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
Kent S. McKenzie, Ph.D............................... ....Plant Breeder
Jeffrey J. Oster, M.S. .... Plant Pathologist

Plant Breeding Support

Matthew A. Calloway……………………………...………...Plant Breeder Assistant
Paramjit S. Deol ....Plant Breeder Assistant
Harbhajan Singh Toor .... Plant Breeder Assistant
Harry P. Wright ....Plant Breeder Assistant
Ann E. Noble ....Post-Graduate Assistant
Alexander I. Roughton .... Post-Graduate Assistant

Field Operations and Maintenance

Bill W. Brandon .... Field Supervisor
Clayton E. Heineman .... .Mechanic and Operator
Sammy R. Langdon .... Maintenance and Operator
Burtis M. Jansen ....Maintenance and Operator

Clerical and Accounting

Lacey R. Stogsdill ....Administrative Assistant
Trasy A. Owen (resigned 3/12/04) ....Administrative Assistant

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James Hill, UC Ex-Officio

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OVERVIEW

Kent S. McKenzie

The California Cooperative Rice Research Foundation (CCRRF) is a private nonprofit research foundation [501(c)(5)] with membership consisting primarily of California rice growers. The Rice Experiment Station (RES) is owned and operated by CCRRF. RES was established at its present site between Biggs and Richvale, California in 1912 through the cooperative efforts of the Sacramento Valley Grain Association, United States Department of Agriculture (USDA), and University of California (UC). The 478-acre RES facility was expanded by approximately 100 acres in 1998 to support weed research, breeding, and foundation seed production. Two new greenhouses were constructed in 1999. One is being used for screening for disease resistance and breeding by RES and the other for weed research by UC. Grower funds for construction of these greenhouses came from the California Rice Research Board (CRRB), CCRRF, and the Rice Research Trust (RRT).

Dr. Kent S. McKenzie is the station director and the scientific professional staff of CCRRF includes plant breeders Drs. Carl W. Johnson, Farman Jodari, and plant pathologist Mr. Jeffrey J. Oster. The project leader position for the premium quality and short-grain breeding was vacant and will be filled by Dr. Junda Jiang beginning April of 2005. Ten career positions consisting of four plant breeding assistants, two postgraduate assistants, 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 not receive any government research funds but 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.

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, Robert Swank, and 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 2004. Dr. Albert J. Fischer, associate professor, Weed Science Program, Department of Vegetable Crops, UCD and Mr. Jim Eckart UCD staff research associate at RES, conducted UC rice weed research on 18 acres. Dr. Jim Hill is coordinating the rice systems research in a new 13 acre research area established at RES and he is being supported by UCD staff research associate Mr. Steve Bickley. Dr. Larry D. Godfrey, extension entomologist, and Richard L. Lewis, postgraduate researcher, Department of Entomology, conducted rice water weevil research. Please refer to the 2004 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. CCRRF did actively oppose Measure D that would have banned research and production of engineered organisms in Butte County. The initiative was decisively defeated in the November election and a CCRRF position statement is included in the Appendix. The campaign presented a huge educational challenge and we were very fortunate to be able to look to third party sources, the University of California, Chico State University and others, who provided scientists to explain the technology, address the questions and concern about this sophisticated technology, and provide forums for public discussion. We are also very grateful to the individuals and organizations like Farm Bureau, BUCRA, and Red Top who devoted so much to this campaign. Future research in this area by RES will depend on California's needs, market acceptance, and the development of research agreements.

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 37 improved rice varieties since the accelerated research program began in 1969. Foundation seed of 15 public rice varieties and basic seed of two Japanese premium quality varieties were produced on 180 acres at RES in 2004. 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. u

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. Kent S. McKenzie served as the project leader for premium quality, waxy, and California short grains (see Short Grains) while a search was conducted to fill that position. He also oversees contracting and coordination the Hawaii Winter Nursery. The rice pathology project is led by RES pathologist Mr. Jeff Oster (see Rice Pathology). In addition to screening for disease resistance, he is conducting 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.

With the increasing demands for high quality rice in all market types, RES has been working to improve rice quality evaluation capabilities. Physicochemical testing for rice quality components is 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 quality lab has continued to expand including DNA marker technology.

Weed control in the breeding nursery can be a serious problem due to open water areas, herbicide resistant arrowhead, and loss of aerial herbicide application. In 2004 aerial herbicide options were available at RES as the result of continuing 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 2004 RES Rice

Breeding Program, including the various breeding nurseries, selected results from large plot yield tests, disease nurseries, greenhouse and field experiments at RES and in growers fields.

BREEDING NURSERIES

Seeding of the 2004 breeding nursery at RES began May 10, and the stand establishment conditions were generally good and the season was near ideal for production especially in Butte County where the Butte County Growers Association reported a pool yield average of 9500 lb/acre.

In 2004, 971 new crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 30,030. 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 2005, thereby accelerating the breeding process.

The 2004 RES breeding nursery occupied approximately 83 acres. Water-seeded yield tests included 4114 small plots and 3375 large plots. Small seed increase plots and cooking samples were grown on 3 acres and included 65 advanced breeding lines. Thirty-eight experimental lines (3168 headrows) were grown for seed increase, quality evaluations, and purification. The nursery included about 59,600 water-seeded and 9,500 drill seeded progeny rows. Selections were made for advancement, quality evaluations, and purification from approximately 10,000 progeny rows. F_2 populations from 2002 and 2003 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 2004.

Headrows (2400) of M-205, S-102, and headrows for four experimental lines were grown for breeder seed production in 2004. 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. A new experimental winter nursery site was identified in September 2001. RES staff has worked with the manager/contractor for the past three seasons in the design, formation, preparation, seeding, and weed control at a new winter rice nursery. This has presented many challenges in both management and site evaluation for the past three seasons. The 2003-2004 nursery site was seeded by RES project leaders November 8-10, 2003. This nursery included 7080 progeny rows, 500 transplanted F_1rows, and 500 rows for Dr. Thomas Tai (USDA-ARS). Harvest was complete in April by RES staff; the seed returned and grown in the 2004 nursery at Biggs. This proved to be the most successful production at this location but critical management deficiencies remained.

After an extensive search, a new 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. F_1 plants from 2004 crosses were transplanted into the nursery in December under RES supervision. Growth, fertilization, and weed control look very good considering this newly cleared land and has suffered from some heavy rain falls. Bird netting has been purchased and installed. Harvest is anticipated to occur in late March and early April.

The 2004 UCD Cold Tolerance Nursery contained 3 acres of precision drill-seeded F_2 populations and 7,000 dry-seeded progeny rows. In the UCD Rice Facility (overseen by Dr. V. Andaya), the nursery management and production were very successful. Blanking in the breeding rows and F_2 populations was at a moderate level and allowed selection of panicles for advancement in 2005. 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.

A new 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 light, but it continues to be a very suitable location to identify highly cold tolerant materials with excellent cooperators. 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. u

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 2004 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 with two planting dates and two replications. The first large plot seeding dates at RES were May 10 to 14, 2004 with the two replications seeded May 26 and 27, 2004. 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®/Londax® (Direct Stream Application) was applied for broadleaf weed control. Two applications of Dimilin® were applied for rice water weevil control.

Tables 1 to 6 contain a summary of performance information from the 2004 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 2005. Complete results of the 2004 Statewide Yield Tests are reported by UCCE in "California Rice Varieties Description and Performance Summary of 2004 and Multiyear Statewide Rice Variety Tests in California" 2004 Agronomy Progress Report, UCD. u

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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
15	99Y469	L	4.6	79	86	28	9.1	10930	9600
13	L204	L	4.8	84	87	1	7.2	10830	9840
14	L205	LR	4.7	85	99	56	8.7	10350	9520
10	M206	M	4.8	80	105	43	7.2	10210	9850
18	02Y505	LR	4.4	85	97	6	8.1	9920	9400
17	02Y045	L	4.7	79	97	33	8.6	9870	9800
2	S102	S	4.9	77	107	92	8.9	9620	9740
4	01Y185	SPQ	4.9	82	101	93	6.8	9610	9540
7	M103	M	4.8	77	101	99	8.7	9380	9200
8	M104	M	4.9	75	95	94	9.0	9380	9660
16	01Y451	LR	4.7	76	104	89	8.9	9120	9640
9	M202	M	4.8	89	103	81	6.5	9050	9560
5	03Y170	SPQ	4.7	80	95	94	8.3	8910	8930
11	00Y805	M	4.9	82	101	69	8.5	8830	9050
6	02Y210	WX	4.7	79	106	98	9.1	8780	9700
3	02Y171	SPQ	4.9	75	94	98	9.0	8340	8970
12	02Y816	M	4.8	86	106	86	7.6	8310	9120
1	CM101	W	4.8	79	101	96	8.6	8150	9250
Mean			4.8	80	99	70		9420	9470
LSD(0.05)			0.1	4	5	26		1130	370
C.V. (%)			2	3.5	3.2	27		8.4	5.6

† 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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
47	02Y516	L	4.4	82	103	16	7.3	11180	9740
48	02Y519	LR	4.8	81	98	5	7.5	11080	9790
33	03Y283	M	4.8	84	101	20	9.0	11020	9470
42	02Y565	SR	4.7	88	96	1	7.2	10640	9800
45	03Y467	LR	4.8	79	97	36	8.6	10610	9540
44	03Y457	LR	4.7	81	106	25	8.4	10590	9430
35	03Y259	M	4.7	84	98	35	6.5	10520	9420
22	03Y177	S	4.5	80	99	58	7.3	10360	9440
21	03Y167	SPQ	4.7	80	97	21	5.9	10170	9190
46	03Y479	LR	4.9	85	93	1	7.0	10130	9170
43	03Y454	L	4.6	83	97	1	6.8	9960	9210
41	03Y878	M	4.8	83	100	85	7.6	9800	9470
20	03Y166	SPQ	4.7	79	95	44	6.7	9770	9440
37	03Y804	M	4.9	78	104	80	7.2	9620	9340
32	03Y235	M	4.8	81	102	54	7.7	9420	9700
19	03Y164	SPQ	4.7	81	94	55	6.6	9380	9600
36	03Y270	M	4.6	79	104	89	8.7	9310	9260
30	03Y253	M	4.6	79	104	76	8.7	9280	9410
34	03Y249	M	4.9	79	99	68	7.1	9270	9480
29	03Y231	M	4.8	77	104	73	8.3	9220	9590
23	03Y183	S	4.7	81	103	86	7.3	9210	9750
26	02Y172	SPQ	4.9	85	103	61	7.6	9210	9340
31	03Y254	M	4.8	78	105	89	8.7	9130	9760
49	03Y485	BA	4.9	79	98	15	6.8	8910	7680
24	01Y295	MPQ	4.8	84	106	79	6.6	8770	9070
40	03Y853	M	4.9	78	100	91	6.5	8720	9240
38	03Y805	M	4.9	77	97	70	7.5	8650	8530
39	03Y851	M	4.8	79	103	96	8.9	8630	9250
28	03Y227	M	4.8	75	98	87	9.0	8610	9370
27	03Y205	MPQ	4.9	78	106	91	8.9	8380	8940
25	01Y195	MPQ	4.9	79	105	89	7.1	8300	9260
50	03Y486	BA	4.9	80	109	86	8.3	7680	7620
Mean			4.7	80	101	55		9550	9290
LSD(0.05)			0.2	3	6	23		1420	680
C.V. (%)			2.6	2.9	4.2	30		10.6	7.4

