2014 RICE BREEDING PROGRESS REPORT

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OVERVIEW

Kent S. McKenzie

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

The RES scientific professional staff includes a director, director of plant breeding, plant breeders, a plant pathologist and research scientist. Eleven career positions consisting of five plant breeding assistants, one DNA lab technician, a field supervisor, one mechanic and field operator, two maintenance and field operators, and two administrative assistants make up the support staff. Approximately 30 seasonal laborers are employed during crucial planting and harvest times.

RES Rice Breeding Program

The RES Rice Breeding Program encompasses 5 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 plant breeder. The rice pathology project supports the breeding projects through screening and evaluating varieties for disease resistance, rice disease research, and quarantine introduction of rice germplasm for variety improvement. The DNA marker lab provides support to all projects. 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. All breeding program members cooperatively participate in the preparation, planting, maintenance, and harvest of the research nurseries. The focus of the RES rice breeding program is on developing improved rice varieties to meet the needs of California growers now and into the future.

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. CCRRF cooperates with UC and USDA under a formal memorandum of understanding. The UC and California Rice Research Board (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 and lodging resistance into future rice varieties. Improved milling yield, grain appearance, and cooking characteristics relative to consumer preference are major components of the plant breeding program. A secondary and important objective is to address industry research needs including support of UC and USDA research by providing land, resources, and management for genetic, agronomic, weed, insect, disease, and other disciplinary research.

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

RES Breeding Program is reviewed annually by the Board of Directors, representatives of the UC, and the CRRB. All research is conducted under permits and in compliance with USDA/CDFA regulations and under approved protocols required by the California Rice Certification Act. CCRRF continues to make investments in facilities, equipment and staff to maintain a vibrant and productive rice research program.

Cooperative Research

Cooperative research is an integral part of rice research at RES involving UC and USDA scientists. Statewide performance testing of advanced experimental lines and varieties was conducted by Mr. Raymond L. Wennig, UCD staff research associate, under the direction of University of California Cooperative Extension Farm Advisors Dr. Randall G. Mutters (Butte), Dr. Chris Greer (Placer, Sacramento, Sutter, Yuba), Dr. Luis Espino (Glenn, Colusa, Yolo), and Specialist in Cooperative Extension, Dr. Bruce A. Linquist, (UCD). The information developed from this cooperative research is valuable to the RES Rice Breeding Program and the California rice industry. Dr. Thomas H. Tai, USDA-ARS Research Geneticist, located at UC Davis (UCD), is working with all project leaders to develop improved breeding and genetics methods for rice variety improvement. Rice quality and genetic research has included studies with USDA scientists Drs. Anna McClung, Georgia Eizenga, Rolfe Bryant, and Ming Chen.

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 2014. Dr. Albert J. Fischer, (professor, Department of Plant Sciences, UCD) and Whitney Brim-DeForest, (Ph.D. student) conducted UC rice weed research on 18 acres. Drs. Randall Mutters, Bruce Linquist, Chris Greer, and Luis Espino, are all doing rice research on 18 acres at RES. They are being supported by UCD staff research associate at RES, Mr. John Ray Stogsdill. Dr. Larry D. Godfrey, (extension entomologist) and Mr. Kevin Goding, (staff research associate, Department of Entomology), conducted rice insect research. RES does provide technical input and support to the California Rice Commission (CRC).

CCRRF staff began conducting cooperative research with biotechnology companies in 1996 on transgenic rice for California. This was very limited, included participants from the private and public sectors, and no transgenic materials have been grown at RES since 2001. Future research in this area by RES will depend on California's needs, market acceptance, regulatory requirements, and the development of research agreements.

Seed Production and Maintenance

The production and maintenance of foundation seed is an important RES activity. The foundation seed program is a cooperative effort with the California Crop Improvement Association to assure availability of pure, weed free and high quality seed for the benefit of the California rice industry. Forty-seven improved rice varieties have been released since an accelerated research program began in 1969. Foundation seed of 15 public rice varieties, 2 experimental increases, and basic seed of one Japanese premium quality variety were produced on 140 acres at RES in 2014. Since 1988, CCRRF has protected new varieties under the Plant Variety Protection Act, Title 5 option that requires seed to be sold only as a class of certified seed. Utility patents have also been obtained. This is being done to ensure that California growers are the beneficiary of their research investments as well as assuring that clean, red rice free seed is produced. Although the foundation seed program is self-sustaining and not supported with CRRB funds, foundation seed and certified seed production provides very significant benefits to the whole California rice industry.

CCRRF has followed an aggressive testing program of foundation seed for the presence of the Liberty Link Trait that was discovered at trace levels in Southern US long-grain rice. All results from the initial 2006 USDA tests and annual foundation and basic seed test from 2007 through 2014 by CRC have been non-detect.

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 10 by 10 ft plots for further screening, evaluation, and seed increase.

7. **Preliminary Yield Tests**. The best small plot entries are grown in replicated 10 by 20 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.

RICE BREEDING PROGRAM

The focus of the RES Rice Breeding Program is the development of improved rice varieties to meet the needs of California growers now and into the future. The breeding program consists of three major rice breeding projects namely: 1) Calrose medium grains, 2) short grains and premium quality, and 3) long grains. In addition to the main conventional grain types, each breeding project is working on specialty market types such as Jasmine, Basmati, and aromatic types for the long grain project: low amylose, waxy, Arborio-type, and premium types for the short grains medium grains project. Each of the breeding projects are under the leadership of a rice breeder and overseen by the Director of Plant Breeding. The rice pathology and the DNA marker laboratory, under the leadership of a plant pathologist and research scientist, respectively, support the breeding projects through disease screening and research, genetic analysis and mapping of important traits, and marker-assisted selection and gene introgression.

The station implemented significant organizational changes as it marked its 100th Centennial Anniversary in 2012. Dr. Virgilio C. Andaya was appointed as the Director of Plant Breeding to provide leadership and guidance for the entire breeding program and build an effective rice breeding team composed of rice breeders, research scientists, plant pathologist and support personnel. Dr. V. Andaya is also in charge of breeding for the Calrose Medium Grains Project (see Calrose Medium Grains). Dr. Stanley Omar Samonte joined the RES in early 2012 to take over the Short Grains and Premium Quality Breeding Project (see Premium Quality and Short Grains). He is also in charge of overseeing the RES data management system or Agrobase, the RES website, and also provides his expertise in statistical analyses of field experiments. Dr. Farman Jodari provides leadership of the Long Grain Breeding Project (see Long Grains) and serves as the liaison to the Southern US Breeding Programs. Retiring in 2015 after a long and dedicated service, Mr. Jeffrey Oster is on his final year of being the station plant pathologist working alongside the breeders in disease resistance screening and resistance gene introgression (see Rice Pathology). Dr. Cynthia Andaya provides leadership over the DNA Marker Laboratory as well as the Grain Quality Laboratory. She is in charge of DNA fingerprinting and marker-assisted breeding efforts, mapping stem rot resistance, and generating mutants and providing assistance to herbicide resistance project now under Dr. McKenzie (see DNA Marker Laboratory).

The Rice Experiment Station is fully funded and supported by the California rice growers. The rice varieties developed at RES by its rice breeders and scientists are planted in more than 90% of California's rice fields annually, and are well known for their excellent grain quality and high yields. Breeders and project leaders at RES also collaborates with scientists from UC Davis, USDA, and rice industry, in conducting on- and off-station field tests and yield trials, grain quality studies or assessment, and genetic research.

CALROSE MEDIUM GRAINS

Virgilio C. Andaya

Project Overview

The predominant rice varieties planted in California are medium grains, commercially and internationally known as Calrose rice. The Calrose brand is famous for quality, earning a reputation of being one of the recognizable brands in the international market.

M-202, M-205, and M-206 are the most dominant early maturing medium grain varieties planted in California to date. Released in 1985, M-202 is an old favorite but acreage in recent years is decreasing in favor of newer, better, and more superior rice varieties in terms of yield, milling, and grain quality. M-206 has excellent milling yields, has high and stable grain yield, and is well-adapted even in areas with cool temperature problems like in San Joaquin County. M-205 is a Calrose variety with high yield potential but has a more restricted area of adaptation compared to M-206. It is later maturing than M-202, is very resistant to lodging, and has superior grain and milling yields.

M-105 was released in 2011 as an alternative to M-104, a very early, cold tolerant variety released in 2000 and formerly the dominant variety in San Joaquin. M-105 is also very early, semi-dwarf, glabrous, high-yielding Calrose variety. Its number of days to heading and yield performance are in between M-206 and M-104. Though M-105 was not as early maturing or as cold-tolerant as M-104, one of its more notable attributes is its superior milling yield or head rice recovery over M-104, M-205 or M-206.

Other medium grain varieties that are still in commercial production are M-208, M-401 and M-402. M-208 carries the *Piz* gene which confers resistance to IG-1 blast pathogen but not resistant to a new blast pathogen that emerged recently. Two late maturing premium quality medium grains, M-401 and M-402, are planted on a limited acreage.

The breeding goals in the Calrose project have not changed over the years, though the focus and emphasis have changed from time to time. The principal objective remains to be the development of varieties with high and stable grain yield, high milling yield, excellent grain quality, with tolerance to cold temperature induced blanking, and resistance to blast and stem rot rice diseases. Moving forward, the project is taking serious steps to further improve the grain quality and cooking attributes of medium grain rice and define a "new" Calrose brand to match changing international market preference for better tasting rice while still aiming for highest possible grain yields.

Breeding Nursery Management

In 2014, RES created a position of Breeding Nursery Manager, who is under the supervision of the Director of Plant Breeding, and is tasked to manage the RES breeding facility, and to assist in organizing and planning breeding operations in coordination with the field supervisor and crew. In addition to the operational changes put into motion in 2012, the creation of the manager will facilitate implementation of procedures to better manage the breeding nurseries, thereby increasing breeding efficiency and effectiveness of the entire breeding program.

Breeding Highlights

Check Varieties

Medium grain varieties still in commercial production are routinely used as check varieties in preliminary yield trials and SW test at the RES location. In 2014, the highest overall grain yield, averaged across three SW experiments, was registered by M-205 (9,820 lbs/acre) followed by M-206 (9,670 lbs/acre). The newest released very early medium grain, M-105, averaged 8,630 lbs/acre while M-202 had the lowest of just 7,740 lbs/acre. Overall, pooled grain yield of the check varieties in 2014 was 8,960 lbs/acre compared to 10,270 and 10,750 lbs/acre in 2012 and 2010, respectively.

It was a warm year in 2014, causing the rice plants to flower earlier than previous years. The average combined number of days to heading of the check varieties is the shortest in the last 5 years. The occurrence of lodging is minimal as plants were shorter.

08Y3269 Approved for Release

A Calrose-type medium grain advanced line, 08Y3269, was approved for release in 2015 as **M-209**. It came from a cross made in the spring of 2004 designated as “R29174”, with complete pedigree designation of “M-205/5/ M-201/M7//M-201/3/M-02/4/M-204”. It is early maturing, high yielding, semi-dwarf, glabrous, medium grain rice line and is developed using the pedigree selection method. The line was evaluated by milling and marketing organizations for milled rice quality and cooking quality and was evaluated to be superior in grain quality and acceptable to the rice market.

08Y3269 was first entered in the Early-Group of the UCCE Statewide Test (SW) in 2010, and by 2013, it was entered in all 3 groups of the SW test. The entry was tested in a total of 38 SW experiments and compared closely with M-202, M-205, and M-206. Table 1 summarized the average performance of 08Y3269 and the average yield advantage over the check varieties.

The overall grain yield of 08Y3269, average of 38 experiments, was 9,680 lbs/acre compared to 8,820, 9,250, and 9,480 lbs/acre for M-202, M-205, and M-206, respectively. Yield advantage over M-202, M-205, and M-206 were 10.2%, 5.5%, and 2.3%, respectively. Best yields of 08-Y3269 were registered in Biggs, Butte, Colusa, Sutter, and Yolo.

Using the 2013 and 2014 SW yield data, trend analysis was performed on 08Y3269, M-202, M-205, and M-206. Table 2 summarized the environment index of each SW location derived by pooling 08Y3269 and checks variety yields, and the average yields of the four entries in each of the locations. Figure 1 showed the plot of environment index (yields) against entry yields. Results indicate that 08Y3269 may be more suited in more favorable rice production areas and becoming less competitive under warmer or colder environment.

Table 1. Agronomic performance of 08Y3269 averaged across all locations of the UCCE Statewide Tests from 2010 to 2014.

