000 rows). Intense selection pressure is applied for important agronomic traits because sources of disease resistance have a number of undesirable characteristics. The objective is to transfer an improved level of disease resistance into future varieties. A major effort is directed toward resistance to blast, but SR continues to receive significant attention. The source of SR resistance also confers aggregate and bordered sheath spot (SS) resistance.

Bakanae is the most recently introduced disease in California, and work is being conducted to determine damage and develop detection and control techniques. Most of this work was completed in 2005.

Stem Rot

Screening for SR resistance in inoculated nurseries and greenhouses usually begins in the F_3 generation. 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 7500 rows in the 2005 SR nursery.

This year, 3400 rows in the stem rot nursery were drill seeded with the new Hege planter. This resulted in less seed drift associated with water seeding, 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 2003-5 results (only for lines tested in 2005).

		2003		2004		2005	
Variety		SR	Yield	SR	Yield	SR	Yield
L205	L	5.3	9108	6.7	8584	5.8	8165
01Y501	L	3.8	9532	5.5	9323	4.7	8684
01Y502	L	3.9	10451	4.7	9126	4.4	8140
03Y496	L			4.8	9222	4.0	9906
04y702	L					3.7	8540
04Y704	L					4.5	9199
05Y499	L					5.4	8368
05Y581	L					4.2	8462
05Y582	L					3.8	9491
05Y587	L					5.2	8451
05Y752	L					4.9	8927
M205	M	4.2	8425	5.5	8705	5.3	8067
M206	M					5.7	7181
S102	S	4.5	8139	5.8	8152	5.8	8028
03Y576	S					4.7	8474
04Y208	S					5.6	8228
04Y638	S					4.6	8362
87Y55(	L	3.2	9138	3.8	7651	3.8	7811
$LSD_{0.05}$		0.6	862	0.6	1436	0.6	552

In previous years, the resistant line 01-Y-502 out yielded L-205 (but not significantly in 2004). The 2004 test suffered from poor weed control and under fertilization due to applicator error. In 2005, it did not out yield L-205, but several new long grain lines out yielded L-205 by 9 to 21 percent. No short grain lines out yielded S102. 87-Y-550 is an old resistant line. Some resistance has been lost in materials developed after 87-Y-550, but yield gains have been large.

Because progress in the medium grain has been difficult, an immediate backcross program has been started. Two long grain and two medium grain lines with 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, large populations must be used. Three hundred seventy crosses were made this year for this purpose. The mode of inheritance of resistance from *O. nivara* is yet to be determined. The BC_1F_1 will be screened for stem rot resistance in the summer greenhouse and plants showing resistance at flowering will be backcrossed again. This will continue until BC_6 has been made, and material will enter the normal yield testing program.

In addition, 161 lines resulting from a cross of M-202 with *O. officinalis* made at the International Rice Research Institute (IRRI) are being brought through quarantine. *O. officinalis* has much higher stem rot resistance than *O. rufipogon*, but has a different genetic structure than cultivated rice. Normally, crosses of *O. officinalis* with cultivated rice are sterile. IRRI used embryo rescue to get fertile plants, but dropped the program when they could not get fertile backcross plants. These lines will be tested for stem rot, sheath spot, and blast resistance. Further crossing of resistant material will be attempted here. A recent report of a successful very wide cross of *Zinzania* with *Oryza sativa* has been reported, using a special crossing technique. This technique will be used in additional crosses (18 this year) of M-206 with *O. officinalis*.

Dr. Thomas Tai has indicated willingness to develop marker assisted selection for the breeding program. His student, Leslie Snyder, is working on this project. About 3600 field transplants and an equal number of greenhouse plants were screened for SR resistance at the station in 2005.

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.