† 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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
78	99Y529	L	4.6	84	99	8	6.6	11100	9970
65	01Y327	SPQ	4.8	88	100	49	6.1	10930	9990
80	03Y113	LR	4.9	86	98	1	8.3	10570	9580
79	01Y655	LR	4.7	84	106	53	7.6	10270	9830
71	M205	M	4.8	90	102	73	6.8	10270	9910
75	L205	LR	4.7	82	98	54	8.9	9810	9210
68	M206	M	4.8	78	104	64	8.2	9650	9650
77	99Y041	L	4.8	86	106	71	7.9	9640	9510
70	M204	M	4.8	87	101	70	6.6	9590	9570
73	02Y382	M	4.7	85	99	55	6.8	9550	9760
69	M202	M	4.8	87	110	81	6.5	9500	9670
62	S102	S	4.9	76	104	64	8.4	9260	9460
72	00Y805	M	5	80	103	96	9.1	9020	8820
74	L204	L	4.8	81	93	11	7.3	9010	9210
67	03Y293	MPQ	4.8	86	107	68	7.9	8920	9340
76	CT201	BA	5	86	104	6	8.1	8500	7760
61	CM101	W	4.8	77	103	73	7.5	8370	8670
63	CH201	SPQ	5	85	98	69	9.2	8120	8530
66	03Y291	MPQ	4.8	85	101	89	6.9	7970	9440
64	BL-1	SPQ	4.9	83	97	64	9.7	7030	7500
Mean			4.8	84	101	56		9350	9270
LSD(0.05)			0.1	3.5	4.7	26		1130	450
C.V. (%)			1.9	2.9	3.3	33		8.5	7.0

† 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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
109	01Y502	SR	4.7	81	93	1	6.3	10990	9830
112	02Y565	SR	4.7	85	97	1	6.7	10430	9760
110	01Y110	LR	4.7	81	98	19	6.9	10370	9430
97	03Y631	M	4.7	86	99	40	7.7	10330	9560
91	03Y269	M	4.9	78	102	83	8.7	10320	9330
90	03Y263	M	4.9	82	95	71	6.9	10150	9260
88	03Y322	S	4.8	83	102	69	6.3	10140	9520
108	03Y496	SR	4.6	84	99	1	8.6	10110	9680
105	03P2659	LR	4.9	86	96	7	6.7	10090	9600
94	03Y366	M	4.8	83	95	55	7.2	10090	9450
101	03Y843	M	4.7	82	99	14	7.8	9870	8990
107	03Y508	LR	4.7	86	91	6	7.1	9780	8480
96	03Y406	M	4.7	81	99	56	7.6	9450	9780
87	03Y316	SPQ	4.8	85	101	50	5.8	9400	9760
104	03P2666	LR	4.8	83	103	60	6.5	9380	8810
93	03Y361	M	4.8	80	96	58	6.2	9380	9270
92	03Y273	M	4.9	82	99	63	7.3	9260	9490
98	03Y388	M	5	78	106	71	6.2	9240	8850
83	02Y308	MPQ	4.8	84	101	83	7.9	9180	9740
100	03Y818	M	4.7	81	98	60	7.9	9160	9120
102	03Y845	M	4.8	78	100	46	7.4	9140	8560
95	03Y369	M	4.8	78	103	71	8.9	9140	9090
99	03Y689	M	4.8	75	99	64	7.1	9080	8700
89	03Y332	SR	4.6	84	97	30	6.7	8990	8150
103	03Y902	M	4.6	79	96	44	7.3	8940	9270
86	03Y295	MPQ	4.8	85	102	58	6.9	8560	8240
84	03Y289	MPQ	4.7	85	98	53	8.0	8160	8410
85	02Y311	MPQ	4.9	85	106	60	6.4	7940	8180
111	03Y549	BA	4.8	92	99	32	7.3	7880	7340
82	02Y343	SPQ	4.9	86	100	75	9.2	7830	8190
81	03Y081	SPQ	4.9	83	98	55	9.2	7500	7430
106	02Y724	BA	4.8	86	94	37	6.4	7180	6420
Mean			4.8	83	99	45		9300	8930
LSD(0.05)			0.1	4	5	25		1260	610
C.V. (%)			2.1	3	3.7	39		9.6	6.9

† 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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
125	03Y324	S	4.6	85	104	14	6.4	12460	10820
126	03Y576	SR	4.5	90	106	11	5.5	11220	10680
133	03Y151	LR	4.7	85	89	2	7.5	11070	10660
129	01Y617	M	4.8	87	101	38	8.4	10820	10510
132	01Y501	SR	4.6	81	92	1	7.8	10350	10800
134	03Y521	LR	4.8	84	89	1	7.5	10340	10360
127	M205	M	4.8	91	104	55	6.3	10180	10410
130	L205	LR	4.8	82	93	19	8.1	10150	10080
123	03Y559	MPQ	4.8	87	106	78	5.9	9780	9740
124	03Y556	MPQ	4.7	89	105	50	5.7	9480	9530
128	M202	M	4.9	88	109	75	5.7	9480	9890
121	M402	MPQ	4.9	96	104	41	5.6	9310	9530
131	CT201	BA	4.9	90	104	2	8.9	8840	8820
122	CH201	SPQ	5	87	102	97	8.5	8220	9020
Mean			4.8	87	100	34		10120	10060
LSD(0.05)			0.2	4	5	29		1520	610
C.V. (%)			2.1	3.6	3.6	59		10.5	7.5

† 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 2004.

Entry Number	Identity	Type†	SV‡	Days§	Ht. (cm)	Lodge (%)	SR¶	---Grain Yield#--- RES	State
149	99Y529	L	4.8	85	101	3	7.5	11520	11590
150	99Y494	LW	5	87	96	1	6.8	11110	10860
144	03Y680	M	4.8	84	97	33	6.4	11110	10680
148	03Y888	M	4.9	89	101	27	7.9	10800	9990
142	03Y605	M	4.8	88	96	51	6.6	10730	10560
151	03Y658	L	4.7	88	96	1	6.4	10660	10360
141	03Y397	M	4.8	87	97	38	6.2	10580	10210
143	03Y411	M	4.8	86	94	55	6.7	10530	10390
146	03Y820	M	4.8	90	105	75	8.4	10340	9490
145	03Y600	M	4.8	85	94	38	6.5	10160	10210
140	03Y418	M	4.9	89	97	29	6.3	10080	10240
139	03Y407	M	4.8	88	100	58	7.8	9940	9960
135	02Y321	MPQ	4.7	88	109	53	8.2	9760	9170
136	02Y313	MPQ	4.7	89	108	73	6.6	9420	9740
138	03Y138	SPQ	4.9	83	100	89	7.3	9260	9090
137	02Y305	MPQ	4.8	85	110	89	6.7	9220	9410
147	03Y857	M	4.9	81	100	86	8.7	8740	9480
152	02Y720	BA	4.6	93	100	20	9.1	8340	8240
154	02 6707	BA	4.9	91	89	2	8.7	8040	7300
153	03 6706	BA	4.9	88	92	33	9.4	7570	7440
Mean			4.8	87	99	42		9900	9720
LSD(0.05)			0.1	4	5.7	30		1340	610
C.V. (%)			2	3.3	4.1	50		9.5	5.5

† 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 2004 Preliminary Yield Tests is presented in Table 7. These tests included 783 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 2005 Statewide Yield Tests. u

Table 7. Summary of Preliminary Yield Tests at RES in 2004.

Test	Number of Entries	All	Highest	Top 5	Check
		Average Yield (lb/acre)†			
Very early					
Short grains	63	9770	12320	11790	10870
Medium grains (A)	30	10070	11630	11050	10270
Medium grains (B)	41	10000	11740	11540	11220
Long grains	75	9420	11610	11080	9910
Early					
Short grains	72	9190	10770	10600	9920
Medium grains (A)	52	9850	11110	10810	10280
Medium grains (B)	51	9740	11310	10040	11100
Long grains	68	9270	10940	10740	9140
Intermediate-Late					
Short grains	34	9330	11290	10700	9740
Medium grains	46	10290	11250	11170	11150
Long grains	30	8580	10380	10180	9840
Special (1 rep)					
Medium grains (Blast)	221	9770	13320	12090	10750

† 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 the experimental CRMG line 00-Y-805 with Pi-z blast resistant gene and its anticipated release as 'M-207' in spring of 2005.

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. Eighty-five back crosses were made with high yielding Chinese introductions with IG-1 blast resistance in 2003. In 2004, five F_3 populations derived from backcrosses to these original crosses were included in the Hawaii Winter Nursery.

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

Calrose Medium Grain Quality

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

M-206

M-206 was released to growers for registered seed production in 2003. It was grown on over 30,000 acres in 2004. Comments, observations, and performance from a variety of information sources are as follows:

1) M-206 field yields are equal or superior to M-202.

2) M-206 has exhibited the potential for whole grain head rice improvement of 1-2 points more than M-202.

3) M-206 is more synchronous in heading than M-202 (shorter duration for flowering duration).

4) M-206 panicles are more visible than other CRMG varieties (on top of plant canopy) giving the impression of under fertilization which generally is not the case.

5) M-206 is adapted to the entire rice growing region and serves well as a companion to other CRMG varieties to spread harvest.

6) Preliminary field observations indicate a similar reaction to blast like M-202 in blast problem fields and not as susceptible as M-104 and M-205.

7) Multi-year moisture measurements and grower comments confirm that most M-206 fields dry down rate slows and remains relatively constant 3-5 days in the moisture range 24 to 20 percent. This is in contrast to most CRMG's that continue to dry down.

Experimental 00-Y-805

00-Y-805 is being proposed as a varietal release in 2005 named M-207. Its anticipated final confirmation will occur in early February. The following describes in summary form the background, agronomic characters and proposed area of adaptation.

00-Y-805 (01-Y-34, 02-Y-13, 04-Y-11, 04-Y-72) is a very early to early maturing, smooth, high yielding, semidwarf, CRMG rice with blast resistance to the California race IG-1 derived from the Pi-z gene. Its pedigree is F_1 (Lafitte/93-Y-82)//M-202 (cross R22821 made in 1997 summer greenhouse). Lafitte (PI593690= Mercury//Mercury/Koshihikari) is a medium-grain variety released by Louisiana State University no longer in commercial production and was the source for Pi-z blast gene resistance. 93-Y-82 (experimental designation 92-Y-624) was a non-released medium-grain whose pedigree is Calpearl/3/M7/M9//M7/4 /Calpearl.

00-Y-805 is essentially an M-202 agronomic type CRMG that is 4 days earlier, lodges 10% more, dries down faster, and has 1-2 points less total and whole grain milled rice when compared to M-202 (Table 8). Over 4 years of statewide testing its yield performance is similar to M-202. 00-Y-805 if released would be the first CRMG with resistance to race IG-1 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 molecular labs using different markers. 00-Y-805 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 and M-202 in visual, cooking, and taste evaluations by various milling and marketing organizations and individual evaluators.

Table 8. Agronomic characteristic means of M-206, 00-Y-805, and M-202 from very early & early groups of the Statewide Yield Tests for 2001 to 2004.