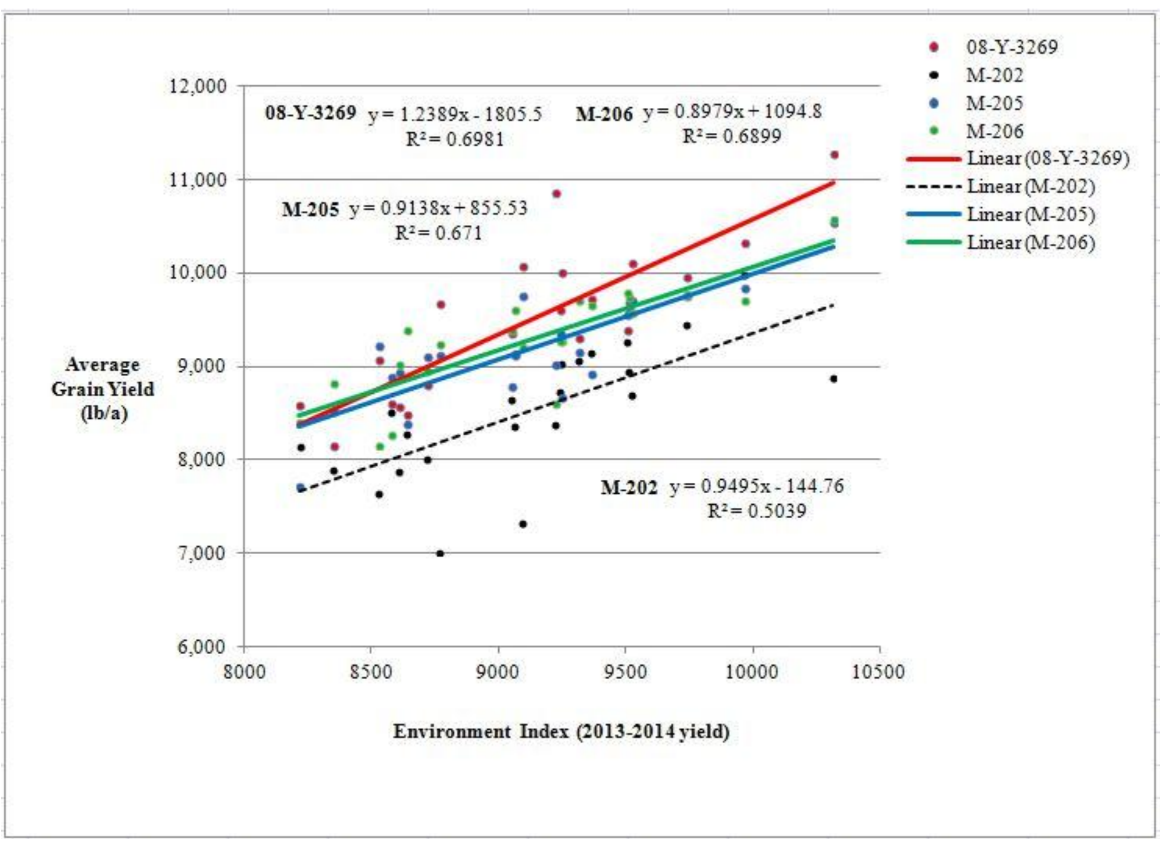
Location†	SV‡	Days§	Height (cm)	Lodging (%)	Grain Yield	% Yield Advantage over		
						M-202	M-205	M-206
E-SW (2010-14)								
Butte	5.0	88	97	4	9330	13	5	4
Colusa	5.0	93	100	6	10140	9	5	3
Biggs	4.8	88	96	1	10080	15	0	4
Yuba	5.0	95	105	17	9600	5	2	-1
Overall Mean	4.9	91	100	7	9790	10.6	3.1	2.7
VE-SW (2012-14)								
Biggs	4.8	87	99	0	10430	23	8	12
San Joaquin	5.0	111	83	1	8280	2	23	-7
Sutter	5.0	91	95	18	9820	4	8	2
Yolo	5.0	90	105	40	9960	8	4	1
Overall Mean	4.9	95	95	15	9620	9.4	10.5	2.1
IL-SW (2013-14)								
Glenn	4.8	94	104	1	8550	2	-1	-3
Biggs	4.9	86	101	0	10690	22	5	6
Sutter-West	5.0	90	104	50	9080	7	5	0
Overall Mean	4.9	90	103	17	9440	10.2	3.2	1.2
Grand Mean	4.9	92	99	11	9680	10.2	5.5	2.3

†E-SW=Early group, VE-SW=Very Early group, IL_SW=Intermediate Late group
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent;
§ Days to 50% heading;
¶ Paddy rice yield in lb/acre at 14% moisture;

Table 2. Environment index and two-year averages (2013-2014) of grain yield in all UCCE Statewide Yield Tests locations for 08Y3269, M-202, M-205, M-206.

Location	Environment Index (lb/acre)	Average Grain Yield (lb/acre) 2013-2014			
		08Y3269	M-202	M-205	M-206
Glenn	8610	8550	8390	8660	8830
San Joaquin	8630	8960	8400	8280	8900
Biggs E	8640	9370	7320	9180	8700
West Sutter	8800	9080	8460	8610	9040
Butte	8830	8860	8120	9050	9320
Yuba	9120	9240	8480	9380	9350
Biggs VE	9160	10460	7860	9400	8910
Colusa	9300	9660	8930	9150	9470
Yolo	9620	9680	9360	9680	9780
Sutter	9640	9820	9520	9510	9710
Biggs IL	9920	10680	8780	10140	10070

Figure 1. Trend analysis of combined 2013-2014 SW average grain yield of 08Y3269, M-202, M-205, and M-206 plotted against grain yield environment index.



The grain dimensions of paddy rice, brown rice and milled rice samples of 08Y3269, M-205, and M-206 were summarized in Table 3. The milled rice grains of 08Y3269 are heavier (1000-grain weight = 22.1 grams) and slightly longer (length = 5.94 mm) compared to M-205 (21.4/5.87) and M-206 (21.3/5.70). The length/width ratio is 2.2, 2.18, and 2.1 for 08Y3269, M-205, and M-206, respectively.

Table 4 summarized the RVA, apparent amylose content, and percent protein content of 08Y3269, M-202, M-205, and M-206 data taken from 2012 to 2013 data through independent external evaluation (USDA and CA Wheat Commission). Based on the results of the RVA, 08Y3269 does not deviate much from the profile of the check varieties. The average amylose content of 08Y3269 (17.1%) was close to M-206 (17.3%), and both are higher compared to M-202 (15.5%) and M-205 (16.9%). The percent protein content of 08Y3269 is 6.3% compared to 5.8%, 6.4%, and 6.8% for M-202, M-205, and M-206 respectively.

Milling yield is one of the most important criteria before releasing a new variety. The % head rice of 08Y3269 when harvested at 18-22% is 65/71 (head/total) compared to 62/67, 65/70, 66/70 for M-202, M-205, and M-206, respectively (data not shown). However, the head rice of 08Y3269 is lower when cut at moistures above 22% compared to the checks. Figure 2 showed the scatter plot of the average head rice percentage plotted against moisture content at sampling, indicating that 08Y3269 may best be harvested at optimum moisture of 18-20%.

Table 3. Grain dimensions of 08Y3269, M-205 and M-206.

ID	Paddy Rice		Brown Rice		Milled Rice			
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)	1000-grain weight	L/W Ratio
M-205	8.41	3.13	6.04	2.78	5.87	2.69	21.4	2.18
M-206	8.16	3.19	5.90	2.79	5.70	2.72	21.3	2.10
08Y3269	8.47	3.20	6.23	2.78	5.94	2.70	22.1	2.20

Table 4. RVA, amylose, and protein content of 08Y3269, M-202, M-205, and M-206. Data were taken from milling plots grown at RES in 2012 and strip trial samples and RES plots in 2013.

ID	Peak	Trough	Break-down	Final Visc.	Setback	Apparent Amylose (%)	Protein (%)
08Y3269	261.9	143.6	118.3	252.0	-9.9	17.1	6.3
M-202	305.5	150.9	154.5	250.7	-54.8	15.5	5.8
M-205	270.1	149.8	120.3	260.4	-9.7	16.9	6.4
M206	272.4	147.6	124.8	257.0	-15.4	17.3	6.8

Figure 2. Scatter plot of % head rice of 08Y3269, M-202, M-205, and M-206 plotted against moisture content at sampling. Data were taken from milling plots at RES in 2011-14 and strip trials in 2013.

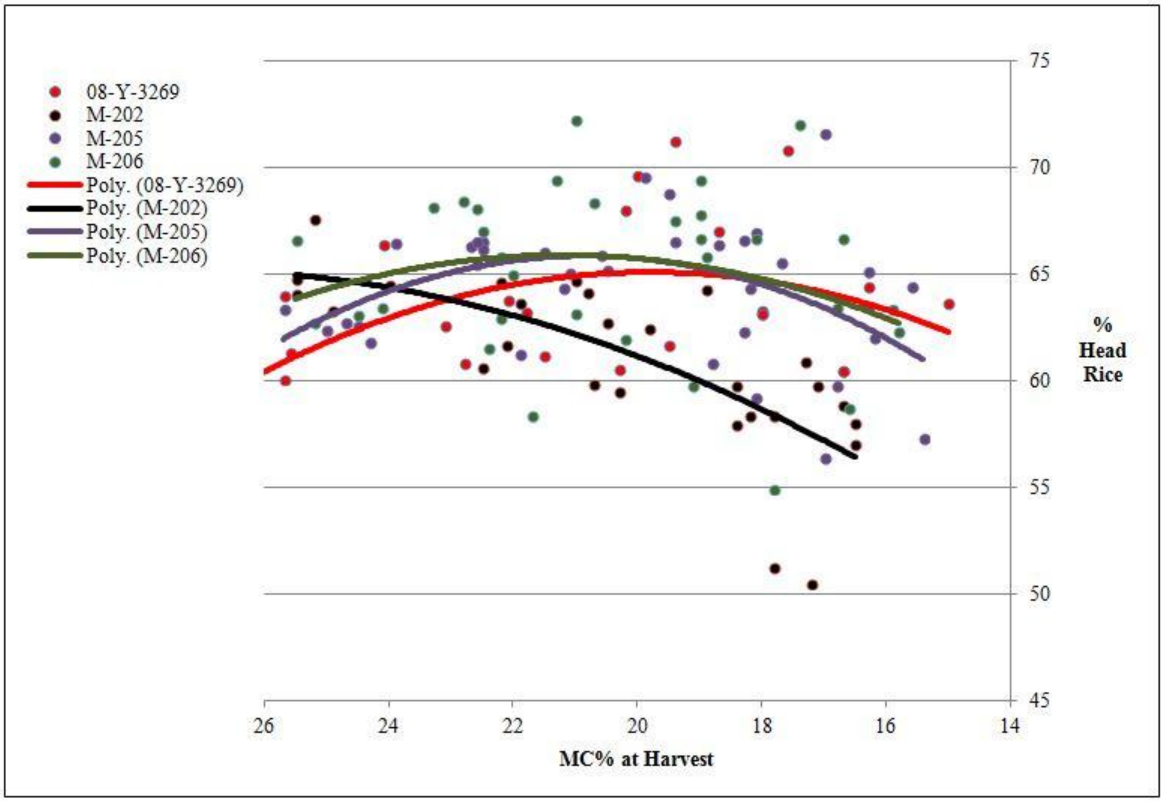


Table 5 summarized the results of cold-induced blanking in San Joaquin (SJ) and at RES using a refrigerated greenhouse (GH). In San Joaquin, field blanking of 08Y-3269 ranged from 2-6% in the period from 2012 to 2014 while the GH tests showed a wider spread of 13-20%. Overall, combined tests indicate that 08Y3269 had an average blanking of 12.6% compared to 11.8%, 12.1%, and 10.6% for M-202, M-205, and M-206, respectively. These results indicate that 08Y3269 may sustain greater damage from cold temperatures if grown in cooler rice areas of California.

Reactions to stem rot, aggregate sheath spot, and blast diseases are summarized in Table 6. Results indicate that 08Y3269 had comparable averaged reaction to stem rot compared to M-205 and better reaction compared to M-202, M-206, and M-208. It has better reaction to aggregate sheath spot compared to M-206 and M-208. However, 08Y3269, having no blast resistance gene as M-202 and M-206 to combat the blast pathogen, had higher susceptibility to the blast disease than M-208.

Table 5. Greenhouse and cold location blanking data of 08Y3269, M-202, M-205, and M-206 taken from 2012 to 2014.

Year	Test	Blanking %			
		08Y3269	M-202	M-205	M-206
2012	GH	20	19	17	15
	SJ	6	5	5	5
2013	GH	16	16	15	14
	SJ	4	4	6	8
2014	GH	13	10	17	12
	SJ	2	2	2	1
MEAN		12.6 (47) ‡	11.8 (94)	12.1 (106)	10.6 (108)

†GH=Greenhouse; SJ=San Joaquin
‡Value in parenthesis is the total number of data points used to calculate overall mean.

Table 6, Stem rot, aggregate sheath spot, and blast scores of 08Y3269, M-202, M-205, and M-206 averaged from 2010 to 2014.

ID	Stem Rot†	Aggregate Sheath Spot‡	Blast§
08Y3269	4.9	1.9	2.8
M-202	5.3	1.9	2.7
M-205	4.8	1.9	2.6
M-206	5.4	2.5	2.4
M-208	5.6	2.5	1.6

† Stem rot score (0-10), 3=all but 1 leaf sheath penetrated, 4=all penetrated, 5=all penetrated but not culm, 6=penetration of culm surface layer, 7=25% of culm girdled
‡ Aggregate Sheath (0-4), 0= none of 4 uppermost leaves damaged, 2=bottom 1 of 4 damaged, 3=bottom 2 of 4 damaged.
§ Blast score (0-4), 0=no symptoms, 1=pinhead, 2=<25% leaf area with susceptible lesions, 3=>25% but <75% leaf area with susceptible lesions, 4= plants dead.

