2013 RICE BREEDING PROGRESS REPORT

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Rice Experiment Station
P. O. Box 306, Biggs, CA 95917-0306
www.crrf.org ricestation@crrf.org

RICE EXPERIMENT STATION STAFF

Administration

Kent S. McKenzie, Ph.D.	Director

Plant Breeding

Virgilio C. Andaya, Ph.D.	Director of Plant Breeding
Farman Jodari, Ph.D.	Plant Breeder
Stanley Omar PB. Samonte, Ph.D.	Plant Breeder
Jeffrey J. Oster, M.S.	Plant Pathologist
Cynthia B. Andaya, Ph.D.	Research Scientist

Plant Breeding Support

Matthew A. Calloway	Plant Breeder Assistant
Baldish K. Deol	Plant Breeder Assistant
Ravinder Singh Gakhal	Plant Breeder Assistant
Davinder Singh	Plant Breeder Assistant
John Bryant III	Plant Breeder Assistant
George Yeltatzie	DNA Lab Technician

Field Operations and Maintenance

Burtis M. Jansen	Field Supervisor
Joseph E. Valencia	Mechanic and Operator
Randall C. Jones	Maintenance and Operator
Paul A. Moore	Maintenance and Operator

Clerical and Accounting

Lacey R. Stogsdill	Administrative Assistant
Pamela L. Starkey	Administrative Assistant

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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 Associate Dean and Rice Specialist, Dr. James E. Hill, (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, Zhongli Pan, 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 2013. Dr. Albert J. Fischer, (professor, Department of Plant Sciences, UCD), Mr. James Eckert, (UCD staff research associate at RES), 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-three improved rice varieties have been released since an accelerated research program began in 1969. Foundation seed of 15 public rice varieties, 1 experimental increase, and basic seed of one Japanese premium quality variety were produced on 170 acres at RES in 2013. 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 2013 by CRC have been non-detect.

Trade names are used to simplify information. No endorsements of named products are intended or criticism implied of similar products not mentioned in this report.

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

Virgilio C. Andaya

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 project, and premium types for the medium grains project. Each of the breeding projects are under the leadership of a rice breeder and overseen by a Director of Plant Breeding. The rice pathology and the DNA marker laboratory, each 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 program implemented significant organization changes as it marked its 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 the breeder 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. Mr. Jeffrey Oster continues to be the station plant pathologist working alongside the breeders in disease resistance screening and resistance gene introgression (see Rice Pathology). Dr. Cynthia B. Andaya provides leadership over the DNA Marker Laboratory as well as the Grain Quality Laboratory. She is in charge of fingerprinting and DNA marker-assisted breeding efforts, mapping stem rot resistance, as well as generating mutants and screening for herbicide resistance (see DNA Marker Laboratory).

Plant breeders and support staff actively participate in preparation, planting, maintenance, and harvest of the research nurseries. Project leaders are also responsible for the overall operation and management of the program. They are likewise involved in cooperative studies with other scientists from the UCD, USDA, and industry, including off-station field tests, nurseries, quality research, and biotechnology.

CALROSE MEDIUM GRAINS

Virgilio C. Andaya

Overview

The predominant rice varieties planted in California are medium grains, commercially and internationally known as Calrose rice. The California Calrose brand is famous for its 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. M-202 is an old favorite, and in its prime, comprised almost 70% of the rice acreage. Acreage in recent years of this variety decreased due to the increased popularity and acceptability of the better yielding and widely adapted variety M-206, which was released in 2003. M-206 has far superior grain and milling yields, and better cold tolerance. Another high-yielding variety but with a more restricted area of adaptation, is M-205. It is later maturing than M-202, is very resistant to lodging, and has superior grain and milling yields. M-104 is a very early-maturing, cold tolerant variety released in 2000 and is the dominant variety in San Joaquin County and in cooler areas. Most recently, a very early maturing variety, M-105, was released as an alternative to M-104.

Other minor medium grain varieties includes a blast-resistant variety, M-208, that carries the *Piz* gene, which is effective in conferring resistance to IG-1 blast pathogen. Two premium quality medium grains, M-401 and M-402, are planted on limited acreage because of their late maturity.

Breeding Objectives

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 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 Calrose to match changing international market preference for better tasting rice while still aiming for highest possible grain yields.

Operational Changes

The RES Breeding Program initiated operational changes in managing the breeding nurseries and yield trials at the station. With the purchase of a research combine in 2011 to cut yield plots, plot dimensions were changed from 12’x15’ to 10’x20’. In the medium and short grain nurseries, the 4’x6’ small plots were changed to 10’x10’ plots to enable the research combine to cut the plots to measure grain yield. This change allowed the projects to determine grain yields in earlier generations or starting in F_5, thereby eliminating low yielding lines earlier and accelerating the selection and advancement of breeding materials for inclusion in Preliminary Yield tests at the station or the UCCE Statewide Tests.

The breeding projects put a lot of emphasis in selecting breeding materials with high and stable milling yields and it is critical that milling samples are taken at the right harvest moisture. The milling plots, which measured 10’x15’ and 4’x6’, were centralized in one strategic location at the main nursery. Being in a centralized area allowed the breeders to manage the plots uniformly and allow for a more efficient cutting by field crews.

To address soil heterogeneity and variation within experimental fields, the program started using a precision fertilizer drill mounted in a GPS-guided tractor to promote uniform fertilizer application and reduce the recurring problem associated with aerial fertilizer application.

A warming basin was also set up for the yield trials to reduce the effect of low water temperature across the fields, thus reducing field variability. The warming basin may be upgraded to a recirculation system in the future.

M-105 Update

M-105 was released in 2011 as an alternative to M-104 in cool rice growing areas. M-105 is very early, semi-dwarf, glabrous, high-yielding Calrose variety. Days to heading and yield performance are in between M-206 and M-104. Resistance to cool temperature-induced blanking is not as high as 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 over M-104, M-205 or M-206. Applications for protection and registration of M-105 were approved under the US Plant Variety Protection Act and US Utility Patent.

Based on feedback by rice growers and reports during the 2013 planting season in Butte County, M-105 is competitive with more popular Calrose varieties and is superior to M-104 in yield and agronomic performance. It was planted to approximately 14% of Butte County Rice Growers Association acreage, achieving and average head rice yield of more than 68%, outperforming M-205, M-206 and M-104.