Character	M-206	00-Y-805	M-202
Seedling Vigor Score	4.9	4.8	4.9
Days to 50% Heading	83	84*	88
Plant Height (cm)	97	97	98
Lodging (%)	30	50	40
Greenhouse Blanking (%)	8	16	15
Blanking at Davis (%)	11	15	18
Blanking at San Joaquin (%)	6	11	12
Overall Blanking (%)	8	14	15
Stem Rot Score	6.2	7.2	6.0
Harvest Moisture (%)	20.7	18.6	20.9
Yield lbs/acre @ 14 %	9187	8791	8901
Total Milled Rice (%)	68.9	67.2	68.5
Whole Grain Milled Rice (%)	65.3	62.6	63.6
1000 Brown Rice Kernel Weight (g)	25.0	22.8	24.2
Brown Rice Kernel Length (mm)	6.1	6.25	6.01
BR Brown Rice Kernel Width (mm)	2.79	2.65	2.84
Brown rice Length/Width Ratio	2.19	2.35	2.12
Apparent Amylose Content (%)	18.0	16.5	16.5
Alkali Spreading Score(1.7% KOH)	6.7	6.7	6.9

* = Significantly different than M-202 at the 0.05 level.

Table 9. Statewide Yield Test over location yield averages of M-206, 00-Y-805, and M-202 for 2001 to 2004. †

Year	Statewide Test Group	M-206	00-Y-805	M-202
2001	Very Early	9150	8750	8610
2002	Very Early	9660	9300	9020
2003	Very Early	8680	8460	8340
2003	Early	8130	8360	8210
2004	Very Early	9853	9051	9558
2004	Early	9653	8822	9668
2004	Strip Trial	10060	9665	9463
Mean		9312	8915	8981

† Pounds/acre at 14.0% moisture.

00-Y-805 is adapted to all growing areas, but it is specifically being released as an alternative to CRMG's in those areas in Glenn and Colusa counties that have fields with reoccurring blast damage. A strip trial in the blast area confirmed that 00-Y-805 can yield with M-202 (Table 9). UCCE Statewide Yield Test data suggests that most other production areas have better alternatives to 00-Y-805. 00-Y-805 could serve as a variety that fills the industry need for future blast outbreaks, provides a blast resistant variety for problem areas, and may minimize future widespread outbreaks of blast. Care should be taken to avoid over-fertilization to reduce lodging and disease pressure. Harvesting should be done at 18-25% moisture to improve head rice potential. Test data indicates 00-Y-805 dries down faster than M-206 and 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 (Tables 1 and 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. Fifteen CRMG blast resistant entries were evaluated (7 in VE, 5 in E, and 3 in I-L). In general, these entries did not have the overall yield stability required by California medium-grain varieties. Pending final review of 2004 data and quality tests, only 1 or 2 CRMG blast resistant entries will be re-tested in 2004.

02-Y-816 is a blast resistant, early, smooth, high yielding, semidwarf CRMG. 02-Y-816 positive attributes are resistance to lodging and milling (whole grain and total) similar to M-202 and has improvements over 00-Y-805. Two years testing in the very early group of the Statewide Yield Tests suggests it has M-202 area of adaptation. It will be tested in 2005 in the early group as well that should provide the necessary information to consider its release and a seed increase is being planned for 2005.

Preliminary Yield Test Entries in Hawaii

There are 26 CRMG entries from 2004 yield tests being grown in the Hawaii Winter Nursery for purification, seed increase, and additional agronomic evaluation (Table 10). Maturities of these entries range from M-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. 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. Twenty-four percent (97 of 400) of the CRMG crosses were blast related. Thirty-three percent of CRMG 2004-05 Hawaii rows (885 rows) were blast related and included 94 pedigrees.

A Special Test of blast resistant entries was conducted at RES (Table 7) and summarized in Table 11. 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 21%) than highest CRMG check M-206. The 67% 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 2005.

Another yield test with selected entries from 1297 rows is planned for 2005. Greenhouse tests confirm they have at least one gene for blast resistance. The performance of these entries suggests that more CRMGs with blast resistance will be in some stage of seed increase in the next five years. The blast gene incorporation is one of the most exciting areas of CRMG research for yield and quality advances.

Table 10. Preliminary Yield Test Calrose medium-grain entries selected and advanced in 2004-05 Hawaii Winter Nursery.

Source	No. of Entries	No. Selected	No. in Hawaii
All entries	441	183	20
Stem rot	7	4	1
Seedling vigor	2	0	0
Blast resistance	225	76	13

Table 11. Mean and yield ranges for entries from the Special Test in 2004. †

Description	Yield	Range
27 checks	9729	5335-11045
12 Hawaii blast resistant entries	11184	9877-13334
All blast entries	9770	5335-13334
Top 5 blast saved	12014	11572-13324

†Single replication large plot yields in lb/acre at 14% moisture.

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. Remaining lines were screened at the cold San Joaquin location. In addition, weeds resistant to this herbicide are already present in California. No breeding research was conducted on transgenic herbicide resistant M-202 in 2004 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 441 entries at this stage in 2004. Thirty-eight of the 183 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-one of 76 advancing blast entries had head rice equal to or 3 points higher than M-202. 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. The 2004 excellent growing season with minimal cool periods and all of off station VESW trials were cut at low harvest moistures providing little information on dry down rate. In previous years it was noted a faster dry down rate in majority of blast entries but this was not observed in 2004.

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, growth response, and emergence). To increase the genetic diversity of CRMG germplasm, five backcross populations involving Chinese introductions have been identified and are being advanced in the Hawaii Winter Nursery.

2004 Project Summary

1. M-206, released to growers in 2003 was widely grown and performed very well.
2. 00-Y-805 is being proposed for release in 2005 as M-207. It is a very-early to early CRMG with IG-1 blast resistance, adapted to all CRMG growing areas, but is being released as a CRMG alternative for those areas with rice blast disease problems.
3. Fast track efforts to develop other CRMG blast resistance varieties continue. 02-Y-816 is a promising line and others are being advanced in Hawaii.
4. Other CRMG breeding and research activities were continued including searching for significantly lower SR scores in high yielding CRMG, milling and dry down studies, as well as the introgression of new germplasm.

2004 Research Direction

1. Tentative strip trials for 02-Y-816 blast entry will be compared to 00-Y-805, M-206 and M-202 in several fields that have had some degree of blast damage every year. Yield performance and milling quality will determine if it will be released.
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. Continue the evaluation of blast resistance entries for faster dry down rates.
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.
6. Continue evaluation and introgression of Chinese introduction backcrosses.

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 these conventional long grains 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. This includes use of amylose, gel temperature, viscogram, and sensory information in addition to grain physical characteristics.

DNA marker technology is also being used at a limited scale for determination or verification of amylose types among conventional and Rexmont type long grains.

During the 2004 season, a total of 109 advanced conventional long-grain selections were tested in statewide and preliminary yield tests. Performance results of a selected number of these entries are listed in Table 12. The overall yields in 2004 for all long grains were lower than expected due to an extended mild weather conditions during the growing season. Several long-grain entries including 99-Y-529, 02-Y-516, 99-Y-41, and 03-Y-658 yielded significantly higher than L-204. Milling yields in these entries remained high, which was also a function of mild temperatures during grain filling stage. Two entries, 99-Y-469 and 99-Y-041, were grown in 2004 headrow blocks. Both experimental lines have yielded consistently higher than L-204 in 1999-2004 Statewide Yield Tests. Cooking quality tests of both lines have shown a significant improvement over L-204. Experimental line 99-Y-469 is being increased for possible release pending results from further quality testing and statewide yield performance trials in

2005. Experimental line 01-Y-502 is a SR resistant line that has also shown very high yield potential, although milling yield of this line has been somewhat lower than L-204. A selected number of long-grain germplasm lines from southern US breeding programs and indica introductions from USDA-ARS Dale Bumpers National Rice Research Center were used in a crossing program for blast resistance, cooking quality, and milling quality improvements.

Table 12. Performance of conventional long-grain entries in 2004 yield and milling tests.

Entry†	Identity	-----Yield (lb/acre) ‡-----		Blanking	Head Rice
		Statewide	RES	(%)	(%)
Very Early Statewide					
47	02Y516	9880	11180	10	65
15	99Y469	10010	10930	5	65
42	02Y565	10150	10640	5	58
17	02Y045	9730	9870	10	61
13	L-204	10120	10830	8	65
Early Statewide					
78	99Y529	9970	11100	10	67
109	01Y502	9830	10980	8	64
112	02Y565	9760	10430	10	57
77	99Y041	9510	9640	8	63
74	L-204	9210	9010	15	64
Intermediate Statewide					
149	99Y529	11590	11520	5	66
151	03Y658	10360	11010	10	62
132	01Y501	10800	10350	25	61
130	L-205	10080	10150	5	64
Very Early Preliminary					
506	03P2854	--	11610	8	64
508	03P2933	--	11140	10	65
473	L-204	--	10260	8	66
Early Preliminary					
564	03Y539	--	10940	30	65
563	03Y537	--	10880	8	65
547	L-204	--	9210	15	66
Intermediate Preliminary					
704	03P2432	--	10380	10	63
710	03P3012	--	10100	15	59
695	L-205	--	9840	5	64

† Entries 42, 109, 112, 132, and 704 are stem rot resistant lines.
‡ Grain yield at 14% moisture.

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. L-205 is an early maturing semidwarf. It averaged 1 to 2 days later and 4 cm taller than L-204. It is also less susceptible to cold induced blanking. L-205 is more likely to become excessively leafy and lodge under excessive nitrogen fertilization. Average brown rice kernel weights of L-205 and L-204 are 21.7 and 25.9 mg, respectively.

Performance of selected Newrex type entries in 2004 yield tests are shown in Table 13. Several experimental lines performed well in statewide trials, with grain yields, averaged over location, ranging between 9580 and 10,660 lb/acre compared 9630 for L-205. Several entries have also shown similar or higher head rice yields as compared with L-205.

Table 13. Performance of Newrex type long-grain entries in 2004 yield and milling tests.

Entry	Identity	----Yield (lb/acre)†---		Blanking	Head Rice
		Statewide	RES	(%)	(%)
Statewide					
48	02Y519	9920	11080	20	59
133	03Y151	10660	11070	10	63
45	03Y467	9900	10610	10	64
80	03Y113	9580	10570	5	63
79	01Y655	9830	10270	30	63
14	L-205	9630	10100	8	64
Preliminary					
501	03P2800	--	10830	8	63
503	03P2815	--	10740	18	59
474	02Y520	--	10370	5	60
484	03P2510	--	10270	15	66
502	03P2807	--	10230	8	61
579	03P2544	--	10160	10	63
548	L-205	--	9800	8	64

†Grain yield at 14% moisture.