Blast Resistance Breeding

Breeding for blast-resistant Calrose has gathered renewed attention in the last few years in response to the breakdown of resistance in M-208. The Medium Grain Project increased efforts in breeding and incorporating new sources of blast resistance genes (*Pi* genes). The initial strategy was to incorporate several blast resistance genes using M-206 as the genetic background via marker-assisted backcrossing and employ a similar strategy using M-205, M-105, and other varieties and advanced lines.

In 2005, a backcrossing project was initiated by Mr. Jeff Oster to introgress different blast resistance genes into the M-206 background. Breeding lines were selected and advanced using DNA markers linked to these genes, and the end-result were 10 near-isogenic lines (NILs). Stable and uniform NILs derived from backcrossing were entered in preliminary yield test (PYT) at the station, including M-206 and M-208 as check varieties. The goal of the PYT was to examine if there are yield penalties and agronomic differences among the isolines and whether they are superior to M-206 and M-208.

In 2013, five near-isogenic lines of M-206 were entered in SW test. A similar number was again entered in 2014 SW test. Table 7 summarized the grain yield and agronomic characteristics of the isolines compared to M-206 and M-208 in the very early group of the SW test. Results showed that among the isolines, 12Y113 performed better than M-206 and M-208 at the RES location and the average of location in the very early group of the SW test. However, it had lower % head rice, and grains were smaller and lighter. This line is currently being evaluated by the milling and marketing organizations for its quality and acceptability. 12Y113 was placed under a notice of experimental increase in 2014 and will retain its status for 2015 for further purification and evaluation.

Stem Rot Resistance Breeding

The medium grain project is coordinating with Dr. C. Andaya and Mr. Oster in screening and genetic mapping population with stem rot resistance. Stem rot resistant lines that recovered the medium grain type from M-206 were isolated from the stem rot resistance mapping project and several of these lines were entered in replicated preliminary yield for yield evaluation. Table 8 summarized the performance of selected stem rot resistant lines compared to M-105, M-205, and M-206. One of the line, 14Y3060, had superior grain yield (10,990 lbs/acre) compared with the highest yielding check variety (M-205=10,750 lbs/acre). However, the line did not have the high level of resistance as 87Y550, had smaller grain size, and low head rice yield. This line is being used for crossing. These lines will be evaluated further and will be used in crossing work.

Mutation Breeding

The Medium Grain Project is continuously searching and evaluating traits that may add value to rice in California using mutation breeding. By generating mutant populations derived from M-202, M-205, M-206, M-401, and other varieties, the project is continuously looking for mutants that are short, early maturing, with noble traits, and perhaps with tolerance to certain herbicides. Generation of mutants and screening protocols in the laboratory is currently handled by Dr. C. Andaya.

Development of herbicide-resistant rice lines is a special project started by Dr. McKenzie for a number of years. He hired a research associate to screen for herbicide resistance or tolerance in the laboratory and greenhouse and under field conditions. This is a challenging project but the potential benefit to the California rice farmer is great if mutants are identified to tolerate registered herbicides in the market and get incorporated in major RES-developed rice varieties.

Table 7. Agronomic and grain characteristics of M-206 isolines containing individual blast resistance genes in the RES location of the very early Statewide Test RES very early SW.

ID	*Pi* Gene	SW Grain Yield†	RES Grain Yield	SV‡	Days§	Lodge (%)	Height (cm)	H/T¶	Length (mm)	Width (mm)	L/W Ratio	1000-grain Weight
12Y113	*Pi-z5*	9620	9750	4.8	82	1	94	60/70	5.80	2.68	2.16	20.9
12Y3097	*Pi-b*	9530	9190	4.7	80	1	91	61/70	5.87	2.65	2.21	20.9
13Y3213	*Pi-40*	8480	8350	4.7	79	6	97	61/69	5.80	2.64	2.20	21.3
13Y3215	*Pi-9*	8420	7330	4.8	82	21	97	55/67	5.60	2.61	2.15	18.6
13Y3216	*Pi-ta2*	8880	7650	4.9	80	11	89	63/70	5.92	2.68	2.20	20.9
M-206		9520	9200	4.8	79	1	94	67/72	5.88	2.64	2.23	21.1
M-208		8590	7780	4.8	82	1	99	62/70	5.96	2.62	2.27	21.3

† Paddy rice yield in lb/acre at 14% moisture
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent
§ Days to 50% heading
¶ Head Rice/Total Rice

Table 8. Performance of select stem rot resistant lines from the mapping population compared against three medium grain varieties.

ID	RES Grain Yield†	SV‡	Days§	Lodge (%)	Height (cm)	SR††	Length (mm)	Width (mm)	LW Ratio	1000-grain weight	H/T¶	MC (%)
14Y3060	10,990	82	4.8	13	98	4.9	5.67	2.46	2.30	19.7	61/69	18.4
14Y3061	10,020	79	4.9	0	94	4.5	5.72	2.54	2.25	20.5	60/70	18.0
M-105	9,910	75	4.9	43	96	5.7	5.78	2.58	2.25	19.9	67/71	19.8
M-205	10,750	88	4.8	3	95	5.5	5.92	2.57	2.30	21.1	68/71	15.8
M-206	10,160	79	4.8	38	98	5.3	5.77	2.56	2.25	21.4	67/72	17.1

† Paddy rice yield in lb/acre at 14% moisture
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent
§ Days to 50% heading
¶ Head Rice/Total Rice
††Stem rot score where 0=no damage, 10=all plants killed.

PREMIUM QUALITY AND SHORT GRAINS PROJECT

Stanley Omar PB. Samonte

Introduction

Premium Quality and Short Grains Project encompass the varietal improvement of the following types:

- Short grain, conventional (SG)
- Short grain, low amylose (SLA)
- Short grain, waxy (SWX)
- Short grain, premium quality (SPQ)
- Medium grain, premium quality (MPQ)
- Arborio or bold grain (BG).

All new lines are bred and selected for improved and stable grain yield and yield-related traits, milling and cooking quality, reduced delay in maturity and blanking due to cold temperature, lodging resistance, very early to early and uniform maturity, and resistance to diseases (stem rot, aggregate sheath spot, and blast). In addition, specific trait parameters are required to qualify a line into a specific grain type. Experimental lines in nurseries and yield tests are compared against check varieties, which include S-102 for SG types, Calamylow-201 (CA201) for SLAs, Calmochi-101 (CM101) for SWXs, Calhikari-202 (CH202) and Koshihikari for SPQs, M-402 and M-401 for MPQs, and 87Y235 for BGs. Selected lines show improvements over their respective checks.

In 2014, major nurseries and tests conducted included:

- Crossing Nursery (2013-2014 Winter and 2013 Summer)
- F_1 Nursery (2013-2014 and 2014-2015 Hawaii, 2014 Summer)
- F_2 Population Nursery (2014 Summer at RES and San Joaquin)
- F_3 to F_4 Nursery (2014 Summer)
- F_5 Nursery (2013-2014 and 2014-2015 Hawaii Winter, 2014 RES)
- 10 x 10 Yield Test (2014 RES)
- Preliminary Yield (PY) Test (2014 RES)
- Statewide (SW) Yield Tests (2014 at multi-locations)
- Cooking Strip Test (2014 Summer)
- Milling Yield Test (2014 Summer)
- Cold Tolerance Tests (2014 San Joaquin and 2014 Greenhouse)

Collaborations were conducted with pathologist Jeff Oster (to determine the reactions of rice lines that were entered into SW and PY tests to stem rot, aggregate sheath spot, and blast) and with Dr. Cynthia Andaya (to determine blast resistant F_3 and F_4 plants through marker-assisted selection).

This project report highlights the performance of SPQ variety CH202, SWX 09Y2141 (which is undergoing foundation seed increase), and elite lines MPQ 11Y2183 and SG 09Y2179 (which are undergoing experimental seed increase).

Short Grain Premium Quality Rice

Calhikari-202, which was released in 2012, has continued to show its advantages over Koshihikari and CH201 (released in 1999) in yield, agronomic traits, quality, and taste. In the SW Tests from 2010 to 2014, CH202 had higher grain yield than CH201 in 33 out of 53 test environments, for a 5-year average of 8555 lb/A, which was 4.7% higher than that of CH201 (8174 lb/acre) (Figure 3). When compared to Koshihikari in 2014, CH202 had higher yield (by about 66%), it had similar seedling vigor ratings, and shorter height by 27 cm (Table 9). Except for the similarity between Koshihikari and CH202 in their seedling vigor rating, CH202 out-performs Koshihikari in heading (19 days earlier), lodging (13% less), head rice percentage (1% higher at 67%), and Satake Taste Analyzer rating (71 for CH202 vs. 69 for Koshihikari). In SPQ grain types, lower head rice protein concentration is associated with better taste, and CH202 had lower protein concentration at 6.1%.

In 2014, there were 3 SPQ lines evaluated in the SW Tests. Among the 3, 11Y2230 and 12Y2178 had higher SW yields than CH202 by 8 and 9 %, respectively, but required more days to reach heading than CH202 by 7 and 10 days, respectively. However, 11Y2230 headed only one day later than CH-201. Grain quality and taste tests are currently being conducted on rice samples obtained from the 2014 crop.

Premium Quality Medium Grain Rice

MPQ 11Y2183 is currently at the forefront of the MPQ selections. It produced higher grain yields than M-402 in SW test locations of both the early maturing and intermediate to late maturing groups by 11 and 14%, respectively (Figure 4). 11Y2183 had slightly lower seedling vigor than M-401 and M-402, earlier heading than M-402 (by 9 days), and shorter height (by 10 cm), less lodging (by 21%), and less blanking than M-401 (by 4%) (Table 10). Its head rice is similar in length to M-401 and similar in width to M-402, and is less chalky than both M-402 and M-401. MPQ 11Y2183 was grown in the experimental seed increase nursery in 2014, and it will be maintained in that nursery in 2015.

In 2014, there were 8 MPQ lines evaluated in the SW Tests. Noteworthy was 12Y2175, which was entered in the early maturing preliminary group and had higher grain yields and earlier heading than both 11Y2183 and M-402.

Conventional Short Grain Rice

This project evaluated 5 SG lines in the 2014 SW Tests, with 09Y2179 and 10Y2043 evaluated in both the very early and the early maturing groups. Grain yield of 10Y2043 (averaged across 8 test location in 2014) was 9970 lb/A, which was 22% higher than S-102 and 11% higher than 09Y2179 (Table 11). Both 10Y2043 and 09Y2179 had similar maximum yields of about 10950 lb/A, obtained at the SW Tests at RES in 2014 and 2011, respectively. Although 09Y2179 was high yielding, it headed 14 days later than S-102, unlike 10Y2043, which headed 2 days later than S-102. This late heading makes it unattractive as a replacement to S-102. Because of this, 09Y2179 will be dropped from the 2015 SW Test. On the other hand, 10Y2043 will be maintained in the SW tests to evaluate the stability of its high yield. It will also continue to undergo purification in headrows, and it will be grown in an experimental seed increase nursery.

Waxy Short Grain Rice

SWX 09Y2141, which has been evaluated in the SW Tests from 2010 to 2014 and was grown in the foundation seed increase field in 2014, and approved for varietal release as **Calmochi-203** in 2015. It originated and was developed from a cross between female parent M7//D51/R57/3/M302/4/

CM101(87Y259)/5/CM101/6/NFD108 /7/ and male parent M102/CM101/3/ Akenohoshi//Calpearl/CM101 in spring of 2000. SWX 09Y2141 is a stable high yielding, semi-dwarf, early-maturing, glabrous, waxy, short grain line.

It had significantly higher grain yield than CM101 in all 38 Statewide Test environments from 2010 to 2014, and showed its adaptability high yielding environments where its yield trendline (with slope b = 1.42) was higher than those of L-206 and M-206 (Figure 5). Maximum yield attained by 09Y2141 was 12,020 lb/A at the Colusa SW test location in 2010. AMMI (additive main effects and multiplicative interaction) analysis indicated that 09Y2141 is adapted to same SW test locations as CM101, which were the very early and early maturing group entries were grown (Table 12). Averaged across the 38 SW test environments, grain yield was 9650 lb/acre for 09Y2141 and 7590 lb/acre for CM101, for a 27% yield advantage (Table 13).

Agronomic, disease reactions, grain quality, and DNA marker comparisons between 09Y2141 and CM101 are presented in Table 13. In the SW Tests from 2010 to 2014, 09Y2141 and CM101 had similar seedling vigor ratings of 4.9. 09Y2141 is a very early heading rice line as it headed at 85 days from planting, which was one day later than CM101. However, the estimated number of days from heading to maturity (20% moisture concentration) was 57 days for the glabrous 09Y2141 and 46 days for the pubescent CM101. In terms of maturity, 09Y2141 matured in 136 days from planting making it an early maturing line, compared to the very early 125 days to maturity for CM101. It is for this reason that 09Y2141 was recommended to be classified as an early maturing variety and be named in the 200-series variety, Calmochi-203.

Plant height of 09Y2141 averaged 102 cm compared to CM101's 97 cm (Table 13). The flag leaves of 09Y2141 were slightly longer and more erect than that of CM101, such that the flag leaves extended above the panicles. The erect flag leaves and its location above the panicles improve light interception by the leaves for photosynthesis and minimize shade by the panicles.