Breeding Highlights

08Y3269, A High-yielding Line

The advanced line 08Y3269 is a semi-dwarf, early maturing, glabrous, and high-yielding Calrose advanced line. It was derived from a cross made in 2004 designated as R29174 with the pedigree “M-205/3/90-Y-63/M-202//M-204”. It was first entered in UCCE Statewide Test (SW) in 2010 and has been tested in a total of 27 yield tests. The agronomic characteristics of the advanced line and its area of adaptation in California are very similar to M-205. If released, may serve as a replacement for M-205 or M-202. 08Y3269 is not recommended in areas where M-205 is not successfully grown such as in cooler rice areas.

08Y3269 performed very well in the statewide tests in the last four years, out yielding M-202, M-205, and M-206 by 8%, 6%, and 2%, respectively (Table 1). This entry performed best in Butte and Colusa counties compared to M-205. Its number of days to heading was one to two days earlier than M-205, with similar seedling vigor and height. In 2013, 08Y3269 was entered in strip trials in Butte, Glenn, and Colusa where milling samples were taken and evaluated (Table 2). Head rice and total milled rice yields, were similar to M-205 and M-206, but may slightly drop if harvested at lower moisture levels. 08Y3269 has slightly larger kernels with less chalk than M-205 and M-206.

The disease reaction of 08Y3269 and other medium grain varieties are presented in Table 3. 08Y3269 has better stem rot resistance score but has no noticeable advantage to the other medium grain varieties in resistance to blast disease.

A proposal for foundation seed increase of 08Y3269 was submitted and approved by the CCRRF Board of Directors in compliance with the RES Variety Release Policy and Protocol.

Table 1. Agronomic performance of 08Y3269 across location and years in UCCE Statewide Test.

Year	Location	Grain Yield#	SV‡	Days§	Ht. (cm)	Lodge (%)	%Yield Advantage Over		
							M-202	M-205	M-206
2010-13	Biggs	10,930	4.8	90	94	0	10	-1	4
	Butte	9,210	5.0	88	94	1	14	6	7
	Colusa	11,040	5.0	98	100	1	8	6	3
	Yuba	10,230	5.0	93	108	1	4	4	-1
	Mean	10,350	5.0	92	99	1	9.1%	3.6%	3.3%
2012-13	Biggs	10,360	4.8	86	97	0	16	11	13
	San Joaquin	6,910	5.0	118	82	1	-1	31	-11
	Sutter	9,190	4.9	88	87	3	4	4	2
	Yolo	9,720	5.0	92	107	89	5	1	-3
	Mean	9,050	4.9	96	93	23	6.1%	11.7%	0.5%
2013	Biggs	10,100	4.8	86	102	0	16	4	6
	Glenn	8,490	5.0	97	99	1	3	1	-10
	Sutter West	8,150	5.0	91	96	1	3	-5	-8
	Mean	8,910	4.9	91	99	1	7.4%	0.1%	-3.9%
Grand Mean		9,650	4.9	93	97	8	8%	6%	2%

‡ 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. Grain characteristics of M-205, M-206, and 08Y3269 in strip trial.

ID	Location	%MC	Head%	Total%	Length (mm)	Width (mm)	L/W Ratio	% Chalk	1000-grain Weight
08Y3269	Biggs	18.8	63	71	6.09	2.60	2.35	8.4	22.7
	Butte	23.1	65	73	6.02	2.59	2.32	8.2	22.9
	Colusa	18.5	71	74	6.19	2.64	2.34	7.8	24.3
	Glenn	20.1	69	73	6.19	2.64	2.34	9.2	23.8
	Mean	20.1	67	73	6.12	2.62	2.34	8.4	23.4
M-205	Biggs	17.7	62	72	5.92	2.55	2.33	8.3	21.7
	Butte	22.6	66	72	5.90	2.56	2.30	7.7	21.8
	Colusa	18.5	71	74	6.10	2.63	2.32	8.1	23.1
	Glenn	18.8	68	73	6.07	2.62	2.32	10.7	23.0
	Mean	19.4	67	72	6.00	2.59	2.32	8.7	22.4
M-206	Biggs	19.0	62	70	5.81	2.61	2.23	11.2	20.2
	Butte	22.6	68	72	5.77	2.60	2.22	8.6	21.3
	Colusa	19.2	72	74	6.08	2.74	2.22	8.2	23.7
	Glenn	20.2	69	73	5.89	2.63	2.24	10.1	21.3
	Mean	20.2	68	72	5.89	2.64	2.23	9.5	21.6

%MC is moisture content at harvest, %chalk, Length, Width and LW ratio measured using S-21 Analyzer.

Table 3. Disease resistance reactions of 08Y3269 against other medium grain varieties.

ID	Stem Rot+				Aggregate Sheath Spot++			Blast#
	2010	2011	2012	2013	2011	2012	2013	2013
08Y3269	4.93	5.18	4.47	5.41	2.76	2.46	1.76	3.33
M-104	5.20	5.95	4.83	6.19	3.32	2.90	2.83	3.25
M-105	5.43	5.58	5.30	6.19	2.88	2.93	2.19	3.42
M-202	5.63	6.00	4.81	5.88	2.69	2.16	1.81	2.92
M-205	5.33	5.27	4.28	5.35	2.54	2.01	1.66	3.33
M-206	5.33	5.43	4.80	6.17	2.82	2.58	2.06	3.17
M-208	5.50	5.60	5.15	5.77	2.80	2.77	2.39	0.38

+ Stem rot score where 0 = no damage, 10 = all plants killed
++ Aggregate Sheath Spot where 0 = no damage, 4 = all plants killed
# Blast Score where 0 = no damage, 4 = all plants killed

Blast Resistance

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 project concentrated efforts in breeding and pyramiding new sources of blast resistance genes that are stable and take a longer time to breakdown. The basic strategy is to incorporate several blast resistance genes initially using M-206 as the genetic background via marker-assisted backcrossing and employ a similar strategy using M-205 and M-105 varieties. Ultimately, the long term goal is to have most medium grains recommended for release to have blast resistance.