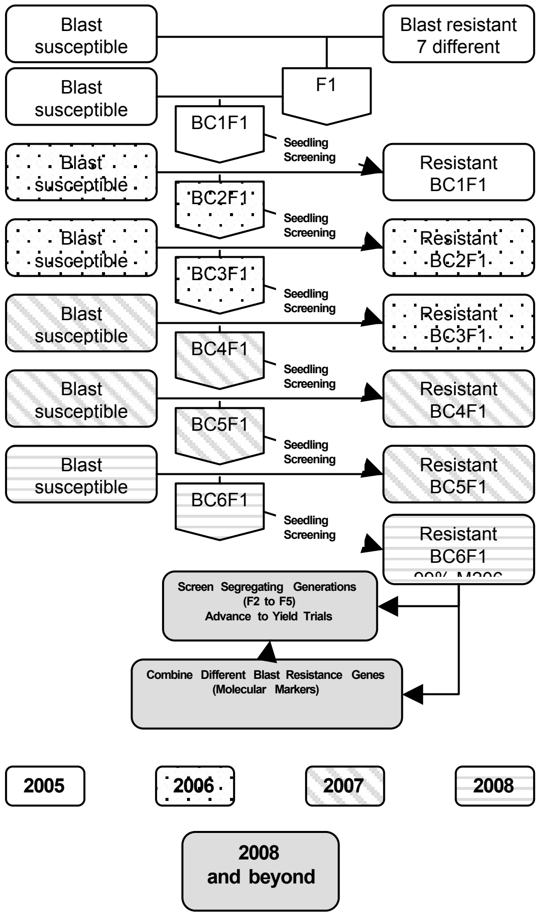
In addition, an immediate backcross program has been started to transfer sheath blight resistance genes from Teqing, Jasmine 85, and MCR10277 to M-206 and L-205 (29 crosses this year). Other researchers are currently developing molecular markers to aid in transfer of this resistance.

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. Blast severity has been low from 1998 to 2005. A few affected fields continue to be found, mostly on the west side of the valley. However, more blast was found in 2003 than in any year since 1998. Due to late planting, more M-104 was grown than usual in 2003. M-104 appears to be more susceptible than other varieties, followed by M-205. None of the Statewide Yield Tests have been affected by blast since 1997, so the entries could not be evaluated.

Major resistance genes limit blast symptom expression to small brown flecks at most, but different races of the blast fungus can overcome this resistance in several years after variety release. The low disease pressure in California may delay this expected breakdown. The first blast resistant variety (M-207, possessing the *Pi-z* gene) was released in 2005. Almost all material presently advancing through the medium grain program possesses only this gene. About 7300 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, tested to verify their blast resistance to the IG-1 race present in California, and a backcross program was started to introduce these genes into M-206. Only genes with a wide spectrum of blast resistance were chosen (*Pi-b*, *P-1, Pi-k^h*, *Pi-k^m*, *Pi-z^5*, *Pi-ta^2*, and *Pi-9*). The first backcross has been made and screened for blast resistance (189 crosses this year). Resistant BC_1F_1 plants will be again backcrossed and the program will continue though 6 backcrosses. This should take another year and a half. By this time, 99.2% of genes in this material will be from M-206. Different blast resistance genes can then be combined using marker assisted selection. These pyramided genes should greatly slow or eliminate the breakdown of major gene resistance. Lines with different single resistance genes can simultaneously be advanced to yield testing.



A cooperative project with the USDA lab at Davis to develop molecular marker screening for these resistance genes is continuing. So far, California materials have been tested against markers for the *Pi-k*^{h}, *Pi-ta*^{2}, *Pi-z*, and *Pi-b* genes. The *Pi-k*^{h} and *Pi-ta*^{2} markers seem to work reasonably well. Markers developed in Texas for the *Pi-z* gene have not worked as well.

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.

Bakanae Disease

Bakanae disease, caused by the fungus *Gibberella fujikuroi* (=*Fusarium fujikuroi*), was found for the first time in Butte and Colusa Counties in 1999. Research at the station established the identity of the disease. It was also found in Yuba and Sutter Counties in 2000 and throughout most of the rice growing region in 2001-2. Since the disease is largely seed borne, it likely was introduced on imported seed that did not pass through quarantine.