The amount of lodging was similar between 09Y2141 and CM101, averaging 41 and 40%, respectively (Table 13). In the Cold Tolerance Nursery at San Joaquin County, average panicle blanking of 09Y2141 (9.3%) was slightly higher than that of CM-101 (6.7%). CM101 is the standard for panicle blanking resistance to low temperature and is usually observed to have low blanking percentages among short grain varieties in cold environments.

Based on the Station's pathologist (Jeffrey Oster) evaluation of disease reactions of 09Y2141 and CM101, both had similar intermediate reactions to stem rot, aggregate sheath spot, and blast (Table 13).

In terms of grain quality, 09Y2141 had higher head rice percentage (65%) than CM101 (63%) (Table 13). Its head rice had larger grain size dimensions (length and width), heavier 1000-grain weights, and lower viscosity than CM-101.

DNA analyses, conducted by Dr. Cynthia Andaya at the DNA Laboratory in RES, determined that the banding patterns of SNP (single nucleotide polymorphism) markers WxIn1, WxEx6, and WxEx10 in the *Waxy* gene were the same at T, A, C, respectively, for 09Y2141 and CM101. With regards to the RM190 marker, which is associated with amylose content, the same banding patterns (no. of base pairs) were exhibited by 09Y2141 and CM-101. The same banking pattern was also observed for the gt-alk marker in 09Y2141 and CM-101, indicating a low gel temperature type.

Head rice samples sent to and analyzed by the Dale Bumpers National Rice Research Center (DBNRRC, Stuttgart, AR) indicated that both 09Y2141 and CM101 had 0% amylose classifying them as waxy rice, and had the same alkali spreading value of 6 classifying them into the low temperature gel type.

Comments from external evaluators in 2013 and 2014 ranged from 09Y2141 being softer than CM101, to it being acceptable and a potential replacement to the current variety.

Low Amylose Short Grain Rice

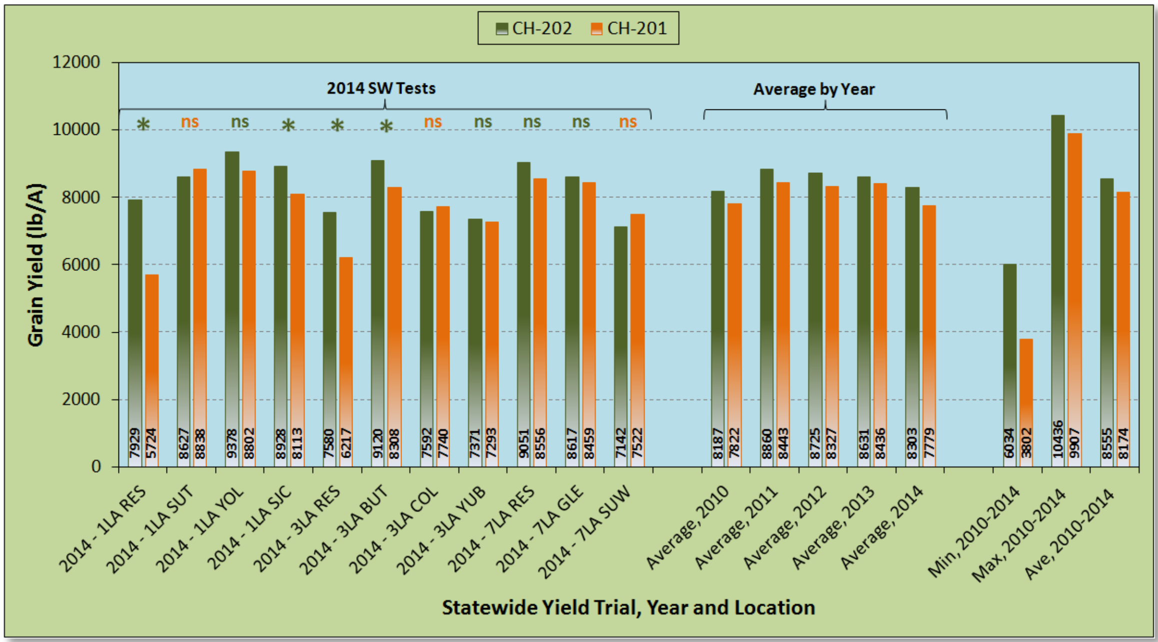
In 2014, there were no SLA entries in the SW tests. However, there were 4 SLA entries that performed well in the PY Tests. In the early maturing group of entries in the PY Test, SLA lines 14Y2110 and 10Y2119 yielded 10230 and 9260 lb/A, respectively, compared to 6710 lb/A for check variety CA201. In the intermediate maturing group, SLA lines 14Y2175 and 14Y2174 yielded 10,760 and 10,120 lb/A, respectively, compared to 7110 lb/A for CA201. Compared to the pubescent CA201, both 10Y2119 and 14Y2174 were glabrous. Grain quality analyses will be conducted and considered alongside yield and agronomic performance data to determine their advancement into the Statewide Tests in 2015.

Arborio or Bold Grain Rice

RES has not yet released a bold grain variety, although it has released 87Y235 as a germplasm in 1994. The development of new BG lines is a first step to promote interest in this type of rice. The improvement of the plant type of our BG lines is of particular interest.

The most advanced BG lines in the Project were evaluated in the Preliminary Yield Tests, and 3 lines showed yield advantages of about 15% over check line 89Y235. Grain quality analyses will be conducted and considered alongside yield and agronomic performance data to determine their advancement into the Statewide Tests in 2015.

Figure 3. Grain yield of short grain premium quality varieties Calhikari-202 and Calhikari-201 in SW Tests from 2010 to 2014.



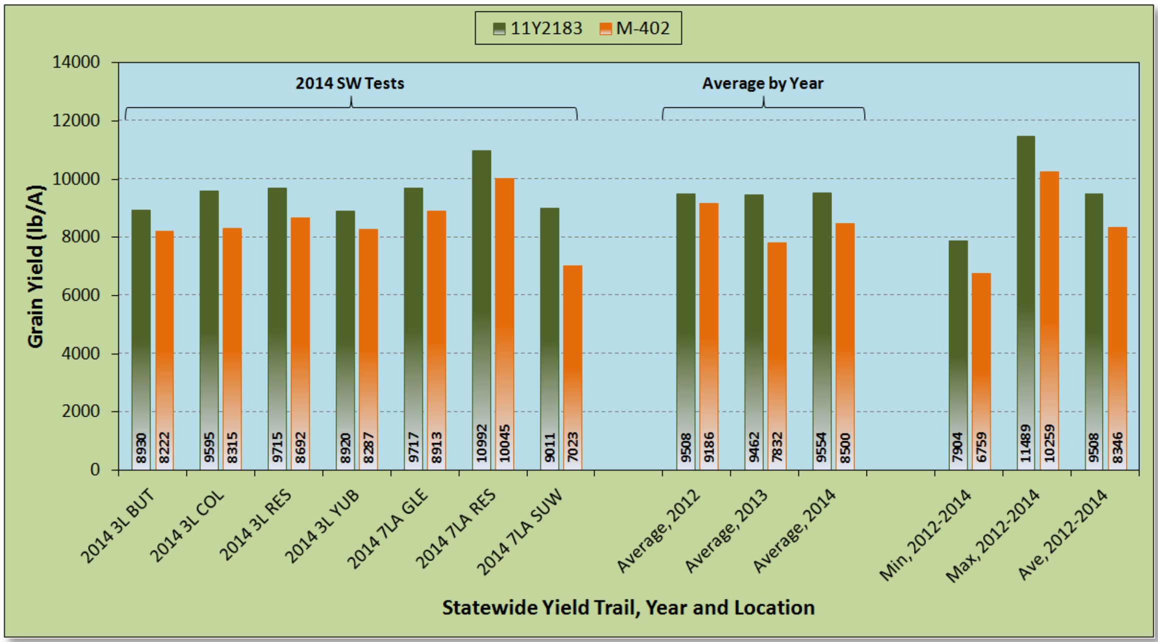
* Significant difference at the 5% level.
ns Non-significant difference at the 5% level.

Table 9. Agronomic, head rice percentage and Satake taste ratings of SPQ varieties.

Trait	Trait Parameter Average		
	CH-202	Koshihikari	CH-201
SV (1-5 Rating) †	4.8	4.8	5
Heading (d) †	81	100	85
Height (cm) †	90	117	93
Lodging (%) †	77	90	68
Head Rice (%) ‡	67	66	62
Protein (%) ‡	6.1	6.5	6.8
Satake Taste Rating ‡	71	69	61

† Source: 2012 to 2014 Statewide Tests
‡ Source: 2013 to 2014 Milling Tests

Figure 4. Grain yield of 11Y2183 and M-402 in the intermediate maturity group across 17 SW locations from 2012 to 2014†.



†3L=Early maturing group and 7LA=intermediate to late maturing advanced group of the SW Test.

Table 10. Agronomic and grain quality trait parameters of 11Y2183, M-402, and M-401 in 2014 and averaged from 2012 to 2014.

Trait	Year	11Y2183	M-402	M-401
Seedling Vigor,	2014	4.8	5.0	5.0
(1-5, 5 Best)	2012-2014, Avg.	4.9	5.0	5.0
Heading	2014	92	103	107
(d)	2012-2014, Avg.	93	102	107
Height	2014	101	99	114
(cm)	2012-2014, Avg.	101	99	111
Lodging	2014	23 ‡	17 ‡	46
(%) †	2012-2014, Avg.	16	9	37
Blanking at San Joaquin	2014	8	6	15
(%)	2012-2014, Avg.	8	5	12
Head Rice	2014	65	67	54
(%)	2012-2014, Avg.	64	67	57
Head Rice Length	2014	6.01	5.69	5.76
(mm)	2012-2014, Avg.	5.96	5.71	5.94
Head Rice Width	2014	2.54	2.49	2.61
(mm)	2012-2014, Avg.	2.49	2.5	2.62
Head Rice Chalky Area	2014	6	6	8
(%)	2012-2014, Avg.	11.3	13	15.3
Head Rice Vitreous	2014	113	112	112
	2012-2014, Avg.	120	119	119

† Source: SW 7L

‡ Source: SW 3L and 7L

Table 11. Trait parameters of short grain 09Y2179, 10Y2043, and S-102 in 2014.

Trait	Average			Source †
	09Y2179	10Y2043	S-102	
Agronomics				
Grain Yield (lb/A)‡	8990	9970	8160	1
Seedling Vigor (1-5)	5.0	4.9	5.0	1
Heading (d)	92	80	78	1
Height (cm)	102	94	97	1
Lodging (%) †	1	78	53	1
Blanking at San Joaquin (%)§	6	6	5	2
Grain Quality¶				
Head Rice (%)	60	61	66	3
Chalky Area (%)	12.0	12.3	11.9	3
Vitreousness (higher = more translucent)	111	113	121	3
Length, Whole Rice (mm)	5.09	5.09	5.46	3
Width, Whole Rice (mm)	2.93	2.85	2.93	3
L/W Ratio, Whole Rice	1.73	1.79	1.87	3
1000-Grain weight(g)				
Disease Reactions††				
Stem Rot (0-10; 0 is Resistant)	4.9	4.6	5.1	4
Sheath Spot (0-4; 0 is Resistant)	0.7	2.4	2.5	4
Blast (0-4; 0 is Resistant)	2.3	1.5	2.1	4

† Average within referenced test or nursery
‡2014 Statewide Tests (Very Early and Early Maturity Group)
§2014 Joaquin Cold Nurseries
¶ 2014 Milling Tests
††2014 Disease Rating Nurseries

Figure 5. Grain yield of 09Y2141 and CM101 in 38 Statewide Tests from 2010 to 2014.

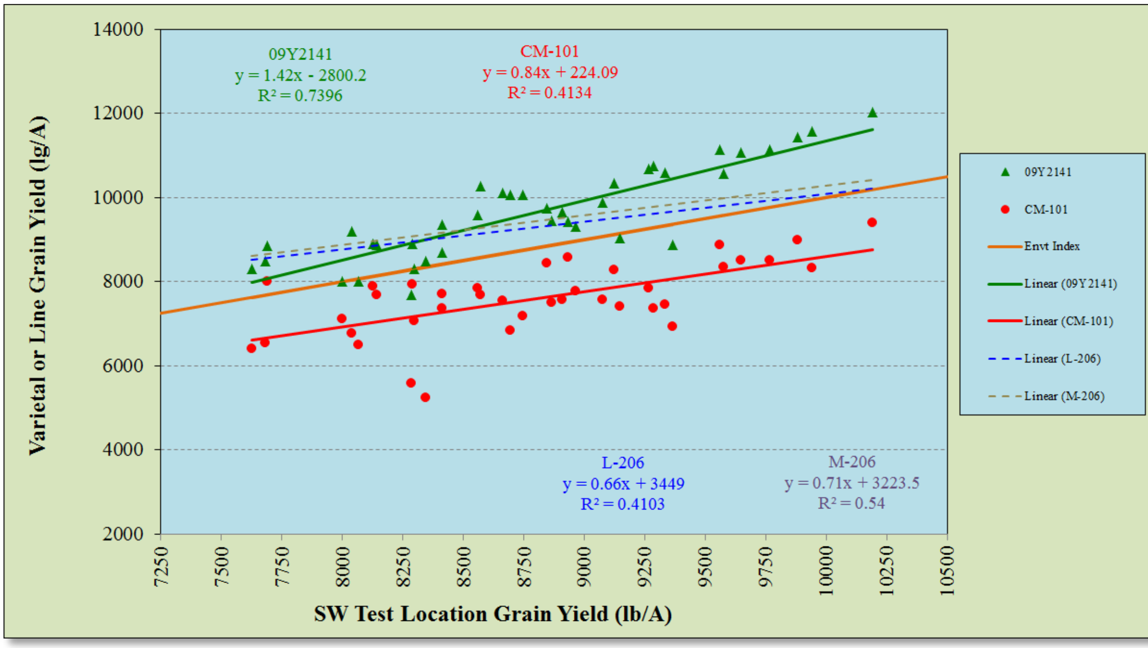


Table 12. Grain yield of 09Y2141 and CM101 at SW locations, averaged across 2010 to 2014.