Specialty Long Grains

Calmati-201 is a true basmati type aromatic long-grain variety. It possesses extreme cooked kernel elongation and cooking qualities that approach those of imported basmati rice, with slightly less flakiness. This semidwarf variety heads at about the same time as A-201 and an average of 5 days later than L-204. Plants of Calmati-201 have pubescent leaves and hulls and occasionally short awns. Plant height of this variety is about 9 cm taller than L-204. Calmati-201 is susceptible to cold induced blanking and is not recommended for cooler regions. Heavy nitrogen fertilization of this variety should be avoided. 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 2004 tests for their agronomic and cooking quality characteristics (Table 14). Seven advanced selections with improved cooking qualities were tested in statewide tests. Experimental line 04-Y-153, has shown a significantly higher elongation ratio, more slender grain shape, and a more flaky cooked grain texture than Calmati-201. This line was purified in 2004 headrow block and is being considered for possible release pending results from further quality testing and statewide yield performance results in 2005

Increase blocks of 38 basmati, as well as conventional type, selections were also grown for detailed evaluation of milling quality and cooking quality attributes. A number of basmati lines with even more slender grain and softer grain texture are currently being advanced in the Hawaii Winter Nursery and will be tested for yield performance in 2005. Emphasis in basmati selections is being placed on recovering slender and flaky-cooking kernels with higher elongation ratios.

Efforts continued in 2004 to breed jasmine types through pedigree and mutation breeding. Crosses and backcrosses were made with Jasmine type material from various sources including Southern U.S. breeding programs and foreign introductions. The extreme photoperiod sensitivity of the original KDM has been a significant barrier. The original Thai Jasmine variety, Kao-Dak-Mali 105 (KDM), was irradiated with gamma ray and a number of early mutants, including 02-Y-710 and 02-Y-712, were obtained. These early mutants are serving as valuable germplasm source for further agronomic improvements.

One waxy long-grain line 99-Y-494 was tested in 2004 Statewide Yield Tests (Table 14). 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.

Milling quality

The milling yields of L-204, L-205, and Calmati-201 represent significant improvement over their predecessors. This was evident from 2004 head rice yields for these varieties (Tables 12-14). 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 for their resistance to grain fissuring. RES is also participating in 'RICECAP' project which is a new USDA initiative with the objective of applying genomic discoveries to improve milling quality and disease resistance in rice. RES is taking part in extensive fissuring studies for this project as well as providing and evaluating a California long-grain population for developing molecular markers associated with milling quality. Further information and updates on the status of this 4 year project can be found at http://www.uark.edu/ua/ricecap/.

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 contribute to improving head rice yields. Milling yield potential of 38 of the most advanced long-grain lines from the Statewide Yield Tests were evaluated in 2004 harvest moisture studies in two maturity groups.

Table 14. Performance of specialty long-grain entries in 2004 yield and milling tests.

Entry	Identity	Specialty Type	---Yield (lb/acre)†--- Statewide	RES	Blanking (%)	Head Rice (%)
Very Early Statewide						
49	03Y485	Basmati	7750	8910	50	56
50	03Y486	Basmati	7620	7550	15	57
14	L-205	Rexmont	9600	10350	5	65
Early Statewide						
111	03Y549	Basmati	7340	7880	10	57
106	02Y724	Basmati	6420	7180	35	60
76	CT-201	Basmati	7760	8500	35	62
Intermediate Statewide						
150	99Y494	L. Waxy	10860	11110	5	64
130	L-205	Rexmont	10080	10150	8	64
153	02 67068	Basmati	7440	7570	35	62
154	02 68079	Basmati	7300	8040	20	62
131	CT-201	Basmati	8820	8840	50	63
Preliminary						
546	03P3442	Basmati	--	8600	15	57
545	03P3441	Basmati	--	8450	40	63
524	03P3277	Jasmine	--	10090	35	57
527	03P3282	Jasmine	--	9360	15	64
549	CT-201	Basmati	--	8180	35	63

†Grain yield at 14% moisture.

Disease Resistance

SR resistance originating from *Oryza rufipogon* has been transferred to a number of high yielding long-grain lines. Twenty four entries with a range of SR resistance were tested in 2004 Statewide and Preliminary Yield Tests. Performance of a selected number of these lines is shown in Table 15. Entries 132 (01-Y-501) and 109 (01-Y-502) have shown significant improvement because they combined low SR score, low blanking, early maturity, and high yield potential for the third 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 2004 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, 582 and 488 are shown in Table 15. 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 2004 with the USDA scientists at Beaumont, TX, and UC Davis for the development and use of genetic markers for blast resistance. DNA marker results from USDA and phenotypic screening information from RES are currently being compared on selected populations to determine the feasibility and efficiency of marker aided selection techniques within breeding program. 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.

A considerable number of early generation blast resistant lines were selected in 2004 and are currently being screened in greenhouse blast tests by the RES plant pathologist. Selections were also made from a number of second backcross F_2 populations and F_3 lines grown at the Hawaii Winter Nursery and UCD and San Joaquin cold tolerance nurseries. u

Table 15. Performance of conventional long-grain entries with resistance to stem rot or the blast race IG-1 in 2004 yield and milling tests.

Entry	Identity	DR†	SV‡	Day§	Ht. (cm)	---Yield (lb/acre) -- Statewide	RES	SR¶	Blanking (%)	Head Rice (%)
Statewide										
132	01Y501	SR	4.6	81	92	10800	10350	7.8	25	61
109	01Y502	SR	4.7	81	93	9830	10980	6.2	8	64
112	02Y565	SR	4.7	85	97	9760	10430	6.7	10	57
108	03Y496	SR	4.6	84	99	9680	10110	8.6	12	60
75	L-205	LR	4.7	82	98	9650	9980	8.9	5	64
Preliminary										
582	03P2633	Blast	4.6	79	99	--	9820	9.5	10	64
488	03P2549	Blast	4.8	85	95	--	9770	9.4	10	64
704	03P2432	SR	4.5	86	90	--	10380	4.4	8	63
701	03P2333	SR	4.5	88	93	--	10070	6.0	12	66
695	L-205	LR	4.6	79	93	--	9840	8.2	5	64

† DR=Disease resistance type where SR=stem rot, Blast=blast resistant, and LR=Rexmont quality.
‡ 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. (Stem rot scores are from greenhouse evaluations with the exception of entries 701, 704, and 695.

PREMIUM QUALITY & SHORT GRAINS

Kent S. McKenzie

Dr. J. Jiang will be joining the RES staff in April 2005 as the new premium quality and short grain project leader. This project is responsible for breeding and research on several different grain and quality types as part of the RES Rice Breeding Program. The emphasis and breeding goals do vary for the different grain and quality types. The 2004 season research highlights from the different project research areas 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 continue to be superior to Koshihikari. 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 Calrose medium grains. Breeding efforts are targeting improving these weaknesses as well as trying to achieve further quality improvements.

Agronomic performance of the most advanced premium quality short-grain breeding lines (SPQ) can be found in Tables 1-6. These eleven experimental lines were advanced because of earlier maturity, smooth hull, different parentage, kernel size, or better yield potential than the check variety Calhikari-201. Agronomic performance and milling data on ten of the eleven advanced breeding lines and three preliminary breeding lines are summarized in Table 16. Most showed higher yield potential and better lodging resistance than Calhikari-201. Entry 004 showed good yield potential in the Very Early Statewide group again in 2004. Entry 19 also yielded well. Preliminary Yield Test entries 198 and 199 gave very high yield at RES. Milling tests were rather severe as reflected by the very low average harvest moistures on the samples shown in Table 16. These lines and others will undergo further quality evaluations in cooking and laboratory tests during the winter. Earlier generation material also was harvested from progeny rows and small plots for cooking and quality evaluation as well. Agronomic data including disease resistance and resistance to blanking will be combined with quality data to select entries for further testing in 2005. Superior lines will be used as parents in future crosses.

Table 16. Agronomic performance and milling averages of selected 2004 premium quality short grain (SPQ) entries in UCCE Statewide and RES Preliminary Yield Tests.

2003 Entry	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	SPQ	19.8	9720	4.9	85	91	50	17.9	65/72
005	SPQ	16.6	9040	4.8	82	84	50	15.5	63/75
019	SPQ	16.1	9720	4.9	82	86	40	14.7	62/72
020	SPQ	17.4	9490	4.9	83	86	40	18.5	64/73
021	SPQ	18.6	9300	4.9	83	86	10	17.6	61/72
026	SPQ	18.2	9210	5.0	86	91	40	16.4	53/72
S-102	S	15.9	9670	5.0	78	94	50	18.5	64/74
Early Statewide									
065	SPQ	16.2	9990	4.8	87	97	50	14.6	49/72
082	SPQ	14.4	8190	5.0	87	97	80	15.5	50/70
087	SPQ	16.5	9760	4.9	86	99	40	15.7	61/73
CH-201	SPQ	15.2	8530	5.0	86	97	80	13.1	49/73
Intermediate/Late Statewide									
138	SPQ	15.9	9090	4.8	88	97	90	14.3	53/71
CH-201	SPQ	14.5	8530	5.0	86	97	80	13.1	49/73
Very Early Preliminary									
195	SPQ	18.2	9710	4.8	76	99	100	16.0	58/72
198	SPQ	21.6	10930	4.6	80	98	40	15.4	54/72
199	SPQ	19.9	10680	4.7	80	101	70	16.4	58/72
Akitakomachi	SPQ	15.9	7120	4.6	78	104	100	16.9	62/71

† 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. Agronomic performance of thirteen advanced premium quality medium-grain breeding lines (MPQ) can be found in Tables 1-6. Agronomic performance and milling data for ten of the advanced breeding lines and ten preliminary breeding lines is summarized in Table 17. In the statewide groups, entries approached the yield of the Calrose medium grain check. As a group the medium grain milling yields were excellent. In the Preliminary Yield Tests conducted at RES entries 299, 330, and 625 showed significantly higher yield potential than the check variety Selection emphases in these materials is toward larger kernels with M-202 grain and milling yields as well as improved lodging resistance. Cooking tests will be conducted on these and other advanced breeding lines in an effort to identify premium quality selections and make improvements in quality, yield, cold tolerance, and disease resistance. Earlier generation premium quality material was harvested from small plots and progeny rows in 2004 for cooking evaluation and further testing in 2005.

Table 17. Agronomic performance and milling averages of selected 2004 Premium quality medium grain entries (MPQ) in UCCE Statewide and RES Preliminary Yield Tests.

2003 Entry	Grain Type	Harv. Moist (%)	Yield (lb/acre at 14%)	SV †	Days to 50% Heading	Height (cm)	Lodge (%)	H_20 (%) ‡	H/T (%)
Very Early Statewide									
024	MPQ	18.5	9020	4.9	86	94	60	22.3	65/72
025	MPQ	18.3	9040	4.9	83	91	60	22.4	67/72
M-104	M	17.7	9550	5.0	81	89	60	16.6	68/73
Early Statewide									
066	MPQ	17.4	9440	4.9	87	99	70	16.3	69/73
067	MPQ	17.8	9340	4.9	86	102	70	19.1	67/73
M-206	M	17.5	9820	4.9	86	94	50	21.8	72/73
M-202	M	17.4	9670	4.9	87	104	70	17.3	64/72
083	MPQ	17.0	9740	4.9	86	97	70	17.7	71/73
086	MPQ	16.7	8240	4.7	87	99	40	19.4	66/73
Intermediate/Late Statewide									
123	MPQ	18.4	9740	4.7	91	102	80	20.5	67/72
124	MPQ	16.8	9530	4.8	92	102	60	15.6	57/71
136	MPQ	17.9	9740	4.7	94	104	90	18.0	66/73
137	MPQ	19.1	9410	4.8	90	104	90	16.2	52/71
M-402	MPQ	19.4	9530	5.0	98	99	70	27.5	67/70
Early Preliminary									
M-202	M	23.8	9440	4.7	84	104	30	19.3	64/71
299	MPQ	22.0	10140	4.7	85	103	30	20.6	62/72
309	MPQ	22.9	9950	4.7	83	101	40	19.3	66/74
311	MPQ	21.7	9610	4.8	85	100	20	18.0	57/72
315	MPQ	21.4	9590	4.7	84	103	30	17.1	57/72
317	MPQ	21.7	9650	4.8	81	103	40	18.9	68/72
318	MPQ	22.3	9830	4.7	85	101	10	20.4	68/72
320	MPQ	25.1	9710	4.8	85	99	30	18.1	60/70
321	MPQ	22.5	9880	4.7	83	99	20	24.2	65/71
330	MPQ	20.6	10370	4.8	79	95	30	20.0	68/72
332	MPQ	20.8	9840	4.7	79	107	40	24.9	68/71
Intermediate/Late Preliminary									
625	MPQ	22.4	10540	4.7	87	108	60	18.6	59/72
M-402	MPQ	23.1	9740	4.7	94	102	10	26.3	69/72

† 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.