Disease Description

Diseased plants appear about 25-30 days after seeding and have greatly elongated, rolled, yellow leaf blades and sheaths. Affected plants are usually scattered throughout a field. Plants elongate as a response to gibberellin production by the fungus. These symptoms are encouraged by warm temperatures (90-100 F), but cooler temperatures may result in yellow, stunted plants. If temperatures are very cool (60-70F), infected plants may be asymptomatic. Leaves tend to droop as they elongate. Elongated leaves form a wider angle with the stem than normal leaves and resist efforts to bend them upward. About 90% of plants die 2-3 weeks after symptom expression, but lesser numbers of other seedlings then develop symptoms throughout the season. Older plants may also be infected and may be very tall or of normal height at flowering, and usually produce fewer tillers. In either case, very little grain is formed, panicles are small, and may turn grey-brown as they age. The crowns of these plants are rotted by the bakanae fungus. The fungus sporulates profusely on dead tissue just above the waterline. Spore masses appear powdery and may be white to pale orange in color. On some stems, a purple-blue discoloration indicates formation of the sexual stage of the fungus, represented by very small, dark-colored, flask-shaped structures. Harvest operations distribute propagules of the fungus throughout the seed. Most seed is superficially contaminated, and may not exhibit symptoms. The fungus does not persist well in soil, although over wintering is possible. Fallowing may be effective in greatly reducing any carry-over inoculum in severely affected fields.

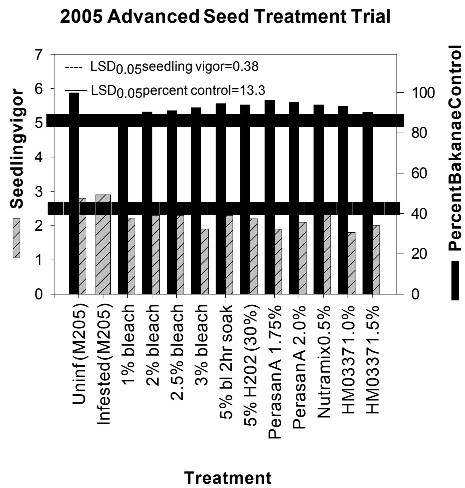
Summary of Research Finding

1. Symptomatic seedlings continue to show up throughout the growing season. Most plants do not live more than 2-3 weeks after symptom expression.
2. Random patterns of symptomatic seedlings occur in the field and observations in field plots indicate the disease does not spread much within a season.
3. Seed assays generally showed about 25-75% of seeds testing positive for the fungus in a seed plate assay would have developed symptoms when planted in the field.
4. Disease incidence increased an average of 13 times, with a range of six to 60 times if unchecked.
5. The low number of dead seedlings and heads shouldn't account for all of the yield loss. The fungus seems to do other damage, perhaps partial root/crown rot resulting in less or incomplete grain fill.
6. The contribution of over wintering inoculum was found to be very low; however practices that reduce residue for inoculum or rotation may be desirable especially for heavily infested fields. If clean seed is used, the disease incidence drops to a very low percentage within 3 seasons. As with other diseases prevalent in California, fertilize for maximum yield, but do not over fertilize.
7. Fungicides and surfactants were extensively tested in the laboratory, greenhouse, field, at RES and in grower fields with UCCE, and reported previously.
8. Many products damaged seedling vigor and growth and/or failed to provide adequate control.
9. The California registered sodium hypochlorite treatment was effective and would appear to be successful in controlling this disease. Several replacement chemicals have been tested and could replace NaOCl if it loses registration.
10. Soak and drain times should be minimized to prevent multiplication of the fungus in seed.
11. Temperatures during soaking and draining could also influence bakanae incidence.

2005 Research

The goals of further testing in 2005 were 1) to find the minimum level of bleach which gives a high degree of control but does not require a rinse and 2) to provide alternative effective seed treatments in the event that bleach becomes unavailable.

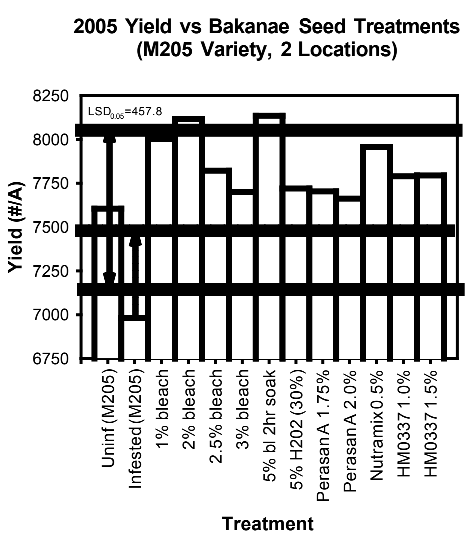
In 2005, two seed treatment trials were conducted in Sutter and Colusa counties in cooperation with Chris Greer and Cass Mutters of UC Extension. All treatments included a 24hr soak/48hr drain and constant temperature of 23C to promote bakanae multiplication.