SW Test Location (No. of SW Tests, SW Expt.)	Grain Yield, Averaged across 2010-2014 (lb/acre)	
	09Y2141	CM101
Yolo (5, 1L)	10681	7796
Yuba (5, 3L)	9917	7801
Butte (5, 3L)	9856	7349
RES (9, 1-7L)	9606	7819
Sutter (4, 1L)	9588	7756
Colusa (5, 3L)	9415	7503
San Joaquin (4, 1L)	9267	7964
Sutter west (1, 7L)	8482	5232
Glenn (1, 7L)	7681	5585

Abbreviations: 1L, 3L, and 7L, are the very early, early, and intermediate to late maturing groups of entries, respectively.

Table 13. Trait parameters of 09Y2141 and CM101 from 2010 to 2014.

Trait	09Y2141	CM101	Source
Agronomics			
Grain Yield (lb/acre)	9650	7590	2010-2014 SW Tests
Seedling Vigor (1-5)	4.9	4.9	2010-2014 SW Tests
Days from Planting to Heading	85	84	2010-2014 SW Tests
Days from Heading to Maturity (20% MC)	57	46	2012-2014 Milling Tests
Days from Planting to Maturity (20% MC)	136	125	2012-2014 Milling Tests
Plant Height (cm)	102	97	2010-2014 SW Tests
Lodging (%)	41	40	2010-2014 SW Tests
Blanking at San Joaquin (%)	9.3	6.7	2010-2014 SW Tests
Disease Reactions			
Stem Rot (0-10; 0 is Resistant)	5.3	5.2	2010-2014 Disease Rating
Aggregate Sheath Spot (0-4; 0 is Resistant)	2.8	2.5	2011-2014 Disease Rating
Blast (0-4; 0 is Resistant)	2.9	2.7	2013-2014 Disease Rating
Grain Quality			
Head Rice (%)	65	63	2012-2014 Milling Tests
Grain Length (mm)	5.2	5.05	2012-2014 Milling Tests
Grain Width (mm)	2.94	2.75	2012-2014 Milling Tests
L/W Ratio	1.77	1.83	2012-2014 Milling Tests
1000-Grain Head Rice Weight (g)	22.8	19.9	2013-2014 Milling Tests
Peak Viscosity (RVA Units)	127	128	2012-2014 RVA Tests
Trough Viscosity (RVA Units)	40	48	2012-2014 RVA Tests
Final Viscosity (RVA Units)	53	62	2012-2014 RVA Tests
Amylose (%)	0	0	2012-2013 DBNRRC
Alkali Spreading Value (1-7 Rating)	6	6	2012-2013 DBNRRC
DNA Markers			
WxIn1 (base)	T	T	2013 DNA Tests
WxEx6 (base)	A	A	2013 DNA Tests
WxEx10 (base)	C	C	2013 DNA Tests
RM190 (No. of base pairs)	124	124	2013 DNA Tests
gt-alk (No. of base pairs)	92	92	2013 DNA Tests

LONG GRAINS

Farman Jodari

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

Conventional Long Grain

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

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

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

Grain yield of L-206 in 2014 multi-location, early and intermediate maturity groups, Statewide Yield Tests averaged 9170 lb/acre (Tables 23, 25, and 27). Average yield for M-205 within the same tests was 9370 lb/acre. Yields of L-206 at colder locations of Yolo and San Joaquin have not been as competitive as medium grain varieties. Based on the results from multiple locations and multiple years, L-206 has shown good yield stability and is adapted to most of the rice growing regions of California except the coldest locations of Yolo and San Joaquin Counties. Average head rice yield of L-206 during 2006–201 seasons was 62%. Average kernel length of L-206 is 7.1 mm.

The long-grain project is currently placing high selection pressure to recombine various quality and agronomic traits, including milling, and cooking qualities, market acceptance, and grain yield. Agronomic and milling characteristics of selected conventional lines with improved quality traits are listed in Table 14. Entries 12Y020 and 11Y1005 performed well in 2014 statewide tests as compared to standard varieties. Of special importance is the performance of both these selections at Yolo test location, both in 2012 and 2013, where they compared favorably with L-206 and M-206. Cooler conditions at Yolo site have been a challenge for many long-grain selections and varieties in the past. Both entries 12Y20 and 11Y1005 are 3 days later than L-206 and about 5" taller. Milling yields of these lines in 2012 to 2014 averaged 3 percent higher than L-206. Overall kernel size and weight of 11Y1005 is the same as L-206, however, grain length of 11Y1005 is 0.3 mm shorter. Kernels of 12Y20 is slightly larger than L-206. Quality evaluations indicate both entries have typical Southern long grain amylose and gelatinization temperature type. RVA amylographic profile of both lines is moderate, similar to L-206. A foundation field production of one of the two experimental lines is planned for 2015.

Table 14 . Performance of selected conventional long-grain entries as compared with standard varieties in 2014 yield and milling tests.

Entry	Type†	Identity	Yield‡		Head Rice§
			Statewide	RES	(%)
Very Early Statewide					
16	L	11Y1005	9570	9560	64
50	L	13Y1073	9970	9850	63
14	L	L-206	8860	8580	62
11	M	M-206	9520	9200	
Early Statewide					
76	L	11Y1005	9630	9280	64
74	L	13Y1073	9890	10330	63
73	L	L-206	9250	8640	62
70	M	M206	9270	9240	
Intermediate Statewide					
131	L	11Y1005	9590	10990	64
157	L	12Y1176	9690	10460	63
130	L	L-206	9620	10340	61
127	M	M-206	9370	10570	
Very Early Preliminary					
1002	L	12Y20	--	11000	66
1056	L	14Y1056	--	11690	65
1001	L	L-206	--	9390	61
Early Preliminary					
1161	L	14Y1161	--	10590	64
1081	L	L-206	--	9160	62
Intermediate Preliminary					
1198	L	14Y1198	--	10860	65
1162	L	L-206	--	10060	65

†L= conventional long grain type, and M=medium grain.
‡ Paddy rice yield in lb/acre at 14% moisture.
§Head rice yields are from solid seeded stands for statewide and preliminary yield tests.

Specialty Long Grains

Expanded breeding efforts in specialty long grain area continued in 2014. Specialty types occupy 50% of the long grain nursery and include Jasmine, Basmati, and conventional aromatics such as A-201. Agronomic and quality of selected specialty lines are shown in Table 15.

Calmati-202 is a true basmati variety released in 2006. It is an early maturing, semi-dwarf, pubescent, aromatic, elongating long grain. Susceptibility to cold induced blanking is significantly higher than standard varieties and therefore is not adapted to cold locations. Average yield of Calmati-202 in 2014 early tests were 6280 lb/acre as compared to 9250 for L-206 (Tables 25 and 26).

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

Milled rice kernels of Calmati-202 are longer than Calmati-201 and slightly shorter than imported basmati rice available in the US market. Grain width is more slender than Calmati-201, but not as slender as imported basmati rice. Cooked kernel length of Calmati-202 is also slightly longer than Calmati-201. The overall appearance of cooked basmati type rice is an important quality feature among basmati rice consumers. Cohesiveness of the cooked grains as well as grain shape and texture of Calmati-202 are distinguishable improvements over Calmati-201. Cooked rice of Calmati-202 that was aged nearly one year was preferred by taste panelists over Calmati-201. Grain fissuring studies have shown that both Calmati-201 and Calmati-202 are susceptible to fissuring at low harvest moistures (data not shown). Timely harvest and proper handling is recommended to preserve milling as well as cooking qualities of this variety. Due to slender grain shape and pubescent hull and leaf, drying rate of the grain at harvest is significantly faster than standard varieties. Recommended harvest moisture is 19 percent.

Two improved experimental basmati lines, 12Y1054, and 14Y149 were tested in the 2014 Statewide Yield Tests (Table 15). Cooking quality evaluations of these lines in earlier generations has shown considerable quality advantages over Calmati-202. 12Y1054 is a very early maturing, true basmati type, pubescent experimental line. 14Y149 is an early basmati line with a significantly closer amylographic profile to imported basmati types. Quality evaluations are currently underway to determine aging effects on elongation and texture of cooked grains of basmati types. This includes two advanced selections 11Y158 and 10Y1199 that were tested previously (RES annual reports 2012 and 2013). Primary advantages of these lines over Calmati-202 variety include higher cooked kernel elongation, more slender grain shape, and a closer cooked grain texture to imported basmati as shown by RVA profile. A stronger RVA profile is expected to improve cooked grain texture resulting in more flakey cooked rice as is the case with imported basmati. Average grain yields in 2014 statewide tests for CT202, 12Y1054, and 14Y149 were 6280, 6040, and 5680 lbs/acre respectively. Small experiments have been planned for 2015 to identify harvesting and processing procedures that can enhance milling yield and cooking quality. These factors include harvest moisture, drying rate, and milling degree. Efforts are underway to continue to improve both grain and milling yields without losing any basmati quality attribute (Table 15).

Efforts also continued in 2014 to develop jasmine types through pedigree and mutation breeding. Crosses and backcrosses were made with jasmine type material from various sources including Southern U.S. breeding programs and foreign introductions. The extreme photoperiod sensitivity of the original Thai Jasmine variety, Kao-Dak-Mali 105 (KDM), has been a significant breeding barrier. Pedigree and mutation breeding efforts are generating breeding lines with diverse and unique quality combinations. Primary objective is to incorporate imported jasmine quality into adapted breeding lines.

In 2014, 9 jasmine type selections were tested in the UCCE Statewide Yield Tests and 37 in preliminary yield tests. Breeding objectives for jasmine type quality include low amylose, strong aroma, a high degree of whiteness, and a smooth cooked grain texture. Two jasmine type entries 11Y106 and 12Y133 have shown good jasmine quality attributes and acceptable agronomic characteristics (Table 15). A foundation seed increase of 11Y106 is planned for 2015.

Efforts in the area of conventional aromatics also continued in 2014. Two conventional aromatic types were tested in 2014 statewide tests. A considerable number of aromatic types are being generated from the populations that were originally intended for jasmine or basmati quality types.

A-202

A-202 is a conventional aromatic variety that was released in January 2014. It is intended as a replacement for A-301. Compared to A-301, A-202 is 9 days earlier, 4” taller, and has a significantly higher seedling vigor score. Grain yields in 2012 and 2013 early statewide tests was 1800 lb/acre higher than A-301 (Table 16). In 2014 it was tested in all locations of statewide tests (Table 17). Average yield overall locations was 9120 for A-202 and 9270 for L-206. Due to a planting error in 2014 statewide test, A-301 yields could not be compared with A-202. Three year average head rice yield of A-202 is %61. A-202, similar to A-301 is susceptible to cold induced blanking and therefore not recommended for cold locations. Aroma volatilization of A-202 is slightly less during cooking process. Flavor sensory, however is similar to A-301. Milled kernels of A-202 is slightly bolder than A-301(Table 18), with average length of 7.36 and average with of 2.27mm. Amylose content, gelatinization temperature type and RVA profile of is typical conventional long-grain type similar to A-301 and L-206. Subjective evaluations of cooked grain texture indicate that A-202 is slightly softer than standard variety, L-206. Areas of adaptation for A-202 include Butte, Colusa, Yuba, Glenn, and Sutter counties.

Milling Quality

Continued improvement in milling yield and milling stability of new long grain varieties to the level of medium grains remains a major objective. Grain characteristics are being evaluated and selected that will lend milling yield stability to long-grain lines under adverse weather conditions and allow a wider harvest window. These may include hull cover protection, grain formation, or physicochemical properties of the grain that result in fissuring resistance. In 2014, all selections in preliminary and advanced yield tests were evaluated in special small or large solid seeded plots to obtain more accurate milling yield evaluation. Advanced lines were evaluated at 6 to 8 different harvest moistures and preliminary entries were tested at two harvest moistures. The goal for long grain is to maintain a minimum of 64% head rice yield in all advancing breeding lines.

Disease Resistance

SR resistance originating from *Oryza rufipogon* continues to be incorporated into an increasing number of high yielding long-grain lines. Despite a close linkage in the SR resistance trait with increased chalkiness and cold susceptibility, selections are being obtained that have broken such a linkage and have combined low SR score, low blanking, and high milling yield. In 2014, 1 entry was tested in statewide tests and 18 in preliminary yield tests with a range of SR resistance. Entry 13Y1037 is a stem rot resistant line that compared favorably with L-206 grain and milling yield in 2014 (Table 24).

Table 15. Performance of selected jasmine and basmati type long-grain entries in 2014 Statewide Yield and RES milling tests.