In 2005, a backcrossing project was initiated to introgress different blast resistance genes (*Pi* genes) into 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) of M-206 containing individual *Pi* genes. Stable and uniform NILs were entered in preliminary yield tests, which also included M-206 and M-208, at RES. The goal was to examine if there are yield penalties and agronomic differences between the isolines and M-206 and whether they are superior to M-208. Table 4 summarized the results of the preliminary yield tests in 2013. Compared to M-206, agronomic performance and grain characteristics varied depending on the resistance gene introgressed. Linkage drag or agronomic penalties associated with specific blast resistance genes may account for the differences.

Seven of these near-isogenic lines were entered in statewide tests in 2013 and the results are presented in Table 5. Among the isolines, 12Y113 yielded better than M-208 with a total grain yield of 9,600 lbs/acre. A notice of experimental increase was submitted for 12Y113.

Table 4. Performance of M-206 isolines in RES Preliminary Yield Test.

ID	Blast Gene	Grain Yield#	SV‡	Days§	Ht. (cm)	Lodge %	% Chalk	Length (mm)	Width (mm)	L/W Ratio	%Head/ %Total (MC)
13Y3210	*Pikh*	7460	4.9	82	100	2	29.3	5.84	2.64	2.21	65/70 (20)
13Y3211	*Pikm*	7800	4.9	81	101	8	20.9	5.82	2.62	2.22	70/71 (18)
13Y3212	*Piz5*	8950	4.9	82	96	10	27.2	5.82	2.64	2.2	67/70 (20)
13Y3213	*Pi40*	7470	4.8	81	99	8	25.3	5.87	2.57	2.28	66/71 (20)
13Y3214	*Pib*	7680	4.9	83	97	3	16.1	6	2.59	2.31	65/70 (19)
13Y3215	*Pi9*	9250	4.9	83	96	17	40.2	5.68	2.6	2.19	58/66 (20)
13Y3216	*Pita2*	7690	4.9	83	98	8	25.9	5.99	2.62	2.28	64/72 (18)
13Y3217	*Pi33*	6720	4.8	84	97	0	15.6	5.52	2.58	2.14	70/73 (20)
13Y3218	*Pi1*	8020	5.0	82	96	2	18.3	5.79	2.62	2.21	65/71 (18)
13Y3219	*Pi2*	8570	5.0	82	97	7	24.2	5.79	2.59	2.23	65/70 (20)
M-206	-	8000	4.9	82	97	8	8.7	5.83	2.59	2.25	69/71 (18)
M-208	*Piz*	8050	5.0	84	97	5	14.2	6.03	2.53	2.38	67/70 (18)
MEAN		7970	4.9	82	98	6.5					
CV		9.8	1.1	1	3	76.3					
LSD (.05)		1290	0.1	1.3	4.8	5.3					

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

Table 5. Agronomic and grain characteristics of M-206 isolines containing individual blast resistance genes in very early preliminary UCCE Statewide Tests.

ID	Gene	Grain Yield#	SV‡	Days§	Ht. (cm)	Lodge %	% Chalk	Length (mm)	Width (mm)	L/W Ratio	1000-grain Weight	%Head/ %Total (MC)
13Y36	*Pi33*	9270	4.9	90	94	2	32.6	5.84	2.59	2.26	21.2	57/69 (21)
12Y114	*Pi40*	8870	5	89	97	8	18.7	5.73	2.53	2.27	20.8	66/69 (21)
13Y34	*Pi9*	9000	5	89	86	20	22.2	5.65	2.62	2.15	20.5	66/69 (20)
12Y3097	*Pib*	9170	4.9	87	94	2	17.8	5.94	2.59	2.29	21.3	64/70 (21)
12Y112	*Pikh*	9320	5	89	97	3	17	5.92	2.61	2.27	21.3	64/69 (21)
13Y35	*Pita2*	8950	4.9	89	94	15	21.8	5.57	2.53	2.2	19.1	59/67 (19)
12Y113	*Piz5*	9600	4.9	90	97	23	17.9	5.77	2.54	2.27	20.6	65/70 (21)
M208	*Piz*	9180	5	91	94	2	17.3	5.94	2.54	2.34	20.9	59/66 (21)
MEAN		9110	4.9	89	94	8						
CV		4.7	1.5	1.6	15.5	177.8						
LSD(.05)		430	0.1	1	5.1	13						

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

Stem Rot Resistance

Several genes control stem rot resistance. The medium grain project coordinated with Mr. Oster and Dr. C. Andaya in screening the mapping population for stem rot resistance at the station with the goal of further narrowing down the chromosomal regions of interest. At least seven quantitative trait loci (QTL) were detected as per latest analysis by Dr. C. Andaya. Three of these QTLs were found to be consistent across locations and years (see DNA Marker Laboratory).

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 small plots for yield evaluation. Table 6 summarizes the performance of selected stem rot resistant lines compared to M-205, M-206, and M-105. These four stem rot resistant selections are significantly better in terms of resistance scores compared to the checks but they still are later maturing and low yielding. However, one line in particular, 13P3395, registered a grain yield that was competitive with the three checks. These lines will be evaluated further and will serve as a good germplasm resource for the different breeding projects.

Table 6. Performance of select stem rot resistant lines from the mapping population compared against three medium grain varieties.

ID	Pedigree	Grain Yield#	Days§	SV‡	Ht. (cm)	Lodge %	SR+
M-205		10930	89	4.7	80	5	4.9
M-206		10580	80	4.9	92	80	6.3
M-105		10370	74	4.9	86	40	6.3
13P3395	SRM4/M206*2	10310	89	4.9	94	0	3.6
13P3396	SRM4/M206*2	9200	87	4.9	88	0	3.8
13P3399	SRM4/M206*2	9110	87	4.7	85	0	3.4
13P3397	SRM4/M206*2	8080	87	4.9	77	0	3.3

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

Mutation Breeding

The Calrose 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, and M-401, we isolated interesting mutants that are short, early maturing, and perhaps with tolerance to certain herbicides. Generation of mutants and screening protocols is currently handled by Dr. C. Andaya.

Development of herbicide-resistant rice lines is a special project started by Dr. K.S. McKenzie for a number of years, working with UC weed scientists for guidance on popular or emerging chemical products and screening methods. The potential benefit to the California rice farmer is significant if mutant lines are identified to tolerate registered herbicides in the market.

In previous years, early M-401 mutants were identified. These mutants were isolated from EMS-treated seeds in the initial chemical mutagenesis experiment in 2010. Performance of the M-401 mutant lines are summarized in Table 7. The mutants flowered about 30 days earlier than M-401, had slightly lower seedling vigor, shorter height, and more prone to lodging. Percent chalky grains is comparable to M-401, but with larger grains. Milling yields were lower based on samples taken at the station.