Conventional Short Grains

S-102, released by CCRRF in 1996, is the predominant California short-grain in commercial production and consistently has been a high yielding entry in the very early advanced group of the Statewide Yield for many years. In combination with its very early maturity and very large kernel it is has be hard to develop lines with those traits that out performs it. Two preliminary breeding lines (206 and 350 in Table 18) selected from crosses with S-102 were tested in Preliminary Yield Tests conducted at RES and displayed very high yield potential and comparable head rice milling yield compared to S-102. Entry 125 was the top yielding entry in the intermediate group of the Statewide Yield Test. Plot yields of this entry at RES average over 12,000 lb/acre in both seeding dates in 2004. These breeding lines, as well as other short-grain breeding lines advanced from small plots and progeny rows in 2004 will be evaluated further in 2005.

Disease Resistance

Because their high yield potential and less demands on cooking characteristics, in the conventional short grains improvement efforts have focused on improving disease resistance with support of the Pathology Project. Breeding for SR resistance remains an important long term objective of the 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. They are not accompanied by some of the weakness of earlier resistant materials, like very poor seedling vigor, high susceptibility to cold temperature blanking, and late maturity. Progress seems to be occurring in grain quality as well. The donor germplasm for this SR resistant material has come from the long-grain project and it has required considerable breeding effort to move this in to the short grains. 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. Table 19 contains some the more outstanding experimental lines from 2004 yield tests.

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. Lines showing blast resistance are being advanced for agronomic and quality testing and re-screened to confirm resistance to race IG-1. High yielding lines from short grain and premium quality medium grain crosses have been recovered. 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 that are often seen in the blast resistant donor parents.

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.

Table 18. Agronomic performance and milling averages of selected 2004 short grain entries (S) in UCCE Statewide and RES Preliminary Yield Tests.

2003 Entry	Grain Type	Harv. Moist (%)	Yield (lb/acre at 14%)	SV †	Days to 50% Heading	Height (cm)	Lodge (%)	H_20 (%) ‡	H/T (%)
Statewide									
22	S	17.0	9510	4.6	81	89	50	19.7	59/72
23	S	17.5	9970	4.9	83	91	50	18.0	63/71
S-102	S	15.9	9670	5.0	78	94	50	18.5	64/74
88	S	15.9	9520	4.9	86	99	40	17.9	63/72
M-202	M	17.4	9670	4.9	87	104	70	17.3	64/72
125	S	16.7	10820	4.3	86	99	50	17.0	58/72
M-205	M	18.4	10360	4.9	94	97	70	18.6	68/73
Preliminary									
206	S	16.5	11110	4.7	74	97	50	17.4	58/73
350	S	18.4	10500	4.8	75	105	100	19.6	66/73
S-102	S	13.4	10870	4.7	75	99	60	14.3	57/72

† 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 19. Agronomic performance and milling averages of selected 2004 stem rot resistant (SR) entries in UCCE Statewide and RES Preliminary Yield Tests.

2003 Entry	Grain Type	SR† Score	Yield (lb/acre at 14%)	SV‡	Days to 50% Heading	Height (cm)	Lodge (%)	H_20§ (%)	H/T (%)
Statewide									
126	SR	4.5	10680	4.5	90	102	40	18.6	63/73
M-205	M	6.9	10360	4.9	94	97	70	18.6	68/73
Preliminary									
208	SR	5.5	11670	4.7	80	92	10	15.3	53/72
S-102	S	8.6	10870	4.7	75	99	60	14.3	57/72
633	SR	5.3	10560	4.5	91	96	0	18.2	65/75
634	SR	5.7	10380	4.7	86	95	0	19.5	59/71
638	SR	5.4	11290	4.6	89	98	0	17.4	58/73
641	SR	5.2	10210	4.7	85	99	0	16.6	61/73
S-301	S	5.4	9330	4.7	95	109	50	25.5	70/72

† 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.

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. One glabrous short-grain waxy (Entry 6) was tested in the very early Statewide Yield Tests in 2004 but did not show significant agronomic advantages over Calmochi-101 (Tables 1). Another set of waxy lines will be advanced from preliminary yield testing. Quality evaluations are planned as well as industry evaluations on the more promising lines. Input from marketing organizations is critical to help RES to improve quality evaluations that complement the needs of the 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 developing 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. Several low amylose rice cultivars have been developed and are in commercial production. 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. Two putative mutants of the California premium quality short-grain cultivar Calhikari-201 were identified and designated BL-1 and BL-2 for advancement and increased in the 2001 winter greenhouse, then transplanted into the 2001 RES nursery. The putative mutants were subjected to laboratory tests at RES to measure apparent amylose content and RVA profiles. These lines were also sent to Japan for evaluation by a cooperating Japanese scientist at a research laboratory to determine the changes in stickiness and hardness for fresh cooked and staled rice. Results showed the low amylose lines had amylose content (8 %) similar to the Japanese low amylose varieties. In addition, Tensipresser analyses and taste panels indicated that California low amylose lines displayed similar stickiness values to Japanese low amylose varieties, but higher values for kernel hardness compared to Japanese low amylose varieties.

Both low amylose lines were field tested in UCCE Statewide Yield Tests in 2002 through 2004 and years yielded 11-15 % lower than their parent Calhikari-201. Statewide Yield Test and RES milling data for the low amylose lines are summarized in Table 20. UCCE conducted two N tests at RES in 2004 and the results are summarized in Table 21. Overall, the low amylose lines possess lower yield potential than Calhikari-201 as well as reduced grain weight and panicle size. In 2003 and 2004, small production fields were grown at RES for large scale milling, quality evaluation, and test marketing. Production of seed and paddy for test marketing is planned for 2005. The breeding program is currently evaluating new low amylose materials in small plots and progeny rows. Breeding efforts are ongoing to address the agronomic problems associated with the current low amylose lines through crosses with adapted California germplasm. The Board of Directors will be deciding on an appropriate format to release this germplasm that represents a new quality and market type for production in California and the US.

Table 20. Average agronomic performance and milling of BL-1, BL-2, Calhikari-201, and M-202 in UCCE Statewide Yield Test (Early Group) 2002 to 2004.

Entry	Grain Type	Harvest Moist. (%)	Yield (lb/acre at 14%)	SV†	Days to 50% Heading	Height (cm)	Lodged (%)	H_20‡ (%)	Head Rice (%)	Total Rice (%)
BL-1	LA	17.4	7060	4.5	83	95	65	17.2	62	71
BL-2	LA	17.0	7160	4.6	85	95	74	18.6	65	72
CH-201	SPQ	16.6	8100	5.0	84	95	68	17.0	58	71
M-202	M	19.8	9050	4.9	85	102	64	17.9	64	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/year.

Table 21. Agronomic performance low amylose entries in UCCE nitrogen fertilizer test at RES in 2004.

Pre-Plant N (lb/acre)	Yield (lb/acre at 14%)	Days to 50% Heading	Height (cm)	Lodge (Score†)	Yield (lb/acre at 14%)	Days to 50% Heading	Height (cm)	Lodge (Score†)
	------------BL-1 (Field J10)------------				-----------BL-2 (Field J5)------------			
0	3450	79	66	1.0	7180	85	79	4.0
50	7920	82	84	1.0	6550	90	95	4.0
100	8070	83	103	5.3	7640	91	102	9.8
150	7340	86	107	7.0	6850	92	103	9.5
200	7910	88	109	7.8	7240	93	108	9.0
Mean	6940	84	94	4.4	7090	90	97	7.9
LSD(0.05)	1510	2	6.1	3.4	1420	3	5.0	3.6
C.V. (%)	14	2	17	50	13	2	3	30

† Subjective rating of 1-10 where 1 = none and 10 = completely lodged.

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.

Cooperative research on some grain quality components and technologies is also a project activity. This includes continuing evaluation of single kernel grain moisture and its variability and impact on milling yield. In addition RES has been evaluating on consignment the Foss Cervitec™ 1625 Grain Inspector. This is an automated high speed grain image analysis inspection system developed to evaluate Asian japonica rice for physical characteristics including, head rice, damaged kernel, fissuring, and kernel dimension. Evaluations are being made using California medium and short grain and this technology holds great potential for using this in evaluating breeding material for quality trait selection. u

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 recent disease in California, and work is being conducted to determine damage and develop detection and control techniques. Most of this work should be completed in 2005.

Stem Rot

Screening for SR resistance in inoculated nurseries and greenhouses 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 8000 rows in the 2004 SR nursery.

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 2002-4 results for lines tested in 2004.

		2002		2003		2004	
Variety		SR	Yield	SR	Yield	SR	Yield
L205	L	6.0	9482.0	5.3	9108.3	6.7	8583.8
01Y501	L			3.8	9531.9	5.5	9322.7
01Y502	L	4.6	11955.0	3.9	10450.9	4.7	9125.6
02Y111	L			4.6	8989.8	5.2	6597.0
02Y480	L			3.9	9007.9	4.0	8151.1
02Y565	L			4.1	9743.2	5.3	9231.0
03Y496	L					4.8	9222.2
03Y497	L					4.9	8077.6
03Y641	L					4.8	8542.9
03Y642	L					4.7	9492.2
M205	M	5.2	10057.0	4.2	8425.2	5.5	8705.1
S102	S	5.7	8846.0	4.5	8138.6	5.8	8152.0
03Y331	S					4.0	8189.9
03Y332	S					4.8	6641.4
03Y572	S					4.1	9222.4
03Y576	S					4.9	9375.2
03Y573	S					4.2	8657.1
87Y55[illegible]	L	3.2	9391.0	3.2	9138.0	3.8	7650.5
$LSD_{0.05}$		0.4	772.2	0.6	861.8	0.6	1436.0

The resistant line 01-Y-502 significantly out yielded L-205 in all years (but not significantly in 2004). The 2004 test suffered from poor weed control and under fertilization due to applicator error. Several short grain lines out yielded S-102, but not significantly. 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.

Dr. Tom Tai has indicated willingness to develop marker assisted selection for the breeding program. His student, Leslie Snyder, is working on this project. About 5200 field transplants and an equal number of greenhouse plants were screened for SR and SS resistance at the station in 2004.