Entry	Type	SV	DH	Ht	Yield†							HR‡
					Early				Intermediate			
					RES	Butte	Colusa	Yuba	RES	Glenn	Avg.	
L-206	L	4.7	77	84	8640	9730	9380	9260	10340	8870	9370	62
11Y106	J	4.6	89	107	8980	8500	7860	6400	9720	8420	8310	55
12Y133	J	4.7	94	86	8240	7990	8260	6320			7700	63
CT202	B	4.9	84	84	6310	7210	6150	5460			6280	57
12Y1054	B	4.9	68	84	6710	6750	5520	5160			6040	50
14Y149	B	4.9	89	91					6200	5160	5680	47

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

Table 16. Yield performance in statewide tests, agronomic, and milling characteristics of aromatic variety A-202 as compared with A-201, A-301, and L-206, from 2012 to 2014.

Year	ID	SR†	VIG‡	D§	HT¶	RES	Butte	Yield†† Colusa	Yuba	Over Locations	HR
2012	A301	5.0	3.6	93	33	8637	8200	6580	5700	7280	53
	A201	5.3	5	89	34	8478	8230	8140	7240	8020	53
	A202	3.7	4.8	85	37	9991	9040	9260	8210	9130	60
2013	A301	5.8	3.6	94	32	7290	8210	7100	6630	7310	53
	A201	6.2	5	89	35	7020	7510	8610	7270	7600	58
	A202	6.0	4.6	84	38	8150	9140	10160	8780	9060	60
2014	L206	4.6	4.7	78	33	8640	9730	9380	9260	9250	62
	A202	4.2	4.8	82	40	9810	8660	9180	9020	9170	63

†SR = stem rot score, where 0 = no damage and 10 = plant killed.
‡VIG = seedling vigor score, where 1=poor and 5=excellent.
§D = Days to 50% heading.
¶ HT = plant height at maturity
††Paddy rice yield in lb/acre at 14% moisture.

Table 17. Yield performance† of A-202 in very early and intermediate/late groups of statewide tests, as compared with L-206, in 2014.

ID	RES-VE	Sutter, Lauppe	Yolo	San Joaquin	RES-I/L	Glenn	Over Locations
L206	8580	9730	9440	8760	10340	8870	9290
A202	8670	8660	9600	8580	10210	8760	9080

† Paddy rice yield in lb/acre at 14% moisture.

Table 18. Grain quality characteristics of aromatic variety A-202 as compared with A-301 and A-201 from 2013.

ID	Aroma content		Dimension			Cook type		RVA			
	2AP† ppb	Area, mm^2	Length mm	Width mm	100wt g	Amylose	Gel type	Peak	Hold	Final	Set back
A301	1221	12.8	7.39	2.17	2.15	23.1	Int.	299	178	312	13
A201	844	12.3	7.40	2.07	1.95	24.8	Int.	225	140	286	61
A202	1051	13.2	7.36	2.27	2.26	23.8	Int.	277	159	292	16
L206	65	12.4	7.20	2.16	1.8	23.7	Int.	280	162	308	28

†2AP analysis was made by UC Davis Department of Viticulture and Enology. Grain dimension measurements of milled rice was made by 'Winseedle' scanning system at RES. Cook type and RVA determination was made at USDA rice quality lab, Stuttgart, AR.

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 3013 rows) for stem rot (SR) resistance in the field and sheath spot and blast in the greenhouse. Since 2005, the immediate backcross program involved screening entries for blast (BL), SR and aggregate sheath spot (SS). Advancing generations from those crosses have been screened for both SR and SS resistance (408 rows plus greenhouse SS screening). Surviving materials have been be stored for future reference. In addition, early generation materials derived from breeder's crosses are cycled through the disease nursery to identify and verify disease resistant lines (about 2724 rows). Intense selection pressure is applied for important agronomic traits because sources of disease resistance have a number of undesirable characteristics. The sources of SR resistance also confer aggregate and bordered sheath spot (SS) resistance. Conversely, the sources of SS resistance also seem to confer SR resistance in some materials.

Stem Rot

Screening for SR resistance in inoculated nurseries and greenhouses usually begins in F_3 for materials provided by the breeders. Resistant germplasm often has low seedling vigor, low tillering, susceptibility to blanking, and late maturity. Only a small percentage of the lines screened show higher levels of SR resistance than current varieties. There were about 6131 rows in the 2014 SR nursery.

This year, 2814 rows in the stem rot nursery were drill seeded. This resulted in less seed drift, establishment of a more uniform stand, and allowed use of higher nitrogen without inducing lodging. Increased nitrogen results in greater disease severity and better screening. However, aerial application was neither uniform nor at the desired rate. This resulted in poor screening results.

Promising long and short grain resistant lines have emerged. In 2013, some high yielding medium grain lines were identified, but resistance was not confirmed in some of them in 2014.

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

In addition, 1054 BC_3F_5 rows of a population established for fine mapping of SR resistance genes from *Oryza rufipogon* (originally identified in a BC_1 mapping population) were evaluated for SR resistance in the field at two sites at the RES. Some materials identified as resistant in 2013 in plots were again resistant in plots and rows, but many others were inconsistent. One reason was lack of nursery uniformity. Fine mapping populations should not be planted in tiers running the length of the field, but rather blocked in groups with tiers perpendicular to the length of the field. In addition, the first 50 feet of the field adjacent to the water inlet should be avoided. Mapping populations should be solid seeded as well as row seeded in the future. Once SR resistance genes are mapped the need for space-consuming solid seeding should be reduced.

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

Aggregate Sheath Spot

An immediate backcross program was started in 2005 to transfer aggregate sheath spot (SS) resistance genes from Teqing, Jasmine 85, and MCR10277 to M-206 and L-206. Existing segregating populations from various backcrosses have been advanced in the greenhouse, where sheath spot screening is conducted. In addition, these same materials were grown in the SR field nursery. Some lines (derived from all three donor parents) again also showed SR resistance equivalent to that found in the wild species. These materials have been put in cold storage for future reference.

Sheath spot screening in the greenhouse of advanced lines was expanded from just the statewide entries to include preliminary trial entries.

Blast

Rice blast disease in California was identified for the first time in 1996 in Glenn and Colusa Counties. It spread over significantly more acres in 1997, and has reached Sutter (1998), Butte (1999), and Yuba (2000) counties. In 1998 to 2009, blast severity was much lower than in previous years. A few affected fields continue to be found, mostly on the west side of the valley. Severity and extent of affected acres in 2010 was higher than most previous years and even greater in 2011. Significant blast was also present in RES fields for the first time in 2011. Blast was lower in severity and incidence in 2012-4. M-104 appears to be more susceptible than other varieties, followed by M-205.

Seedlings of all statewide entries were screened against a mixture of IG1 and IB1 races this year in the greenhouse. This test should confirm presence of major genes in candidate varieties and perhaps provide some information on relative susceptibility of lines without major genes (almost all are highly susceptible). However, a seedling test will not necessarily predict adult plant disease resistance.

Historically, major resistance genes limit blast symptom expression to small brown flecks at most, but different races of the blast fungus can overcome this resistance within several years after variety release. The first blast resistant variety (M-207, possessing the *Piz* gene) was released in 2005, followed by M-208 (also with *Piz*) in 2006. Symptoms were noted on M-206 at low frequency in 2009.

IRRI reported development of monogenic lines each containing one major gene for blast resistance. These lines were brought through quarantine and tested to verify their blast resistance to the IG1 race present in California. A backcross program was started in 2005 to introduce these genes into M-206. Only genes with a wide spectrum of blast resistance in worldwide tests were chosen (*Pib*, Pik^h, Pik^m, Piz^5, *Pi9*, *Pi40*, and $Pita^2$). Seven backcrosses were made and screened for blast resistance. Theoretically, 99.6% of genes in this material are from M-206. In 2009, homozygous resistant lines were selected from the F_2 aided by molecular markers. Selections were made from these lines and brown rice has been evaluated for seed traits by the medium grain breeder. Four lines (*Pi40*, *Piz*^{5}, *Pikh*, *Pib* genes) were entered in the early statewide trial in 2012-4, and they yielded more than M208, and even as much as M206.

Blast infection was found in M-208 fields in 2009-13. DNA tests confirmed that infected plants were M-208 and DNA markers indicated the *Piz* resistance gene was present. UC Riverside researchers found that DNA patterns of all fungi isolated from M-208 are similar to each other (genetically closely related, or of the same lineage) and to the IG1 race found in 1996.

A new race has been found which is significantly different pathologically from IG1. So, even though all isolates appear to be genetically related, the M-208 isolates can infect rice with *Piz* and *Pik* resistance genes, while IG1 isolates cannot. This virulence pattern is representative of race IB1.

Lines with different blast resistance genes from the M-206 backcross program (below) were screened against the M-208 isolates. Again, lines with and *Piz* and sometimes *Pik* genes were susceptible. However, lines with other genes were resistant.

The components of M-208 were also tested individually. They are still resistant to IG1, but not IB1. It is too early to judge whether *Piz* resistance has been overcome in an epidemiological sense, since frequency of infection in M-208 fields was about 1 in 5,000 to 10000 plants in 2010-13. The new race may be able to attack scattered M-208 plants (it is virulent), but we do not know if it will severely damage M-208 in the future (will it be reproductively fit?). In California, it may be difficult to determine whether the blast fungus has epidemiologically overcome *Piz* resistance in subsequent years if environmental conditions are not always as favorable to disease as in 2010-11.

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

Marker	Gene
RM224	*Pi1*, *Pik*^{h}
RM1233	*Pik*^{m}
AP5930F	*Pi2, Piz, Piz*^{5}, *Pi9, Pi40*
RM7102	*Pita*^{2}
RM208	*Pib*

Pi40, *Pik*^{h}, and *Pita*^{2} genes from the above program have been pyramided into 3 gene lines, and are being advanced for agronomic evaluation. These genes were chosen for their broad spectrum and complementary resistance to blast races. Presence of several genes in a variety should prevent rapid loss of resistance when exposed to natural blast fungus populations.

Over five hundred blast single spore IB1 isolates taken from M-208 as well as typical IG1 isolates have been screened first on the old international differential set of varieties and selected isolates then screened on the new IRRI monogenic and NIL lines (which represent a wider variety of blast resistance genes). Monogenic lines have only one blast resistance gene, but may have different genetic backgrounds. NIL (near isogenic lines) have one gene per line and have nearly the same genetic background. NILs are preferable, since they differ from each other only for the blast resistance gene. The following table demonstrates how an IG1 and IB1 race differ from each other on the old differential set (R=resistant, S=susceptible).

				Old Internat. Diff. Set							
	M205	M206	M208	Newbonnet	NP125	Usen	Dular	Kanto 51	Cal-oro	Mars	Katy
Resistance genes											
Race			Piz	Pikh	Pik?	Pia, ?	Pik, Pika?, ?	Pik, Pish	Piks	Piz, Piks	Pita2, Piks, ?
IG-1	S	S	R	R	R	S	R	R	S	R	R
IB-1	S	S	S	S	S	S	S	S	S	S	R

This screening also evaluated all gene sources for resistance to IG1 and IB1 isolates. The genes showing widest spectrum of resistance to all isolates are (in descending order): (Pi40, Pita2, Pib, Pizt, Pi33 (CIAT), Piz5CAR)>(Piz5CA, Pi20, Pi9).

Combining Disease Resistance

A first attempt at combining blast, SR and SS resistance is in progress. It involved a cross of a 4 gene blast pyramid line with a SR resistant line. This attempt involves rapid generation advance with disease screening in the greenhouse. Specifically, F_2 populations were screened against blast in March, 2014. The F_3 was screened against SR in June, and the F_4 against blast in November. The F_5 will be screened against SR in the field in 2015. A portion of the seed will be used in SS screening in the greenhouse. Selecting for SR resistance in materials derived from wild species tends to enrich for SS resistance as well. It is hoped that agronomically acceptable lines with resistance to all three diseases can be identified in this way.

Quarantine Introductions

The building blocks for any breeding program are varieties with traits desirable in commercial production. From time to time, varieties are imported for use in the breeding program.

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

DNA MARKER LABORATORY

Cynthia B. Andaya

Overview

The DNA Marker Lab performs activities in support of the different breeding projects and spearheads the implementation of special projects. The lab is involved in the following activities: marker-aided selection (MAS) for the for the short, medium and long grain breeding projects; fingerprinting and purity testing of advanced lines and RES-released rice varieties; gene introgression and pyramiding of blast resistance genes; genetic mapping of stem rot resistance gene(s); herbicide resistance screening; and generation of mutant populations using both irradiation and chemical mutagenesis.

The herbicide resistance project is now a separately funded endeavor under the supervision of Dr. Kent McKenzie. The lab is supporting the project by generating rice mutant populations using chemical mutagenic agent and validating the identity of the putative mutants using DNA markers.

The main goal of the DNA marker laboratory is to assist the breeders in their selection work by using DNA marker technologies. The use of molecular markers reduces the number of breeding lines that the breeders will advance and grow in the field through initial MAS, thereby reducing costs and increasing breeding efficiency.

In 2014, the bulk of work in the DNA Lab came from MAS for the different grain types, fingerprinting materials, and fine mapping of the stem rot resistance region. Materials generated from blast resistance gene pyramiding and mutagenesis work were transferred to our plant breeders.