Tests will be done to determine if these mutants have maintained the premium quality attributes of M-401. ◆

Table 7. Performance of M-401 mutants isolated from chemical mutagenesis.

ID	Grain Yield#	SV‡	Days§	Ht. (cm)	Lodge %	% Chalk	Length (mm)	Width (mm)	L/W Ratio	1000-grain Weight	%Head/ %Total
M401ES1-1	8890	5.0	89	102	13	5	6.08	2.55	2.39	24.0	63/73
M401ES1-2	8600	4.9	89	94	5	17	6.12	2.65	2.31	23.9	63/73
M401ES1-3	7090	4.8	88	96	10	22	6.18	2.63	2.35	24.2	61/72
M401ES1-4	7430	4.9	89	95	15	9	6.14	2.63	2.33	24.4	59/73
M401ES1-5	7690	4.9	88	98	18	9	6.14	2.63	2.33	24.4	60/73
M401ES2-1	8020	4.9	89	100	10	12	6.12	2.6	2.36	24.2	60/73
M401ES2-2	9080	4.9	89	102	8	11	5.96	2.62	2.28	23.4	50/70
M401ES2-3	6500	4.9	88	95	3	11	6.16	2.62	2.35	24.1	58/73
M401ES2-4	7730	4.8	89	95	5	14	6.15	2.63	2.34	23.9	55/72
M401ES2-5	8200	4.9	89	102	8	14	6.11	2.65	2.30	24.0	56/72
M401ES2-6	7710	4.9	89	96	3	12	6.16	2.64	2.34	24.1	56/73
M401ES2-7	7060	5.0	88	100	10	13	6.11	2.64	2.32	23.8	54/73
M401ES2-8	8900	4.9	88	98	5	13	6.12	2.67	2.30	23.8	58/73
M401ES2-9	8110	4.9	89	99	8	11	6.13	2.62	2.34	23.9	57/72
M-206	6250	4.9	82	96	5	10	5.80	2.61	2.23	21.5	64/71
M-401	6970	5.0	118	111	0	14	5.99	2.65	2.26	23.2	
MEAN	7760	4.9	90	98	7.7						
CV	15.8	1.4	1.1	6.5	96.2						
LSD (.05)	2560	0.2	2.0	13.3	13.3						

‡ SV = seedling vigor score, where 1 = poor and 5 = excellent;
§ Days to 50% heading;
\# Paddy rice yield in lb/acre at 14% moisture

PREMIUM QUALITY AND SHORT GRAINS PROJECT

Stanley Omar PB. Samonte

Introduction

The Premium Quality and Short Grains Project encompasses 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), and
- 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. In addition, there are specific trait parameters that are selected 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 (CA-201) for SLAs, Calmochi-101 (CM-101) for SWXs, Calhikari-202 (CH-202) and Koshihikari for SPQs, M-402 and M-401 for MPQs, and 87Y235 for BGs. Selected lines must show improvements over their respective checks.

In 2013, major nurseries and tests conducted included:

- Crossing Nursery (2012-2013 Winter and 2013 Summer)
- F_1 Nursery (2012-2013 and 2013-2014 Hawaii, 2013 Summer)
- F_3 to F_4 Nursery (2013 Summer)
- F_5 Nursery (2012-2013 and 2013-2014 Hawaii Winter)
- 10 x 10 Yield Tests (2013 RES)
- Preliminary Yield Tests (2013 RES)
- UCCE Statewide Yield Tests (SW) (2013 at multi-locations)
- Cooking Strip Test (2013 Summer)
- Milling Yield Test (2013 Summer)
- Cold Tolerance Nursery (2013 San Joaquin and 2013 Greenhouse).

Collaborations were conducted with pathologist Jeff Oster (to determine the reaction of rice lines to stem rot, sheath spot, and blast) and Dr. Cynthia Andaya (to determine blast resistant plants through marker-assisted selection).

This project report highlights the performance of new SPQ variety CH-202, and elite lines MPQ 11Y2183, SG 09Y2179, and SWX 09Y2141.

Premium Quality Short Grain Rice

Calhikari-202, which was released in 2012, has continued to show its yield advantage over CH-201 (released in 1999). In the SW Tests from 2010 to 2013, CH-202 had higher grain yield than CH-201 in 26 out of 42 test environments (6 of 9 in 2010, 8 of 11 in 2011, and 6 of 11 in both 2012 and 2013) for a 4-year average of 8,621 lb/acre, which was 4% higher than that of CH-201 (8,278 lb/acre). Head rice percentage averaged 64% across 2012 and 2013 for both CH-202 and CH-201. Satake Rice Taste Meter scores in 2013 were similar between CH-202 and Koshihikari, and higher than CH-201. Satake taste scores were 65, 64, and 56, respectively.

In a comparison between CH-202 and CH-201 in 42 SW Tests from 2010 to 2013, CH-202 was the higher yielder more frequently in RES, Yolo, and Yuba test locations, CH-201 was the higher yielder more frequently in San Joaquin and Colusa test locations, while both varieties were higher yielders on equal occasions in Sutter, Butte, Glenn, and west Sutter test locations.

There were 5 SPQ entries in the preliminary group of the 2013 SW Tests. Among these, 12Y2167 was noteworthy because of its higher yield, lower lodging, less blanking, and lower chalkiness compared to checks CH-201 and CH-202.

Premium Quality Medium Grain Rice

In 2013, there were 8 MPQ lines evaluated in the SW Tests, consisting of 2 (11Y2183 and 11Y2022) in the advanced group and 6 in the preliminary group. 11Y2183 was an outstanding line among MPQ entries. It was evaluated in two maturity groups (early and intermediate/late) of the SW Tests, and had significantly higher yields than M-402 in 5 of the 7 test locations (Fig 1).

When averaged across 2012 and 2013, 11Y2183 yielded 9480 lb/acre, which was 15 and 10% higher than M-402 and M-401, respectively (Fig. 1). Compared to M-402 and M-401, 11Y2183 had higher whole milled rice yield, similar seedling vigor, earlier heading, less chalkiness, and better taste (Table 8). A notice for the experimental seed increase of 11Y2183 in 2014 has been submitted.