None of the seed treatments differed significantly from the uninfested control treatment.

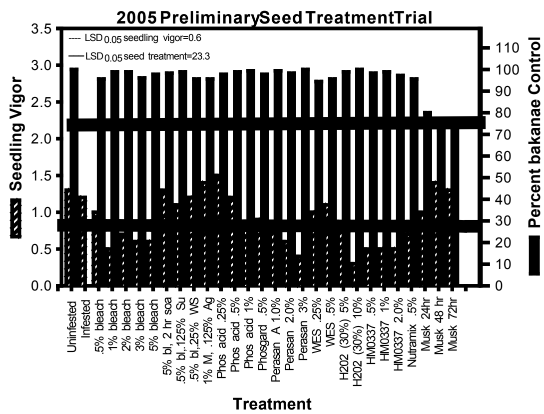
Seedling vigor was reduced for all seed treatments except for 0.5% Nutramix (phosphorous acid).

The following graph shows yields for the same treatments.



All treatments yielded more than the infested check. Only the 2% bleach and 5% bleach (2 hour) treatments yielded more than the uninfested check. The infested treatment showed a significant 8.2% yield reduction over the uninfested treatment.

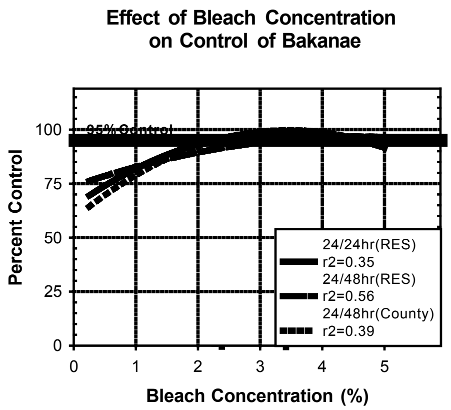
The following graph presents results from the preliminary seed treatment trial conducted at the RES. All treatments were given 24hr soak/24hr drain.



This trial contained all of the advanced trial entries as well as other experimental chemicals and combinations. All treatments except Muskodor were not significantly different from the uninfested check. All bleach treatments (except the 5% 2 hour) as well as Perasan, 10% H_20_2, HM0337, and Nutramix also showed reduction in seedling vigor.

The testing program for alternative seed treatments is now concluded. The current recommendation is for 2.5% bleach (6% NaOCl) without a rinse or 5% bleach for 2 hours followed by replacement with water. The 5% treatment is a little more effective and a little less harmful to seedling growth. Several effective, relatively safe treatments have been identified as backups to the bleach treatment.

The following graph shows results from different bleach treatments averaged over three years of testing (2003-5).



Note that the bakanae fungus can multiply even in seed treated with bleach. A bleach concentration of 1% can result in significant bakanae development. This does not happen with bleach concentrations of 2-3%. Seed rinsing is not necessary with these bleach concentrations.

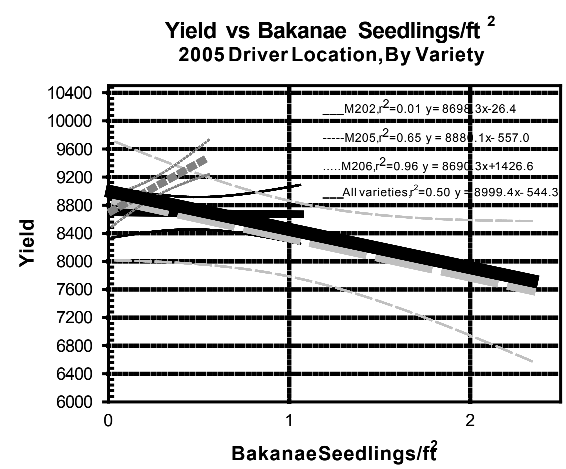
Varietal Resistance

The following table presents results from 2003-4 field trials:

Variety	Bakanae (% of Trial Ave)
L-204	38.1%
L-205	0.0%
CT-201	404.3%
Akitakomachi	16.4%
Koshihikari	6.8%
CM-101	62.6%
CH-201	18.5%
M-103	65.5%
M-104	107.9%
M-401	112.5%
M-402	27.1%
S-102	120.1%
M-202	137.0%
M-204	135.3%
M-205	168.2%
M-206	49.2%
A-201	4.4%
	$LSD_{0.05}$=46.6%