Marker-Aided Selection

MAS for both blast resistance and grain quality is now a routine work at the RES DNA Lab. The laboratory is capable of screening multiple blast resistance genes in a single PCR reaction through multiplexing. The lab is using five microsatellite or simple sequence repeat (SSR) markers namely: RM108, AP5930A, RM224, RM331 and RM7102, to screen for the presence of absence of specific blast resistance genes (Table 19). In 2014, a total of 5,400 breeding lines were screened from the medium and short grain projects for blast resistance using different blast resistance markers (Table 20). In the medium grain project, a total of 4770 plants were screened for blast resistance using MAS, generating 23,850 data points. Likewise, a total of 630 plants were evaluated in the SG project, generating 2520 data points.

Around 1,800 long grain breeding lines were evaluated using five DNA markers for grain quality in the first quarter of 2014. Using the grain quality markers: gt-alk, RM190, and Waxy SNPs Intron1, Exon6, and Exon10, about 9000 data points were generated. The genotype scores for these markers give the long grain rice breeder a predicted quality scores for amylose type, gel temperature, and viscosity. Though the marker data is not the breeders' ultimate selection criteria, it can assist them in discarding materials that does not conform their set standard.

Table 19. List of DNA markers used in MAS for blast resistance.

DNA Marker	Blast Resistance Genes
RM7102	*Pi-ta, Pi-ta2*
RM331	*Pi-33*
RM224	*Pi-1, Pi-kh, Pi-km*
AP5930A	*Pi-z2, Pi-z5, Pi-9, Pi-40*
RM108	*Pi-b*

Table 20. Number of lines evaluated using MAS for blast resistance in the breeding projects.

Project	Number of Lines	Number of Data Points
Medium Grain	4770	23,850
Short Grain	630	2520
Total	5400	26,370

DNA Fingerprinting

An important component of the DNA lab is to provide assistance in variety identity and purity assessment. In 2010, the lab started building a database of marker size information for SSR markers and performed DNA fingerprinting of all rice varieties released at RES as well as other rice variety introductions. As of 2014, marker information for 220 markers run against 50 rice varieties is available. The lab will continue to add DNA markers to the database since the success of DNA fingerprinting activities depends largely on markers that can distinguish one variety from another.

The lab has developed a panel of composed of 11 DNA markers that can distinguish a medium grain variety from another. These markers were labeled using fluorescent dyes to facilitate multiplexing and faster data analysis. A similar panel to fingerprint long grain and short grain varieties is under development.

Fingerprinting requests vary from year to year depending on the need of the breeding program. In 2014, the medium grain project put in a request to fingerprint various breeding materials (Table 21). About 1,030 lines, consisting of 08Y3269 and M-202 head row samples, M-401 mutant lines, and medium grain quality lines, were assessed using different markers, totaling 10,440 data points.

Twelve SSR markers were used to discriminate a proposed for release medium grain advanced line, 08Y3269, from other medium grains (Table 22). The gel image of the ABI run is shown in at bottom of Table 22 and is aligned with the columns for the respective markers. For each marker, the banding pattern is examined and given a number.

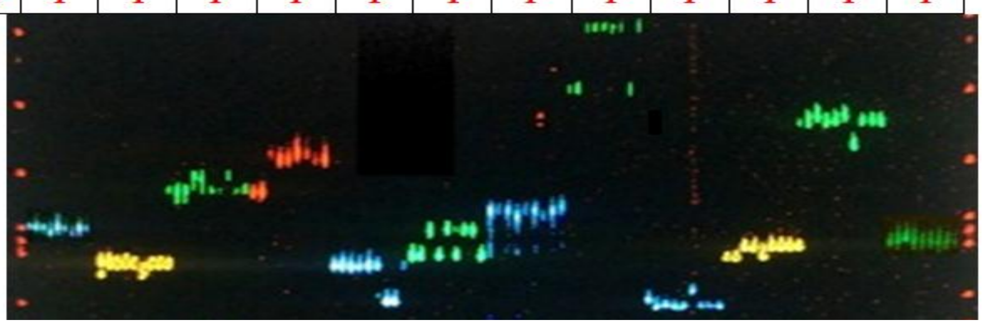
If there are 2 bands, one band will be given a "1" and the other band is assigned as "2"; and if there are 3 bands, a value of "3" is given to the third band, and so on.

Table 21. Materials fingerprinted for the MG and LG project.

Material	No. of Lines	No. of Markers	No. of Data Points
M-202 HR	410	17	6970
08Y3269 HR	400	4	1600
M-401 mutants	50	17	850
MG, quality	170	6	1020
LG lines	100	11	1100
LG mutants	35	9	315
TOTAL	1165		11,855

Table 22. Microsatellite markers (SSR) identified for use in DNA fingerprinting to identify and discriminate medium grain varieties. Accompanying picture shows the image of a gel run using the ABI 377 DNA sequencer.*

ID	Marker											
	A	B	C	D	E	F	G	H	I	J	K	L
M-104	1	1	1	3	1	1	1	2	2	2	1	1
M-105	1	1	1	3	1	1	1	2	1	2	2	1
M-202	1	1	2	2	1	2	1	1	1	1	1	2
M-205	2	1	2	1	1	1	2	1	1	1	1	1
M-206	1	1	1	1	1	2	1	1	1	2	2	1
M-208	1	2	1+2	2	1	1	1	1	3	1	3	1
M-401	2	1	2	2	2	2	2	1	1	1	1	1
M-402	1	1	1	1	2	2	1	2	1	1	1	1
08-Y-3269	1	1	1	1	1	1	1	1	1	1	1	1



*RM are microsatellite markers (SSR) used for DNA fingerprint. To discriminate 08Y3269 from any other medium grain variety, use the RM marker with different alleles (1, 2,3, colored yellow in the table). For example, to discriminate against M-206, use F, J, and K.

The banding pattern generated for each of the marker in the set is unique for each variety, thus serving as a fingerprint. Using the 12 markers, the 8 medium grain and 08Y3269 can be adequately and distinctly distinguished from each other.

In the long grain project, around 135 entries were fingerprinted (Table 23). The materials consisted of experimental lines and mutants.

Fingerprint data assures the breeders of the identity and purity of their materials. In addition to in-house fingerprinting, varietal identity service was also performed on commercial rice fields (non-RES samples) to answer seed contamination questions.

Mapping Stem Rot Resistance

The ultimate goal of mapping the stem rot resistance is to find a tightly-linked marker that can be used for marker-aided selection by the different breeding programs.

An advanced backcross recombinant inbred line mapping population from the cross 87Y550/M-206*2 was used to map the stem rot resistance from a wild rice relative, *O. rufipogon*. In the first replicated stem rot screening trial performed in Biggs in 2010, and in a follow-up study in Biggs and Glenn in 2011, genetic mapping analysis had identified putative quantitative trait loci (QTL) that are associated with stem rot resistance.

From 2011 to 2013, the medium grain breeder (VC Andaya) and the plant pathologist (J Oster) generated a fine mapping population to further delineate the region close to the QTL region. The population was generated from a cross between the most resistant line SRM1-4 which was derived from the initial mapping population and M-206. The fine mapping population consisted of BC_3F_6 lines. The evaluation of the fine mapping population in 2013, however, was not successful due to erratic disease infection.

In 2014, another trial was set-up in the field at RES. A total of 340 lines from the fine mapping population were planted. Tissues were harvested and DNA extractions were performed for use in on-going genotyping work using 29 selected markers. As phenotype scores are highly affected by the environment, across year and across location, another replicated stem rot evaluation may be needed before for 2015.

BREEDING NURSERIES

Seeding of the 2014 breeding nursery began May 12, and was completed May 30th. In 2014, 1360 crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 45,184. Crosses made in the early spring were grown during the summer in an F_1 nursery to produce seed for the F_2 generation. Crosses made this past summer were planted in the Hawaii Winter Nursery and/or the greenhouse so the segregating F_2 generations could be grown for selection purposes in 2014, thereby accelerating the breeding process.

The 2014 RES breeding nursery occupied approximately 76 acres. Water-seeded yield tests included 5054 small plots and 3038 large plots. The nursery included about 60,600 water-seeded and 19,970 drill-seeded rows and plots. F_2 populations from 2012 and 2013 crosses were grown in precision drill-seeded plots on 7 acres. An estimated 150,000 panicles were selected from the various F_2 populations in nurseries for further screening and advancement. Selected material is being advanced in the Hawaii Winter Nursery and greenhouse facilities. The remainder will be screened and processed for planting in 2015.

Headrows (1600) of M-202, A-202, Koshihikari, and experimentals 08Y3269 and 09Y2141 were grown for breeder seed production in 2014. This headrow seed can be used for several years to produce breeder seed because it is stored under low temperature and proper humidity conditions.

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

Selection and harvest of the 2013-14 winter nursery was completed and seed returned to RES and planted in May. The 2014-15 winter nursery of 9281 rows was planted November 3-6, 2014, and 600 F_1 populations were transplanted to the nursery December 8, 2013. Selection and harvest will occur in April, and seed returned for processing and planting in the 2015 RES breeding nursery.

The San Joaquin Cold Tolerance Nursery was planted in cooperation with two local rice growers. The 7 acre drill-seeded nursery included 6720 rows, and 5 acres of F_2 populations. Stand establishment and weed control was good. Very little blanking was observed in the rows, but blanking occurred in the F_2 populations for selection.

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

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 University of California Cooperative Extension (UCCE) and also tested at RES. The 2014 Statewide Yield Tests were conducted at seven locations in commercial fields by Mr. Raymond L. Wennig, Dr. Bruce A. Linquist, Dr. Luis Espino, Dr. Randall G. Mutters, Dr. Chris Greer, , and Dr. James E. Hill. Advanced selections were tested in one of the three maturity groups: very early, early, or intermediate to late with standard check varieties included for comparison. Each maturity group was subdivided into an advanced and preliminary experiment. The advanced entries and checks had four replications and the preliminary entries had two replications. Plots were combine-size (10 by 20ft) and the experimental designs were randomized complete blocks.

All of these advanced large plot entries were also tested at RES in a randomized complete block design. The large plot seeding dates at RES were May 2-4, 2013. The plot size was 10 by 20 ft with the center 7 ft combine harvested (140 ft^2).

Water-seeding and conventional management practices were used in these experiments. Bolero UltraMax®, and SuperWham® and Grandstand® were applied for weed control and one application of Lambda Cy was applied for rice water weevil control. Cerano® was used in the nursery as well.

Tables 23 through 28 contain a summary of performance information from the 2014 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 2015. Complete results of the UCCE Statewide Yield Tests can found on the web at http://ucanr.edu/sites/UCRiceProject/Research/Agronomy_Progress_Reports/.

Table 23. Agronomic performance means of very early advanced entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES (4 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
12	08Y3269	M	4.8	84	97	1	4.7	10070	9670
10	M-205	M	4.7	86	94	1	4.5	9770	9380
13	12Y113	MB	4.8	82	94	1	4.5	9750	9620
16	11Y1005	L	4.8	80	104	1	4.8	9560	9570
7	11Y2022	MPQ	4.7	80	99	1	4.6	9540	9630
15	11Y1008	L	4.7	79	91	1	5.0	9220	9500
11	M-206	M	4.8	79	94	1	4.7	9200	9520
6	09Y2179	S	4.9	87	91	1	4.2	9020	9050
14	L-206	L	4.7	77	84	1	5.0	8580	8860
5	09Y2141	SWX	4.9	77	91	13	4.7	8470	9350
8	M-104	M	4.8	75	89	6	5.7	8150	9240
4	CH-202	SPQ	4.8	77	89	63	4.4	7930	8710
2	S-102	S	4.9	75	89	3	4.7	7640	8470
9	M-202	M	5.0	84	97	1	4.9	7330	8620
1	CM-101	SWX	4.9	74	86	8	4.6	6540	7590
3	CH-201	SPQ	4.9	82	86	25	5.3	5720	7870
MEAN			4.8	80	92	8	4.7	8530	9040
LSD (.05)			0.1	1	2	16	0.7	600	660
CV			1.8	1	4	141	10	5	5

† L = long grain; M = medium grain; M = medium grain, blast resistant; MPQ = premium quality medium grain; S = short grain; SPQ = premium quality short grain; and SWX = short grain waxy.
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent.
§ Number of days to 50% heading.