Conventional Short Grain Rice

The project evaluated 5 SG lines in the 2013 SW Tests, consisting of 2 (09Y2179 and 09Y2036) in the advanced group, and 4 in the preliminary group. 09Y2179 was the outstanding line among the SG entries. It had significantly higher grain yields than S-102 in 3 of the 4 test locations of the Early Maturing Group of the SW Tests (Fig. 2).

When averaged across 2011 to 2013, 09Y219 yielded 9690 lb/acre, which was 14% higher than S-102 (Fig. 2). Compared to S-102, 09Y2179 had higher whole milled rice yield, higher head rice percentage, more days to heading, less lodging, and better resistance to sheath spot (Table 9). SG 09Y2179 has a glabrous grain compared to the pubescent grain of S-102.

SG 09Y2179 was purified in head rows in 2013. A notice for the experimental seed increase of 09Y2179 in 2014 has been submitted.

Waxy Short Grain Rice

The project evaluated 3 SWX entries in the SW Tests in 2013. SWX 09Y2141 was grown in both the very early and early maturity groups, and it had higher grain yield than CM-101 and the two SWX entries.

SWX 09Y2141 is high yielding, semi-dwarf, early-maturing, and glabrous. It has been evaluated in the SW Tests, as an entry in the early maturing group in 2010, and as an entry in both the very early and the early maturing groups from 2011 to 2013, for a total of 27 SW test environments (or year-location combinations). In 2013, 09Y2141 was purified in isolated wet-seeded headrows.

In comparison to the SWX check variety CM-101, 09Y2141 had significantly higher grain yield in all SW Test environments that it was tested in from 2010 to 2013. Test locations were at Butte, Colusa, RES, San Joaquin, Sutter, Yolo, and Yuba. The yield advantage of 09Y2141 over CM-101 ranged from 17 to 39%. Overall, grain yield (averaged across 27 environments) was 10,000 lb/acre for 09Y2141 and 7,860 lb/acre for CM-101 (Table 10).

Table 10 shows the trait parameters of 09Y2141 and CM-101. Compared to CM-101, 09Y2141 was similar in seedling vigor, taller by about 3 cm, it required two more days to reach heading, and lodged 3% more. SWX 09Y2141 had a higher head rice percentage at 65%, larger grain size dimensions, and lower viscosity when cooked. Blanking, which was based on the San Joaquin Trials, was slightly higher in 09Y2141 than CM-101.

In 2013, some comments from the external evaluations on cooking quality indicated that 09Y2141 was softer than CM-101, and that it may be useful for soft *Mochi* such as Raw *Mochi* and *Wagashi*, Japanese traditional confectionery.

The SW Tests have shown 09Y2141 to be superior to CM-101, which was released in 1985 and is the standard short waxy grain variety. In 2014, 09Y2141 was approved for foundation seed increase.

Low Amylose Short Grain Rice

In 2013, two SLA lines were evaluated in the SW Test. SLA 09Y2159 was evaluated in the early-maturing advanced group while 11Y2229 was evaluated in the very early maturing preliminary group.

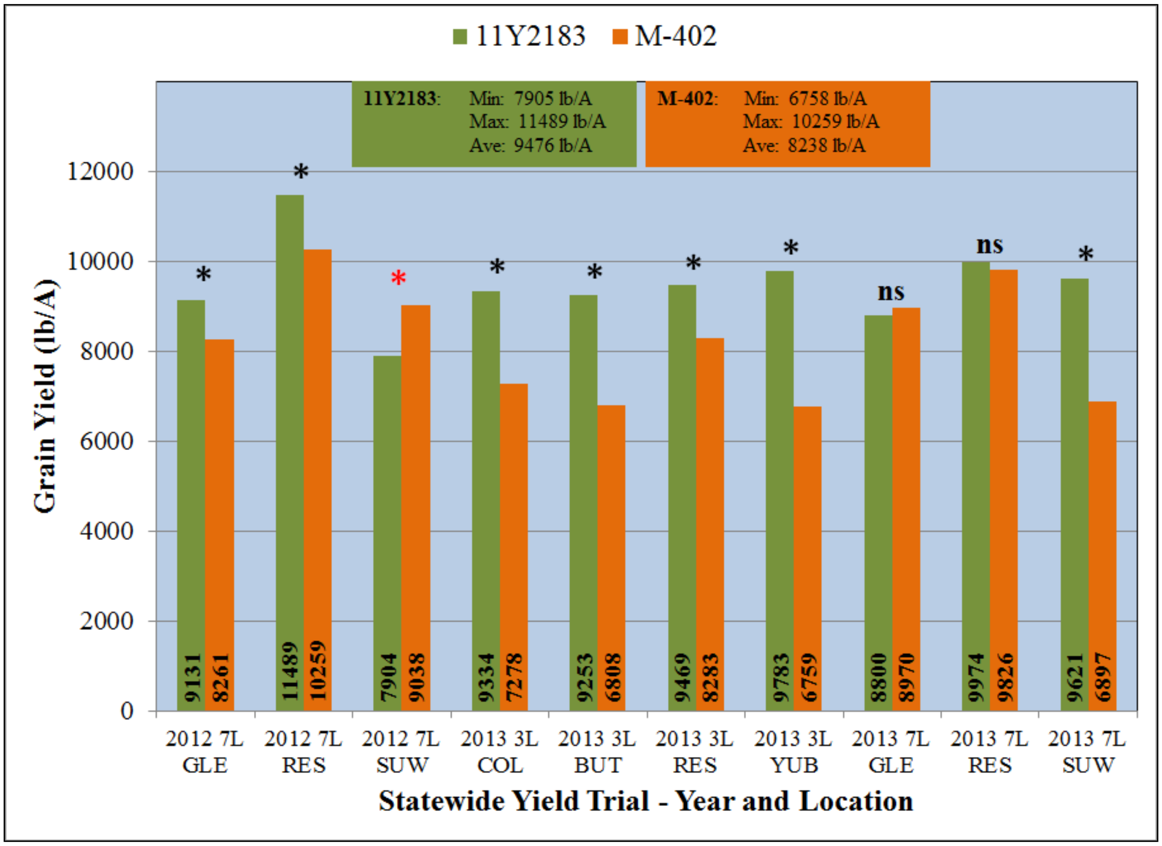
Grain yield of 09Y2159 (8660 lb/acre at RES and 8530 lb/acre when averaged across Colusa, Butte, Yuba and RES) was higher than that of CA-201 (6590 lb/acre in RES, and 6380 lb/acre statewide average). However, its head rice percentage (61%) was lower than that of CA-201 (70%), as well as its seedling vigor rating (4.4 vs. 4.9). 09Y2159 could be used as a yield-improved SLA parental line in future crosses with SLA lines that have higher headrice percentage and seedling vigor rating.