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. Sheath spot is more widespread than stem rot, and can cause significant damage. Field tests in the stem rot nursery are probably inadequate because of interference from stem rot and because of field conditions unfavorable to sheath spot development in many years.

Molecular markers will also be sought for resistance derived from *O. rufipogon* in cooperation with the USDA lab at UC Davis.

Blast

Rice blast disease in California was identified for the first time in 1996 in Glenn and Colusa Counties. It spread over significantly more acres in 1997, and has reached Sutter (1998), Butte (1999), and Yuba (2000) Counties. In 1998 to 2004, blast severity was much lower than in previous years. A few affected fields continue to be found, mostly on the west side of the valley. However, more blast was found in 2003 than in any year since 1998. Due to late planting, more M-104 was grown than usual in 2003. M-104 appears to be more susceptible than other varieties, followed by M-205. None of the Statewide Yield Tests have been affected by blast since 1997, so the entries could not be evaluated.

Major resistance genes limit blast symptom expression to small brown flecks at most, but different races of the blast fungus can overcome this resistance in several years after variety release. The low disease pressure in California may delay this expected breakdown. Varieties possessing single blast resistance genes could be released first followed later by varieties with several different resistance genes. The genes chosen for this scheme have resistance to many blast races. The fungus will not easily overcome several genes having broad-spectrum resistance. About 5600 lines were screened for major gene resistance in the greenhouse this past year.

A cooperative project with the USDA lab at UC Davis to develop molecular marker screening for these resistance genes is continuing. So far, California materials have been tested against markers for the Pi-kh, Pi-ta^2, Pi-z, and Pi-b genes. The Pi-kh 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.

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

Bakanae Disease

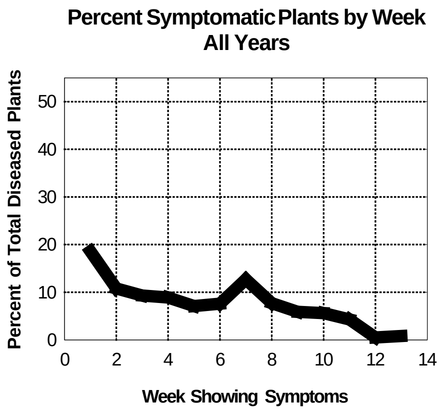
Bakanae disease, caused by the fungus *Gibberella fujikuroi* (=*Fusarium fujikuroi*), was found for the first time in Butte and Colusa Counties in 1999. Research at RES established the identity of the disease. It was also found in Yuba and Sutter Counties in 2000 and throughout most of the rice growing region in 2001-2. Incidence was lower in 2003, when seed treatment with 1-5% bleach (6% NaOCl) was widespread. Since the disease is largely seed borne, it likely was introduced on imported seed that did not pass through quarantine.

Disease Description

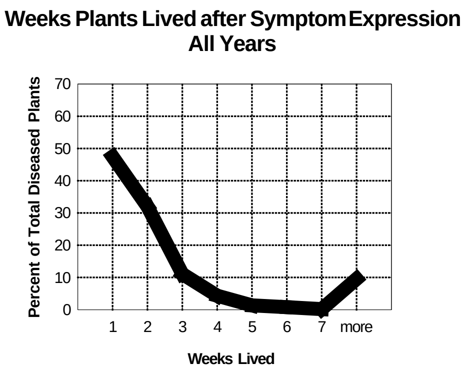
Diseased plants appear about 25-30 days after seeding and have greatly elongated, rolled, yellow leaf blades and sheaths. Affected plants are usually scattered throughout a field. Plants elongate as a response to gibberellin production by the fungus. These symptoms are encouraged by warm temperatures (90-100F), but cooler temperatures may result in yellow, stunted plants, or 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.

Disease Progress

The following graphs illustrate when symptomatic plants showed up during the season and how long they lived. Results are the average for years 2000-2.



New symptomatic seedlings continue to show up throughout the growing season. Most plants do not live more than 2-3 weeks after symptom expression.



Random patterns of symptomatic seedlings in the field and observations in field plots indicate the disease does not spread much within a season.

Since the fungus reportedly does not over winter efficiently, this data underscores the importance of seed borne inoculum.

Seed Assays

Assays were developed detect the bakanae fungus in seed lots by direct plating of seed onto medium selective for fusaria fungi. Another technique involved shaking a quantity of seed in an equal volume of water, and plating a dilution series with the resulting suspension onto selective medium. The latter test required less labor, allowed use of larger seed lots, and was more sensitive than the seed plating assay. Color formation in the medium by the pathogen on certain nutrient media and color of the fungal colony surface allowed differentiation from other fungi. Once yield loss data are established, seed lot assays can indicate the potential of a seed for yield reduction.

Generally, about 25-75% of seeds testing positive for the fungus in a seed plate assay would have developed symptoms when planted in the field.

Seed plate and greenhouse assays produced similar results.

Disease Increase

Seed from fields of known disease incidence was harvested and planted into rings for two successive years. Disease incidence increased an average of 13 times, with a range of six to 60 times.

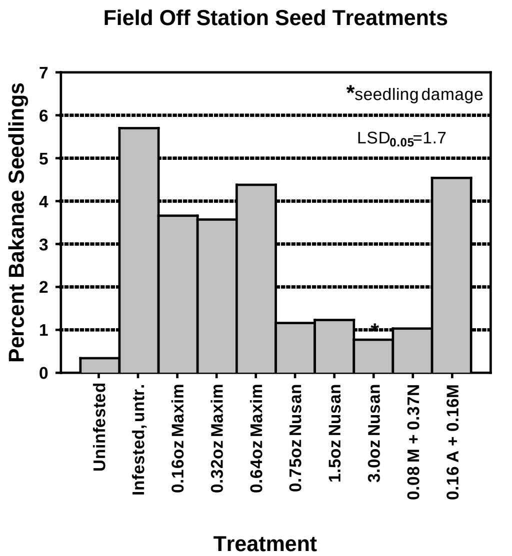
An attempt was made to assess the importance of over wintering inoculum on disease development. One field had 3% disease incidence in 2000. Seed flown onto this field was assayed every year. By 2002, field incidence levels had fallen to 0.05%.

Seed Treatment

Fungicides were also tested in the laboratory, greenhouse, and field. Both Maxim and Nusan are registered for use on rice as a seed treatment (0.16 and 1.25oz/100# seed, respectively).

In 2002, three field trials were located in Butte (late summer test), Sutter, and Yuba counties in cooperation with Jack Williams and UCCE.

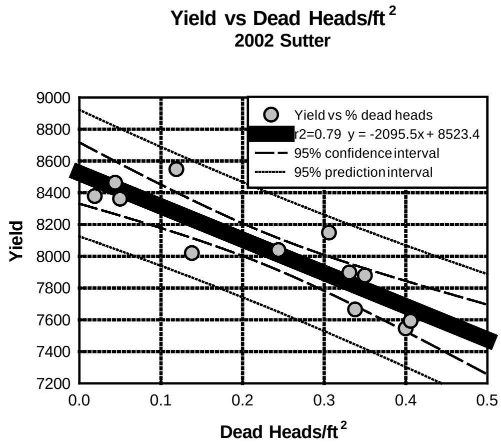
The Yuba trial did not show any yield differences among treatments, and bakanae levels were less than 3.5% diseased seedlings.



The Sutter trial showed significant yield decreases. The infested, untreated treatment had a high of 10% yield loss when bakanae seedling loss was 8.7%.

Maxim fungicide was ineffective at any concentration. Nusan was more effective, but the 3oz rate decreased seedling growth at 2-3 weeks after planting. The Maxim-Nusan combination was as good as Nusan alone, but at lower fungicide rates. There was no yield loss for treatments including Nusan. The Apron-Maxim combination was ineffective.

Both seedling death and dead heads were correlated with yield loss. The low number of dead seedlings and heads shouldn't account for all of the yield loss. The fungus seems to do other



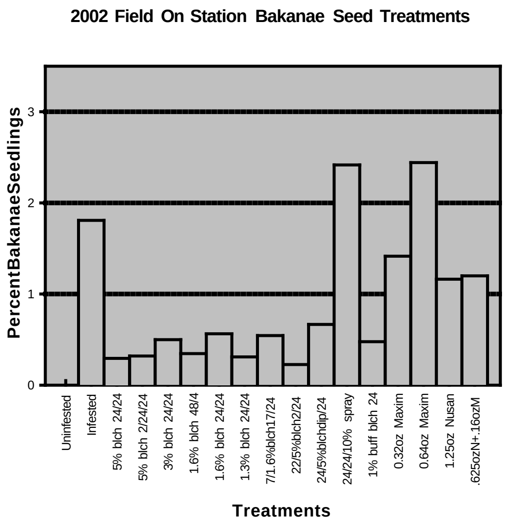
damage, perhaps partial root/crown rot resulting in less grain fill.

In 2001, laboratory, greenhouse, and field tests indicated 5-10% bleach (0.25-0.5% sodium hypochlorite) greatly reduced bakanae incidence but seedling growth was also reduced about 20% at 14 days after seeding. Plants recovered, however, as the season progressed.

In 2002, an additional trial was conducted at the Rice Station with concentrations of bleach ranging from 1.3-5% (0.068-0.26% sodium hypochlorite). All treatments produced equivalent control of the disease. However, laboratory and greenhouse tests indicate the fungus is not killed with 1% bleach. The five percent bleach treatment (24 hour soak/24 hour drain) produced a growth reduction of 16% about two weeks after planting. If treatment was restricted to the first two hours of soaking, or if the bleach concentration was lower, there were no growth reductions. This treatment is registered for use in California.

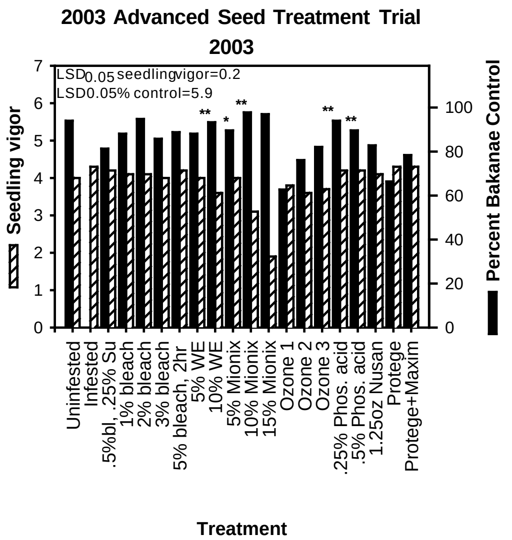
Maxim again failed to give acceptable control, and Nusan and Maxim-Nusan combination did not perform as well as in off station tests.

In 2003, seed treatment trials were conducted at five locations (Butte, Sutter, Yuba, Colusa, and Glenn counties) in cooperation with Jack Williams and Chris Greer of UC Cooperative Extension.



A heavily-infested seed lot was used, but symptom expression was low. No yield differences were observed.

The following graph presents results stated as percent disease control.



The bleach-only treatments did not differ from each other very much either in seedling vigor or percent bakanae control.