Table 24. Agronomic performance means of very early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at San Joaquin, Sutter, Yolo, and RES (2 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
19	10Y2043	S	4.8	76	84	11	4.3	10210	10320
50	13Y1073	L	4.8	80	89	1	4.6	9850	9970
51	13Y1037	LSR	4.9	80	97	1	-	9280	9160
36	12Y3097	MB	4.7	80	91	1	4.5	9190	9530
35	11Y3672	M	4.8	79	94	1	5.2	8990	9500
37	13Y3012	M	4.9	76	94	1	5.4	8970	9220
25	12Y2108	MPQ	4.8	84	102	1	4.8	8930	9000
26	12Y2174	MPQ	4.9	84	102	1	4.7	8880	9400
27	12Y2163	MPQ	4.8	86	91	1	5.2	8790	9280
41	13Y3052	M	4.8	77	97	1	5.1	8700	9050
52	A-202	LA	4.9	82	97	1	-	8670	8850
31	08Y3126	M	4.9	79	91	1	5.3	8570	9340
18	M-402	MPQ	5.0	101	97	1	3.9	8500	8400
34	11Y3606	M	4.9	78	89	1	4.9	8420	9430
32	11Y3326	M	4.8	78	91	1	5.2	8410	9570
43	13Y3093	M	4.8	79	86	1	5.1	8360	9340
46	13Y3213	MB	4.7	79	97	6	5.2	8350	8480
33	11Y3403	M	4.8	79	86	1	4.6	8340	8830
22	13Y2015	S	4.7	80	91	1	3.5	8310	9240
39	13Y3043	M	4.8	76	89	6	5.0	8270	9270
42	13Y3071	M	4.7	77	89	1	5.4	8220	9280
40	13Y3046	M	4.7	76	89	35	5.2	8090	9410
45	13Y3192	M	4.8	81	91	1	5.4	7990	9290
44	13Y3150	M	4.8	79	89	1	5.0	7950	9390
24	12Y2104	MPQ	4.8	85	99	1	4.8	7910	8930
38	13Y3036	M	4.8	78	91	20	5.0	7830	9170
28	M-208	MB	4.8	82	99	1	5.3	7780	8590
21	12Y2167	SPQ	4.9	82	89	1	5.1	7730	8480
29	M-105	M	4.8	75	91	6	5.7	7680	9470
48	13Y3216	MB	4.9	80	89	11	5.5	7650	8890
47	13Y3215	MB	4.8	82	97	21	5.0	7330	8420
30	M-203	M	5.0	83	97	35	5.2	7130	8060
20	11Y2223	S	4.7	74	84	1	5.2	6460	7910
23	09Y2064	SWX	4.7	79	86	1	4.6	6220	8380
49	13Y3220	MQ	4.9	85	97	45	5.1	6060	7720
17	CA-201	SLA	4.9	79	84	45	5.0	4150	6160
MEAN			4.8	80	92	7	5.0	8120	8960
LSD (.05)			0.1	1	3	24	0.7	1100	1025
CV			2	1	4	160	10	7	6

† L = long grain; LA = long grain, aromatic; Lsr = Long grain, stem rot resistant; M = medium grain; MB = medium grain, blast resistant; MPQ = premium quality medium grain; S = short grain; SLA = short grain low amylose; SPQ = premium quality short grain; and SWX = short waxy grain

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

¶ LSR = stem rot score, where 0 = no damage and 10 = plant killed.

Table 25. Agronomic performance means of early advanced entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (4 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
74	13Y1073	L	4.7	79	89	1	4.4	10330	9890
65	11Y2183	MPQ	4.8	91	91	1	5.0	9710	9270
71	08Y3269	M	4.8	87	99	6	4.8	9670	9300
72	12Y113	MB	4.8	83	97	60	5.0	9600	9530
76	11Y1005	L	4.8	78	99	1	5.1	9280	9630
70	M-206	M	4.9	80	94	55	5.3	9240	9270
69	M-205	M	4.8	89	94	1	5.5	9140	9190
75	11Y1008	L	4.6	79	91	1	5.2	9000	9610
67	09Y2179	S	4.8	89	97	1	5.5	8760	8920
73	L-206	L	4.7	78	84	18	4.6	8640	9250
66	09Y2141	SWX	4.8	77	94	50	4.8	8310	8570
64	CH-202	SPQ	4.7	80	84	85	4.3	7580	7920
62	S-102	S	4.9	75	91	70	5.5	7320	7850
68	M-202	M	4.8	88	97	1	5.2	7010	8030
61	CM-101	SWX	4.7	76	89	45	5.1	6400	7040
63	CH-201	SPQ	5.0	84	86	68	6.6	6220	7390
MEAN			4.8	82	92	29	5.1	8510	8790
LSD (.05)			0.1	2	5	17	0.7	540	615
CV			2	2	3	41	9	5	5

† L = long grain, M = medium grain, MB = medium grain, blast resistant; MPQ = medium premium quality; S = short grain; SPQ = premium quality short grain; and SWX = short waxy grain.
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent.
§ Days to 50% heading.

Table 26. Agronomic performance means of early preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Colusa, Butte, Yuba, and RES (2 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
79	10Y2043	S	4.8	75	89	97	5.0	10950	9660
84	12Y2175	MPQ	4.6	86	102	11	4.9	10550	9980
111	13Y1156	LA	4.8	80	91	18	4.6	10020	9990
101	13Y3193	M	4.7	87	94	1	5.4	9820	9100
103	A-202	LA	4.8	82	102	23	4.2	9810	9170
98	13Y3176	M	4.7	84	97	1	5.0	9790	9470
94	13Y3131	M	4.8	82	99	1	4.9	9740	9590
112	13Y1059	L	4.8	80	97	1	4.4	9660	9500
95	13Y3146	M	4.8	82	94	11	4.5	9550	9510
110	13Y1132	LJ	4.7	83	94	1	4.5	9520	9040
85	11Y2182	MPQ	4.6	89	94	1	5.2	9480	9170
96	13Y3156	M	4.7	87	91	1	4.2	9460	9300
92	10Y3737	M	4.3	87	97	1	5.7	9270	9370
86	M-208	MB	4.9	83	94	1	5.2	9070	9150
99	13Y3177	M	4.7	82	94	11	5.1	9030	9150
100	13Y3181	M	4.7	81	97	1	4.9	9010	9040
115	13P358	LJ	4.7	83	102	13	-	8990	8920
109	11Y106	LJ	4.6	89	107	1	3.8	8980	7940
91	10Y3703	M	4.8	85	97	1	4.8	8910	8880
93	11Y3655	M	4.9	86	94	1	4.7	8820	9190
97	13Y3158	M	4.9	84	89	1	4.7	8770	8850
78	M-402	MPQ	5.0	107	97	1	5.1	8690	8380
87	M-105	M	4.7	75	91	11	5.3	8570	8830
114	13Y1106	L	4.7	80	91	1	5.3	8280	9200
106	12Y133	LJ	4.7	94	86	1	5.1	8240	7700
83	11Y2230	SPQ	5.0	82	94	35	4.8	8220	8520
107	12Y1178	LJ	4.6	84	97	1	4.4	8180	7460
102	A-201	LA	4.8	79	91	1	4.6	8090	8760
88	M-203	M	4.9	83	107	60	5.3	7750	7720
80	09Y2122	S	4.7	78	99	50	5.0	7710	7910
81	12Y2107	SWX	4.7	79	97	6	5.0	7550	8460
116	13P296	LJ	4.9	80	99	1	-	7230	8040
82	11Y2160	SWX	4.8	76	91	55	5.4	7160	8200
90	13Y3224	MQ	4.6	86	99	45	5.1	7110	7800
108	12Y1054	LB	4.9	68	84	1	4.4	6710	6040
89	13Y3223	MQ	4.6	85	94	35	5.5	6710	7290
113	13Y1117	LA	4.5	85	91	1	5.4	6520	7560
104	CT-202	LB	4.9	84	84	1	4.4	6310	6280
77	CA-201	SLA	4.8	80	89	80	5.0	4950	6440
MEAN			4.7	83	95	15	4.9	8540	8580
LSD (.05)			0.2	2	5.08	16	0.7	480	732.5
CV			3	1	3	52	9	3	4

† L = long grain; LA = long grain aromatic; LB = long grain basmati; LJ = long grain jasmine; M = medium grain; M = medium grain, blast resistant; MPQ = premium quality medium grain; MQ = medium grain quality; S = short grain; SLA = short grain low amylose; SPQ = premium quality short grain; and SWX = short waxy grain.

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

Table 27. Agronomic performance means of intermediate to late advanced entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (4 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
128	08Y3269	M	4.9	86	99	1	4.6	11270	9960
129	13Y3212	MB	4.9	81	99	1	5.3	11210	9550
131	11Y1005	L	4.9	79	94	1	5.0	10990	9590
124	11Y2183	MPQ	4.9	88	94	1	5.3	10990	9910
127	M-206	M	4.9	79	97	23	5.5	10570	9370
126	M-205	M	4.9	87	91	1	4.8	10550	9380
130	L-206	L	4.9	78	91	1	4.7	10340	9620
121	M-402	MPQ	5.0	101	99	1	4.1	10040	8660
123	CH-202	SPQ	4.9	79	86	90	4.5	9050	8270
125	M-202	M	5.0	85	97	1	5.0	8870	8800
122	CH-201	SPQ	5.0	82	89	70	5.5	8560	8180
MEAN			4.9	84.1	94	17	4.9	10220	9210
LSD (.05)				2	5	18	0.7	720	900
CV			1	2	4	73	10	5	7

† L = long grain; M = medium grain; M = medium grain, blast resistant; MPQ = premium quality medium grain; and SPQ = premium quality short grain.
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent.
§ Days to 50% heading.
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Table 28. Agronomic performance means of intermediate to late preliminary entries in Statewide Yield Tests at RES and over-location mean yields at Glenn, Sutter, and RES (2 reps) locations in 2014.

Entry Number	Identity	Type †	SV ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	Grain Yield (lb/A, 14% MC)	
								RES	State
135	11Y2182	MPQ	4.9	89	99	1	5.1	10780	9740
153	12Y1022	LA	4.9	81	97	1	4.5	10640	9600
138	M-208	MB	4.9	84	97	1	5.0	10600	9200
157	12Y1176	L	4.9	80	102	1	4.8	10460	9690
137	09Y2141	SWX	5.0	75	94	6	4.8	10260	9570
145	A-202	LA	4.9	83	99	1	3.7	10210	9510
147	13P266	LJ	4.9	81	91	1	-	10090	9880
144	13Y3219	MB	4.9	81	97	1	5.2	9900	8610
150	11Y106	LJ	4.9	85	102	1	4.3	9720	7830
139	M-105	M	4.9	76	99	40	5.3	9650	8300
136	12Y2178	SPQ	4.9	91	89	45	4.1	9590	8660
132	M-401	MPQ	5.0	106	99	1	4.6	9550	8330
141	13Y3220	MPQ	4.9	86	94	11	5.1	8800	7810
151	12Y135	LJ	4.9	89	91	1	5.6	8770	8760
154	13P277	LJ	5.0	82	99	1	-	8490	9190
140	M-203	M	4.9	85	112	15	5.3	8280	7360
134	CM-101	SWX	4.9	74	91	75	4.5	8180	6980
155	13Y1178	LJ	4.9	81	94	1	5.3	8060	8590
142	13Y3223	MPQ	4.9	84	97	13	4.8	8060	7360
143	13Y3224	MPQ	4.9	84	99	10	5.0	7990	7820
148	13Y1055	LB	4.9	82	89	1	4.7	7590	7020
152	13Y135	LB	4.9	86	91	1	4.6	7330	7190
156	13P477	LB	4.9	86	94	1	-	6600	5450
149	13P454	LB	4.9	89	91	1	-	6200	4700
133	KOSH	SPQ	4.9	124	114	90	5.4	5550	4970
MEAN			4.9	86	97	13	4.8	8850	8090
LSD (.05)				4	3	29	0.7	980	1210
CV			1	2	4	110	10	5	7

† L = long grain; LA = long grain aromatic; LB = long grain basmati; LJ = long grain jasmine; M = medium grain; M = medium grain, blast resistant; MPQ = premium quality medium grain; and SPQ = short grain premium; and SWX = short waxy grain.
‡ SV = seedling vigor score, where 1=poor and 5=excellent.
§ Days to 50% heading.

PRELIMINARY YIELD TESTS

Preliminary Yield Tests are the initial step of replicated large plot testing for experimental lines. The experimental design, plot size, and production practices are identical to the Statewide Yield Tests grown at RES. Two replications are planted at the early and late seeding date. A summary of the yields of 2014 Preliminary Yield Tests is presented in Table 29. These tests included 536 entries and check varieties.

Results in Table 29 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 2015 Statewide Yield Tests. ◆

Table 29. Summary of Preliminary Yield Tests at RES in 2014.

Test	Type	Number of Entries	All	Highest	Top 5	Check	Standard
			----------Average Yield (lb/acre)†----------				Check
Very Early							
Short grains	Conventional	8	9510	10050	9810	8510	S-102
	Specialty rice	50	8840	10230	9990	8390	CH-202
Medium grains	Conventional‡	62	9780	10990	10710	9910	M-105
	Premium	--	--	--	--	--	M-402
Long grains	Conventional	62	10830	11830	11660	10040	L-206
	Specialty rice	16	9360	10960	10590	10570	A-202
Early							
Short grains	Conventional	21	9590	11380	10440	9050	S-102
	Specialty rice §	39	9370	11200	10710	9160	CH-202
Medium grains	Conventional	87	10160	11090	11020	10270	M-206
	Premium	27	10880	11100	10740	9920	M-402
Long grains	Conventional	53	9690	10730	10600	9160	L-206
	Specialty rice	28	7940	10820	10140	9660	A-202
Intermediate-Late							
Short grains	Conventional	10	10490	11400	11130	9470	S-102
	Specialty rice¶	10	10250	11020	10710	9970	CH-202
Medium grains	Premium	18	11070	12260	11730	10740	M-402
Long grains	Conventional	6	10010	10860	10150	10060	L-206
	Specialty rice	39	7560	10910	10000	10090	A-202

† Paddy rice yield at 14% moisture
‡SPQ,SWX,BG
§ SPQ, SLA, SWX
¶ SLA, SPQ