Arborio or Bold Grain Rice

Currently, Arborio or bold grain rice types are being grown on a small acreage in California. RES has not yet released a BG variety, although it has released 87Y235 as a germplasm in 1994. The development of new BG lines is a first step to increase interest in this type of rice. The improvement of the plant type of our BG lines is of particular interest.

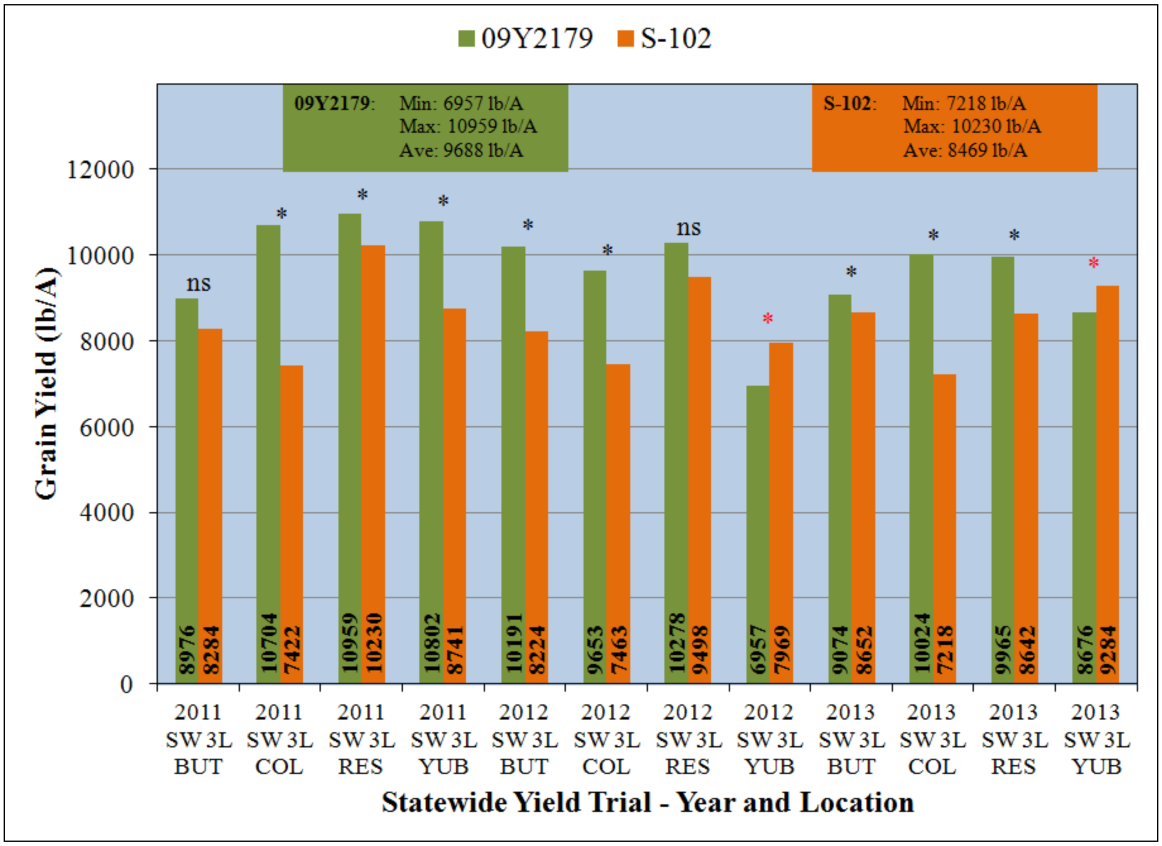
A BG entry (11Y2111) was evaluated in the 2013 SW Tests. However, 11Y2111 will be dropped because of its non-significant yield difference when compared to check 89Y235. ◆

Fig. 1. Grain yield of premium quality medium grain 11Y2183 and M-402 in the intermediate maturity group of the SW Tests in 2012 and 2013.



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

Fig. 2. Grain yield of short grain 09Y2179 and S-102 in the early maturity group across of the SW Tests from 2011 to 2013.



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

Table 8. Trait parameters of premium quality medium grain 11Y2183, M-402, and M-401 from 2012-2013.

TRAIT	2012			2013			Average †		
	11Y2183	M-402	M-401	11Y2183	M-402	M-401	11Y2183	M-402	M-401
Agronomics									
Grain Yield (lb/A)	9508	9186	8620	9462	7832	8670	9476	8238	8645
Head Rice (%)	64	65	57	64	68	61	64	67	59
Whole Milled Rice Yield (lb/A)	6085	5971	4913	6056	5326	5289	6065	5519	5101
Seedling Vigor (1-5, 5 Best)	5.0	5.0	5.0	4.9	5.0	5.0	5.0	5.0	5.0
Heading (d)	91	97	103	94	107	110	93	102	107
Height (cm)	102	99	107	99	100	112	101	100	110
Lodging (%)	12	2	34	13	9	32	13	6	33
Blanking (%)	5	4	-	10	5	8	8	5	8
Grain Quality									
Milled Kernel Length (mm)	5.91	5.68	5.95	5.97	5.76	6.12	5.94	5.72	6.04
Milled Kernel Width (mm)	2.44	2.46	2.53	2.48	2.56	2.71	2.46	2.51	2.62
Milled Kernel L/W Ratio	2.42	2.31	2.35	2.40	2.25	2.26	2.41	2.28	2.31
1000-kernel wt (g)	21.4	19.2	21.9	21.6	20.1	23.3	21.5	19.7	22.6
Total Rice Chalky Area (%)	20	23	24	8	10	14	14	17	19
Total Rice Whiteness	126	124	124	127	127	129	127	126	127
Total Rice Vitreous	126	124	124	122	121	121	124	123	123
Milled Kernel Protein (%)	5.6	6.0	5.0	6.1	5.0	4.8	5.9	5.5	4.9
Blind Taste Test (Rank)	1.4	1.7	1.9	1.5	2.2	2.0	1.5	2	2
Disease Reactions									
Stem Rot (0-10, 0 Resistant)	4.8	4.3	4.9	6.3	5.5	5.1	5.6	4.9	5.0
Sheath Spot (0-4; 0 Resistant)	1.3	0.8	0.6	1.6	1.1	0.6	1.5	1.0	0.6
Blast (0-4; 0 Resistant)	-	-	-	2.8	3.0	-	2.8	3.0	-

† Average across yield tests or nurseries from 2012 to 2013.