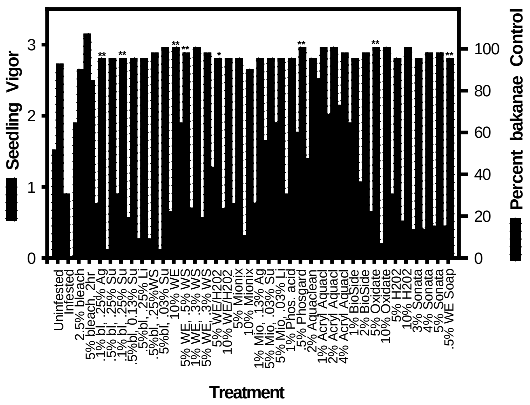
The 10% Wilbur Ellis low pH material (WE), 10 and 15% Mionix, and both phosphorous acid treatments prevented multiplication of the fungus on seed even with a 72 hour drain period.

Protégé, Maxim-Protégé, the lower ozone concentrations, and bleach + Surfonic were less effective than the other treatments. The highest ozone concentration and the Nusan treatment were barely better than the less effective treatments. The best treatments were 2% bleach, 10% Mionix, and 0.25% phosphorous acid (better than 94% control).

Some treatments also reduced seedling vigor at 14 days after planting. Ten percent WE, 10% Mionix, and all ozone treatments moderately affected vigor, while 15% Mionix severely affected vigor. Stand counts were affected similarly, except there was no significant difference among treatments.

One hundred and six different seed treatments were evaluated in a preliminary experiment at the Rice Station. These treatments included effect of soak and drain times on bakanae disease development and additional seed treatment materials, including those in the advanced trials. Seed treatments providing 95% or better control are in the following graph.

2003 Preliminary Seed Treatment Trial



Surfactants, both alone and in combination with bleach and the low pH compounds, may improve control. Low concentrations of Agrimul (=Ag), Surfonic (=Su), Liquinox (=Li), and Wilbur Ellis soap (=WS) can even reduce the required concentration of bleach 10 times.

Several treatments slowed bakanae multiplication on treated seed (5% WE/$H_2 0_2$), or prevented it (1% bleach+0.25%Ag, 1% bleach+0.25% Su, 10% WECO, 5% WE+0.5%WS, 0.5% phosphorous acid, 5% Oxidate, and 0.5% WE soap).

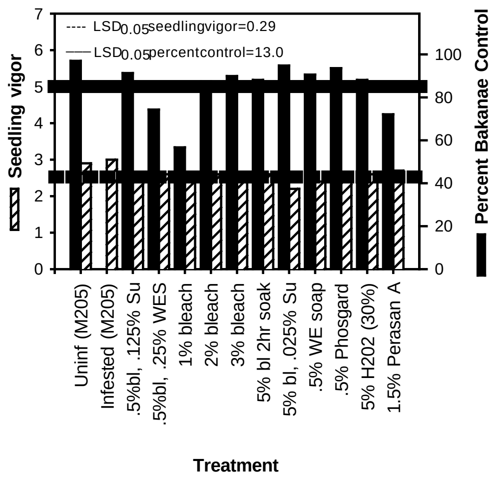
Phosphorous acid, hydrogen peroxide, and bleach are equally economical and effective. Bioside and Phosgard are more expensive, but probably still affordable along with some of the surfactant combinations. The Mionix and Wilbur Ellis products do not have pricing.

All seed treatment experiments above were performed with M-202. A greenhouse test was conducted with the best treatments against a range of varieties (L-205, CT-201, M-104, M-202, M-204, M-205, M-206, S-102, M-401, and CM-101). The following table summarizes results. The untreated entry is expressed as % germination and cm of growth 10 days after planting (vigor). All other treatments are expressed as % of untreated entry.

Treatment	Average for Varieties			
	% germ.		Vigor	
	ave	range	ave	range
Untreated	82	69-91	29	27-30
0.5% bleach, 0.125% Surfonic	90	79-103	100	93-105
0.5% bleach, 0.25% WE soap	97	91-108	101	94-109
2% bleach (6% NaOCl)	102	90-142	101	96-110
1% WE acid, 0.25% WE soap	91	81-108	99	92-108
1% Mionix acid, 0.125% Agrimul	92	79-104	97	90-103
5% H202	97	63-98	99	91-107

In 2004, three seed treatment trials were conducted in Butte, 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. Seed treatments which prevent fungal multiplication after treatment should give the best result under these conditions.

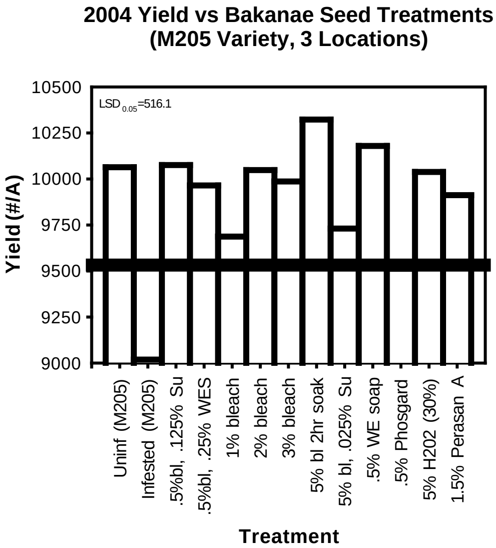
2004 Advanced Seed Treatment Trial



Several seed treatments did not differ significantly from the uninfested control treatment. These were 0.5% bleach + 0.125% Surfonic, 2% bleach, 3% bleach, 5% bleach (2hr soak), 5% bleach + 0.025% Surfonic (best treatment over all), 0.5% Phosgard, and 5% H_2O_2.

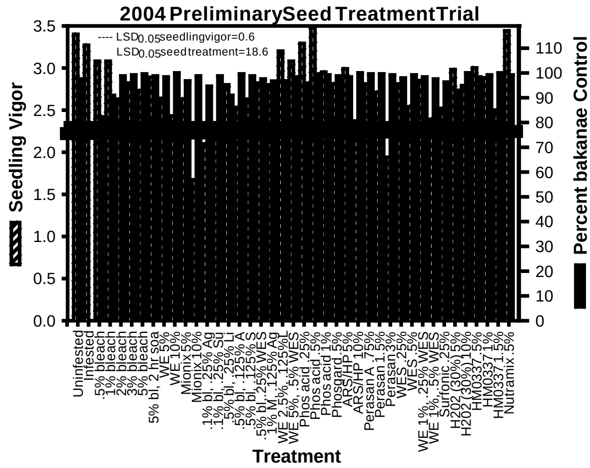
Seedling vigor was reduced for the 3% bleach, 5% bleach+0.025% Surfonic, 0.5% WECO soap, and 0.5% Phosgard treatments, but the differences were not large except for the 5% bleach + 0.025% Surfonic treatment.

The following graph shows yields for the same treatments.



Of the treatments providing control equivalent to the uninfested treatment, only 0.5% Phosgard resulted in a yield reduction. The infested treatment showed a significant 10.4% yield reduction.

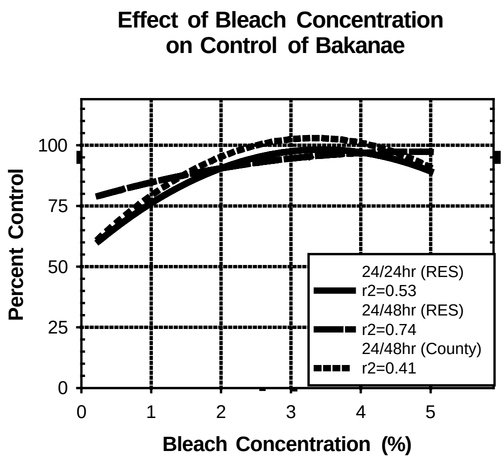
The following graph presents results from the preliminary seed treatment trial conducted at the RES. All treatments were given 24hr soak/24hr drain, which is a probably closer to most commercial condition than the 48 drain used in the advanced trials.



This trial contained all of the advanced trial entries as well as other experimental chemicals and combinations.

The goals of further testing are 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.

The following graph shows results from different bleach treatments.



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. The Clorox label will be amended to include 2.5% Clorox Ultra® with no rinse.

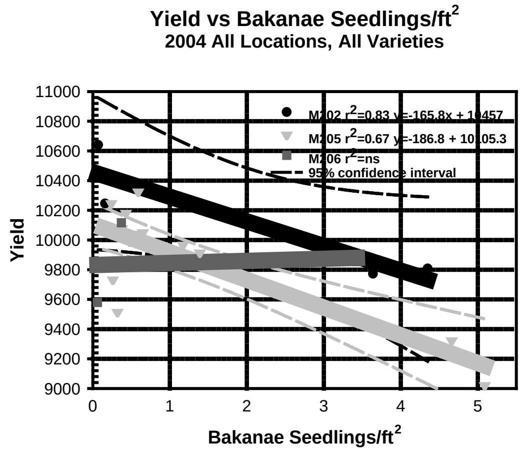
Varietal Resistance

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 three locations for effects on yield.



Correlations between yield and bakanae incidence were moderate to high for M-205 and M-202, but not significant for M-206. Yield of M-206 apparently is not affected by bakanae symptoms and might be considered tolerant to bakanae. But, from the variety resistance table, lower bakanae incidence would be expected in M-206. These results need confirmation in trials with a wider range of seed infestation.

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

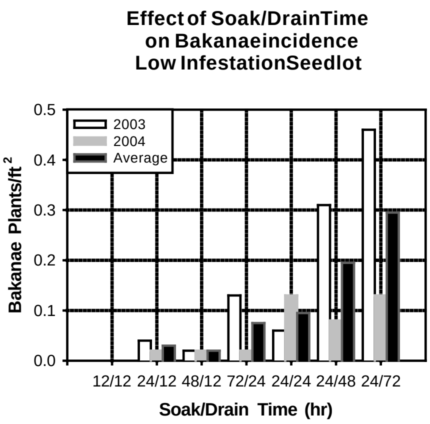
Numbers in the table above refer to season long bakanae densities. On the basis of three years' data, disease incidence early in the season will be a fraction of season long (cumulative) densities. If a scout entered a field 4 weeks after planting, a density of 1.25

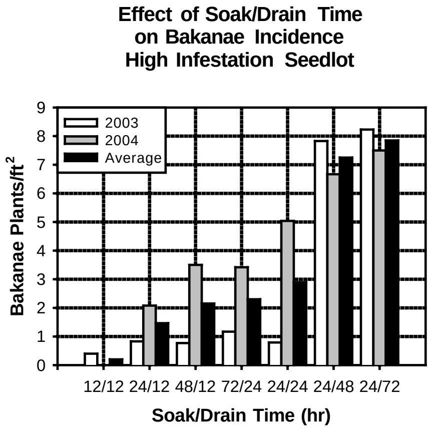
bakanae seedlings/ft^2 would correspond with an expected 5% yield loss.

For the first time, 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. Further work on screening technique needs to be done.

Cultural Practices

The following two graphs show the effects of soak and drain times on disease incidence in the field. Separate tests were performed on seed with low and high bakanae spore infestations. The low infestation seed lots had assay values of 0-4.5 spores/ml, while the high infestation seed lots ranged from 700-10000/spores/ml.