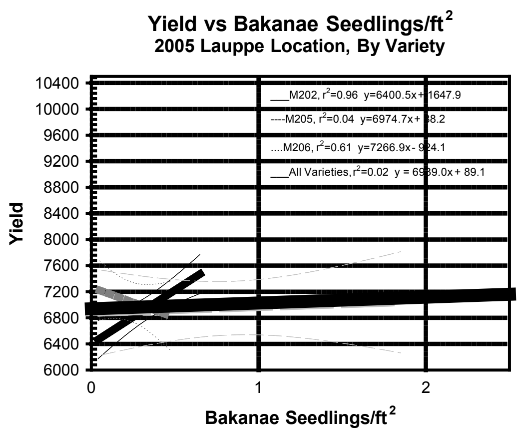
Results from the two years correlate very well (r^2=0.85).

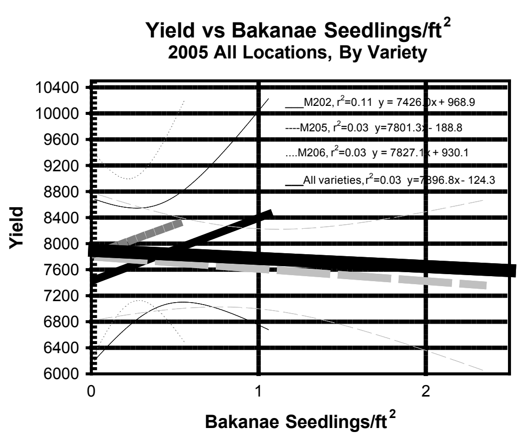
In addition, three varieties infested with different spore concentrations of the bakanae fungus were tested at two locations for effects on yield



At the Driver location, M-202 yield was not correlated with bakanae symptoms, while M-205 yield was moderately negatively correlated, and M-206 was highly positively correlated.

At the Lauppe location, M-202 yield was highly positively correlated with bakanae symptoms, while M-205 yield was not correlated, and M-206 yield was moderately positively correlated.





Over all locations and all varieties, variety yield did not correlate with bakanae symptoms. This is in contrast with previous data which showed a yield loss for M-202 and M-205 with increasing bakanae symptoms. Part of this inconsistency could be attributed to bakanae levels too low in 2005 to cause significant yield loss.

The following table summarizes yield losses from regional trials.

2002 Range of Yield Loss			
	Bak/ft^2	% bakanae	% Loss
M202	1.6-3.0	5.2-9.7	5.2-9.8
2004 Range of Yield Loss			
M202	3.1-7.0	10.5-21.5	4.9-11.0
M205	2.8-7.8	10.7-30.0	5.2-13.6
M206	?-3.4	?-18.2	No loss
2005 Range of Yield Loss			
M202	0.03-0.85	0.09-3.04	Inconsistent
M205	0.05-2.1	0.16-7.92	Inconsistent
M206	0.03-0.52	0.11-1.69	Yield gain

Although 2005 yield results were inconsistent, the order of susceptibility (M-205>M-202>M-206) agrees with previous data.

Numbers in the table above refer to season long bakanae densities. On the basis of three years' data, disease incidence early in the season will be a fraction of season long (cumulative) densities. If a scout entered a field 6-8 weeks after planting, a density of 1.0 bakanae seedlings/ft^2 would correspond with an expected 5% yield loss.

Again this year, all statewide entries were screened against the bakanae fungus in the greenhouse. Results show a range of disease severity (8.6 to 76% incidence), but are not completely consistent from trial to trial or with field trials. A switch was made this year from row planting to space planting in flats in the greenhouse. However, results did not correlate well with field trials. A complicating factor in the field trials was that certain varieties did not emerge when artificially infested with the bakanae fungus. Further work on screening technique needs to be done.

Quarantine Introductions

The building blocks for any breeding program are varieties with traits desirable in commercial production. This past year, 37 entries passed through quarantine (materials with single blast resistance genes). One hundred sixty one more entries have been planted and will be harvested in 2006 (crosses made at IRRI of M-202 with *O. officinalis* for stem rot resistance).

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

THE CALIFORNIA RICE INDUSTRY AWARD

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

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

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 2005, the 10th fellowship of $2,500 was awarded to Leslie Snyder. Leslie is a Ph.D. student in the Genetic Graduate Group at UCD.