Table 9. Trait parameters of short grain 09Y2179 and S-102 in 2013 and when averaged across referenced tests or nurseries.

TRAIT	2013		Average †		
	09Y2179	S-102	09Y2179	S-102	Reference
Agronomics					
Grain Yield (lb/A)	9435	8449	9688	8469	1
Head Rice (%)	58	57	61	59	2
Head Rice Yield (lb/A)	5472	4816	5910	4997	1, 2
Seedling Vigor (1-5)	4.9	4.9	4.8	5	1
Heading (d)	92	80	90	82	1
Height (cm)	104	99	105	102	1
Lodging (%)	1	44	2	58	1
Blanking (%)	7	6	7	6	3
Grain and Cooking Quality					
Milled Kernel Length (mm)	5.23	5.34	5.15	5.34	4
Milled Kernel Width (mm)	2.96	2.93	2.88	2.94	4
Milled Kernel L/W Ratio	1.77	1.83	1.79	1.82	4
1000-kernel wt (g)	22.5	23.1	22.0	23.2	4
Total Rice Chalky Area (%)	28	10	27	28	4
Total Rice Whiteness	137	126	132	125	4
Total Rice Vitreous	116	119	122	121	4
Milled Kernel Protein (%)	5.7	6.2	5.7	6.3	5
Satake Taste Meter (35-100 score)	57	57	57	57	6
Blind Taste Test (Rank)	1.5	1.5	1.5	1.5	6
Disease Reactions					
Stem Rot (0-10; 0 Resistant)	5.2	5.9	4.8	5.8	7
Sheath Spot (0-4; 0 Resistant)	0.7	2.1	1.0	2.6	7
Blast (0-4; 0 Resistant)	3.0	3.3	3.0	3.3	8

† Average across referenced tests or nurseries
[1] 2011-2013 Statewide Tests
[2] 2011-2013 Milling Tests
[3] 2011-2013 San Joaquin Cold Nurseries
[4] 2012-2013 Milling Tests
[5] 2011-2013 Milling Tests
[6] 2013 Cooking Tests
[7] 2011-2013 Disease Rating Nurseries
[8] 2013 Disease Rating Nursery

Table 10. Trait parameters of waxy short grain 09Y2141 and CM-101 in 2013 and when averaged across years.

TRAIT	2013		Average †		
	09Y2141	CM-101	09Y2141	CM-101	Reference
Agronomics					
Grain Yield (lb/A)	9861	7882	9999	7862	1
Head Rice (%)	64	61	65	62	2
Whole Milled Rice Yield (lb/A)	6311	4808	6499	4874	1, 2
Seedling Vigor (1-5)	5.0	4.9	4.9	5	1
Heading (d)	85	83	87	85	1
Height (cm)	100	93	101	98	1
Lodging (%)	27	31	38	35	1
Blanking (%)	17	11	11	8	3
Grain and Cooking Quality					
Milled Kernel Length (mm)	5.19	5.07	5.15	5.00	4
Milled Kernel Width (mm)	2.93	2.79	2.92	2.72	4
Milled Kernel L/W Ratio	1.77	1.81	1.77	1.84	4
1000-kernel wt (g)	22.9	19.7	23.6	19.2	4
Total Rice Chalky Area (%)	110	109	130	156	4
Total Rice Whiteness	30	41	41	57	4
Total Rice Vitreous	41	53	54	73	4
Milled Kernel Protein (%)	5.9	5.9	5.5	6.3	5
Disease Reactions					
Stem Rot (0-10; 0 Resistant)	5.8	5.5	5.4	5.3	6
Sheath Spot (0-4; 0 Resistant)	2.4	2.3	2.7	2.5	7
Blast (0-4; 0 Resistant)	3.5	3.0	3.5	3.0	8

† Average across referenced tests or nurseries
[1] 2010 to 2013 Statewide Tests
[2] 2010-2013 Milling Tests
[3] 2012-2013 San Joaquin Cold Nursery
[4] 2012-2013 Milling Tests
[5] 2011-2013 Milling Tests
[6] 2010-2013 Disease Rating Nursery
[7] 2011-2013 Disease Rating Nursery
[8] 2013 Disease Rating Nursery

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 2013 multi-location, early and intermediate maturity groups, Statewide Yield Tests averaged 9220 lb/acre (Tables 18 and 20). Average yield for M-205 within the same tests was 9040 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 2006–2013 seasons was 61%. Kernel length of L-206 ranged between 7.1 and 7.3 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 11. Entries 12Y020 and 11Y1005 performed well in 2013 statewide tests as compared to standard varieties. Of special importance is the performance of 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 4 days later than L-206 and about 5” taller. Milling yields of these lines in 2012 and 2013 averaged 3 percent higher than L-206. Overall kernel size of 11Y1005 is the same as L-206. 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. Preliminary head rows have currently been planted in Hawaii winter nursery. Head row blocks of both lines will be planted in 2014 nursery.

Table 11. Performance of selected conventional long-grain entries as compared with standard varieties in 2013 yield and milling tests.

Entry	Type†	Identity	Yield‡		Head Rice§
			Statewide	RES	(%)
Very Early Statewide					
37	L	12Y20	9790	9880	63
10	L	11Y1005	9730	10980	62
8	L	L-206	9210	9970	59
4	M	M-206	9130	8610	66
Early Statewide					
63	L	11Y1008	10100	9180	63
62	L	09Y1122	9920	9400	63
60	L	L-206	9410	8420	61
55	M	M-206	9150	8160	--
Intermediate Statewide					
128	L	12Y1155	10010	10890	56
127	L	12Y1168	9620	9850	53
111	L	L-206	9020	9460	59
109	M	M-206	9260	9570	--
Very Early Preliminary					
1063	L	13Y1063	--	11530	59
1035	L	13Y1035	--	11430	59
1001	L	L-206	--	9470	62
Early Preliminary					
1100	L	13Y1100	--	10690	57
1082	L	L-206	--	9840	60
Intermediate Preliminary					
1202	L	13Y1202	--	10550	59
1163	L	L-206	--	9090	59

†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 2013. 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 Tables 11 and 12.