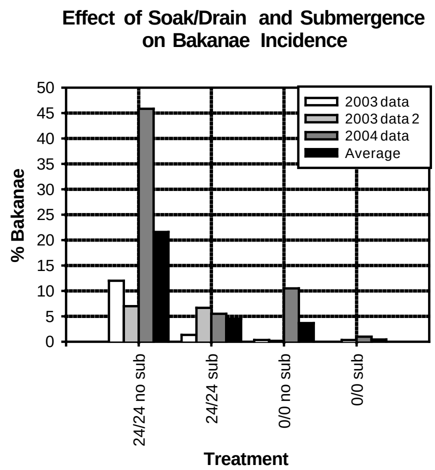




For low infestation seed lots, bakanae incidence in the field did not increase for the 12hr soak/12 hr drain treatment, and increased with longer drain times. Differences were not significant according to ANOVA analysis. For heavily infested seed lots, the same pattern was evident and differences were significant.

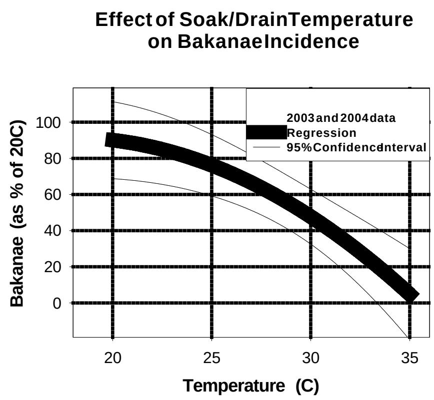
Drain times were most important for increasing bakanae incidence in 2003, but total soak and drain time better explained the 2004 results. One exception is the 72hr soak/24hr drain treatment, where disease did not increase as much as in the 24/72 treatment.

Other trials explored the effect of submergence and soaking/draining on bakanae incidence.



Both submergence immediately after sowing and planting of dry seed greatly reduced bakanae incidence.

Temperatures during soaking and draining could also influence bakanae incidence.



Bakanae incidence gradually declined with increasing temperature to very low levels at 35C. This information is important to assure high bakanae levels in seed treatment trials. It may also explain, along with varying soak/drain times, differences in water management, and varietal susceptibility why bakanae levels vary from field to field.

Since over wintering inoculum also plays a role in disease development, straw decomposition should be encouraged. Straw can be burned or worked thoroughly into the soil. Flooding may help reduce inoculum if it encourages straw decomposition. Since the fungus does not over winter well, rotation may be a good way to reduce inoculum in heavily infested fields.

As with other diseases prevalent in California, fertilize for maximum yield, but do not over fertilize

Quarantine Introductions

The building blocks for any breeding program are germplasm with traits desirable in commercial production. This past year, two entries passed through quarantine.

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. u

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. u

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

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.

Fellowships of $2,500 were awarded to Kristie Pellerin, Leslie Snyder, and Greg Van Dyke. Kristie J. Pellerin is a Ph.D. student in Biology in Agronomy & Range Science at UCD, Leslie Snyder is a Ph.D. student in the Genetic Graduate Group at UCD, and Greg Van Dyke is a graduate student working toward his Masters degree in Agricultural Business at California Polytechnic State University San Luis Obispo.

APPENDIX

MISSION STATEMENT

Our primary mission is the development of improved rice varieties and agronomic management systems for the benefit of the California Rice Industry. 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. A secondary and important objective is support of UC and USDA research by providing land, resources, and management for genetic, agronomic, weed, insect, disease, and other disciplinary research.

RESPONSE TO PROPOSED GMO INITIATIVE IN BUTTE COUNTY

1. CCRRF Board of Directors is opposed to the Proposed Butte County Ordinance Prohibiting the Growing of Genetically Engineered Organisms because it will greatly restrict our ability to pursue our mission:

    a. It would prohibit indefinitely any rice improvement research at the Rice Experiment Station (RES) involving "genetic engineering technology". It would also prohibit all greenhouse and field research in this area by our cooperators from the University of California and USDA. Independent third party research is essential to achieve an objective scientific evaluation on new technology. This information is needed for review and decision making for research activities, commercialization, as well as public policy.

    b. The proposed ordinance has many ambiguities and does not clearly exclude proven and accepted breeding methods (induced mutation and crossbreeding). These methods have provided important agronomic and quality traits for California rice varieties and are a safe and proven technology that has been used in genetic research and the development of rice germplasm worldwide. For example, M-401, a premium quality semidwarf variety widely grown in Butte County, was a product of induced mutation. Production could be prohibited by this ordinance denying county rice growers a profitable production option.

    c. It would permanently ban the production of any "genetically engineered organism" in Butte County. This allows no opportunities in the future for farmers, including rice growers, to respond to consumer, market, regulatory, or environmental demands using this technology. They would be denied the choice to utilize any future benefits of this technology and be placed at a competitive disadvantage.

    d. The proposed ordinance places a very significant new financial and regulatory burden on the Agricultural Commissioner to enforce the provisions as an unfunded local mandate. The high cost of testing and the labor to do it would detract resources for other services they provide for the county. Regulating this ordinance will have significant fiscal impact on the county budget.

2. CCRRF research serves and is supported by all California rice growers. This proposed ordinance will have consequences outside the boundaries of Butte County by denying growers and consumers in other counties the potential benefits of this technology. These new technologies need to be available as research and development tools for rice research and varietal development for the entire California Rice Industry.

3. Although there is currently no recombinant DNA research underway at RES, biotechnology holds great promise for rice improvement and germplasm development. Rice is serving as an international model system for crop genetics research that will bring forth many discoveries that can benefit rice improvement. Research and the germplasm developed employing these new technologies need to be available for the benefit of the California Rice Industry and the public as well. This ordinance would restrict such activities and access to them.

4. To pursue our mission, RES and cooperating scientists need to be permitted to evaluate and utilize available technology and rice germplasm in the laboratory, greenhouse, and field. This ordinance prohibits field testing which is a necessary part in the process of varietal development.

5. In the 92 year history of this organization, "new rice breeding technology" including artificial hybridization, introduced rice germplasm, and induced mutation have provided tremendous contributions to our industry. Applications of new technologies have been instrumental in the industry's survival and prosperity.

6. Research activities at RES are done in a prudent manner in compliance with all federal, state laws, and local regulations governing transportation, growing, and handling of germplasm. They are annually reviewed by the CCRRF Board of Directors and representatives of the University of California and the California Rice Research Board. Organization and policy of CCRRF encourages active grower input and participation in RES research direction.

7. Varietal release and commercialization of all of our new rice varieties are subject to extensive review and oversight to protect the California Rice Industry and the public interest. It first requires approval by the CCRRF Board of Directors, is reviewed by the University of California/California Crop Improvement Certification Technical Committee, and is finally reviewed by the Rice Advisory Board of the California Rice Commission for 'commercial impact'. Under existing state law, research and production protocols to prevent mixing or other contamination are required on varieties designated as having 'commercial impact' and must be approved by the Secretary of Agriculture of the California Department of Food and Agriculture. Federal approval would also be required for any restricted technology.

8. The CCRRF Board of Directors and the membership include a diverse group of California rice growers who belong to many different marketing and milling organizations. The Board recognizes and respects grower, marketer, and consumer choice in selection of the rice varieties they use as well as the production methods. CCRRF policies and decisions on research are formulated based on scientific merit and in the best interests of all its rice grower members.

CCRRF Board of Directors

July 1, 2004

Rice Research Proposal

Rice research at RES in 2005 will continue toward the primary objective of developing improved rice varieties for California. Project leaders will concentrate efforts on developing rice varieties for the traditional short-, medium-, and long-grain market classes. Research efforts will continue to improve and develop specialty rice such as waxy (mochi or sweet) rice, aromatic rice, and others as an adjunct breeding effort. Heavy breeding emphasis will continue on improving grain quality and disease resistance. Efforts will be made to effectively use new as well as proven breeding, genetic, and analytical techniques. Following are the major research areas of the RES Rice Breeding Program planned for short-, medium-, and long-grain types in 2005.

Quality

Efforts to identify, select, and improve culinary and milling quality in all grain types will continue to receive major emphasis. Improved techniques for cooking evaluations are being used and screening for cooking quality expanded. The RES quality lab is being expanded to support quality evaluation and research for variety development.

Resistance to Disease

The RES Rice Breeding Program is continuing efforts to address the issue of developing disease resistance in our California varieties. Evaluation and screening for SR and SS resistance will be conducted by the plant pathologist on segregating populations, advanced breeding lines, and current varieties. Rice blast disease presents an additional threat to California. Research and breeding activities to address rice blast have been implemented and greenhouse screening for resistance is continuing. Incorporating blast resistance into varieties with the necessary agronomic quality characteristics for California is being emphasized in the breeding program. Expanded facilities and research at RES are helping to address this challenge. Relevant disease related research including improvement of screening and selection methods will also continue. Improved and new sources of resistance will be used in the crossing program. New resistant sources and foreign germplasm will continue to be evaluated as potential parental material. Foreign germplasm will be introduced through quarantine for use in breeding and research. The RES plant pathologist will conduct cooperative research on the bakanae disease of rice.

Yield

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

Tolerance to Low Temperature

Tolerance to low temperature remains an essential character needed in California rice varieties. Segregating populations and advanced experimental lines will continue to be screened in the San Joaquin and UCD nurseries for resistance to blanking, normal vegetative growth, minimum delay in maturity, and uniform grain maturity. This will be supplemented by information provided by two seeding dates of advanced material at RES, refrigerated greenhouse tests, and data from the UCD, San Joaquin, and Hawaii nurseries.

Lodging and Maturity

Testing, screening, and selection will continue for short stature varieties with improved resistance to lodging. Efforts will continue to develop improved varieties that have a range of maturity dates with major emphasis placed on early, very early rice, synchronous heading, and uniformity of ripening.

Seedling Vigor

Screening and selection for seedling vigor will continue on all breeding material.

Cooperative Projects

Cooperative research by the rice breeding program staff with USDA, UC, and others in the area of biotechnology, genetics, quality, agronomy, entomology, plant pathology, and weed control will be continued and expanded in 2005. Emphasis will be placed on applied research and more basic studies that may contribute to variety improvement.

Rice Research Priorities and Areas of Breeding Research

General Rice Research Objectives of Rice Experiment Station

The primary research objective of RES is development of high yielding and quality rice varieties of all grain types (short, medium, long) and market classes to enhance marketing potential, reduce cost, and increase profitability of rice. A secondary but important objective is to support and enhance UC and USDA rice research through cooperative projects and by providing land, water, and input resources for weed control, insect, disease, and other disciplinary research.

Rice Breeding Research Areas and Priorities

Rice breeding research priorities at RES can be divided into General Priorities, that are applicable to all rice varieties developed for California, and Specific Priorities, that may differ between grain types, market classes, special purpose types, and the special interests of the plant breeding team members.

General Rice Breeding Priorities Applicable to All Public California Rice Varieties.

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

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

Short Grains and Premium Quality Medium Grains

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

Calrose Type Medium-Grains

- Improve conventional medium grains
- Develop blast resistant medium grains
- Increase genetic diversity
- Utilize DNA markers for blast resistance genes with USDA researchers

Long Grains

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

Rice Pathology

- Bakanae research and fungicide testing
- Screening and evaluation of advanced breeding lines for blast, stem rot, sheath spot, and bakanae.
- Transfer of stem rot and aggregate sheath spot disease resistance from wild species of rice
- Mapping of stem rot resistance genes and marker aided selection for stem rot and blast in conjunction with USDA Rice Geneticist and UCD researchers
- Facilitate transfer of wide spectrum blast resistance genes to adapted medium grains

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