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 2013 early and intermediate-late tests were 6070 lb/acre as compared to 9220 for L-206 (Tables 21 to 23).

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.

Three improved experimental basmati lines, 11Y158, 12Y1054, and 13Y135 were tested in the 2013 UCCE Statewide Yield Tests. Cooking quality evaluations of these lines in earlier generations has shown considerable quality advantages over Calmati-202. 11Y158 is an early maturing, true basmati type, pubescent experimental line that was in the advanced purification stage in 2013. Headrow components from these lines are being evaluated for subtle basmati quality differences such as cooked grain texture. 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. Aging of this selection by one year has increased its RVA viscosity values. A stronger RVA profile is expected to improve cooked grain texture resulting in more flakey cooked rice as is the case with imported basmati. An average grain yield over 6 statewide locations was 4800 lbs/acre for 11Y158. Primary drawback of 11Y158 is a low milling yield of 36%. This compares with 61% for Calmati-202. Small experiments have been planned for 2014 to identify harvesting and processing procedures that can enhance milling yield and cooking quality. These factors include harvest moisture, drying rate, and milling degree. Based on the current grain and head rice yield estimates, whole grain production per acre of this line can be estimated at 2000 lb/acre. Standard long grain variety L-206, at the same time, with the current level of production can potentially yield 6200 lb/acre of whole grain. The current market price differential between basmati rice and standard long grain is considerably higher than 3 to 1 ratio. Efforts, however, continue to improve both grain and milling yields without losing any basmati quality attribute. Entries 12Y1054 and 13Y135 showed significant advantages in both areas in 2013 tests (Table 12).

Efforts continued in 2013 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 2013, 5 jasmine type selections were tested in the UCCE Statewide Yield Tests and 50 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 12Y1178 and 11Y106 have shown good jasmine quality attributes and acceptable agronomic characteristics (Table 13).

Efforts in the area of conventional aromatics increased in 2013 due to a need for an A-301 type variety replacement that possessed improved agronomic traits. Four experimental lines, 11Y1049, 11Y1096, and 12Y1128 and 12Y1037 were tested in 2013 statewide tests. Entry 11Y1049 was grown as foundation seed in 2013. This line has approved for release and will be describe in the later section of this report.

Release of A-202

Aromatic long-grain experimental line 11Y1049 was approved for release by the CCRRF Board of Directors in January 18, 2014 as ‘A-202’. 11Y1049 is an early maturing semidwarf selection (Table 14). Compared to A-301, it is 9 days earlier, 4” taller, and has significantly higher seedling vigor score. Two year average yield in early statewide tests was 1800 lb/acre higher than A-301. Average headrice yields during 2012 and 2013 were 60% and 53% for 11Y1049 and A-301, respectively. 11Y1049, similar to A-301, is sensitive to cold induced blanking and therefore not recommended for cold locations. Susceptibility to stem rot and aggregate sheath spot diseases is not significantly different from A-301 or A-201. Plants of 11Y1049 are glabrous and anthocyanin pigmentation occurs only in appiculi and fades at maturity. Aroma volatilization of 11Y1049 is slightly less during cooking process. Flavor sensory of this line, however, is similar to A-301. Milled kernels of 11Y1049 are slightly bolder than A-301 (Table 14), with average length of 7.36 and average width of 2.27 mm. Amylose content, gelatinization temperature type, and RVA profile of 11Y1049 is typical conventional long-grain type, similar to A-301 and L-206. Subjective evaluations of cooked grain texture indicate that 11Y1049 is slightly softer than Standard variety, L-206.

Areas of adaptation for 11Y1049 include Butte, Yuba, Colusa, Glenn, and Sutter counties. A 4 acre foundation field of 1049 was produced in 2013 at RES. To expedite the foundation seed production, a block of breeder seed was produced during the winter of 2012 in Kauai winter nursery.

Table 12. Performance of selected jasmine and basmati type long-grain entries in 2013 Statewide Yield and RES milling tests.

					Yield†							
					Early			Intermediate				
Entry	Type‡	SV	DH	Ht	RES	Butte	Colusa	Yuba	Sutter-W	Glenn	Avg.	HR§
L-206	L	4.6	81	86	9000	9390	10250	9590	8720	8870	9220	59
11Y106	J	3.6	94	104	8790	8710	6170	7240	7890	7790	7960	49
12Y1178	J	4.8	85	99	6970				7100	7560	7210	61
CT202	B	4.9	84	94	5890	6450	5970	5750	6040	6340	6070	60
12Y1054	B	4.9	77	89	5440	5920	6160	5710			5810	49
13Y135	B	4.9	84	89	6960				5860	5990	6270	55
11Y158	B	4.7	93	76	4650	4680	5580	4330	4670	4820	4800	40

† Grain yield in lb/acre at 14% moisture.
‡ L= conventional long grain type, J = jasmine type, B = basmati type.
§Head rice yields are from solid seeded stands for all entries.

Table 13. Performance of selected jasmine and basmati type long-grain entries in 2013 Statewide Yield and RES milling tests.

					Yield†							
						Early		Intermediate				
Entry	Type‡	SV	DH	Ht	RES	Butte	Colusa	Yuba	Sutter-W	Glenn	Avg.	HR§
L-206	L	4.6	81	86	9000	9390	10250	9590	8720	8870	9220	59
11Y106	J	3.6	94	104	8790	8710	6170	7240	7890	7790	7960	49
12Y1178	J	4.8	85	99	6970				7100	7560	7210	61
CT202	B	4.9	84	94	5890	6450	5970	5750	6040	6340	6070	60
12Y1054	B	4.9	77	89	5440	5920	6160	5710			5810	49
13Y135	B	4.9	84	89	6960				5860	5990	6270	55
11Y158	B	4.7	93	76	4650	4680	5580	4330	4670	4820	4800	40

† Grain yield in lb/acre at 14% moisture.
‡ L= conventional long grain type, J = jasmine type, B = basmati type.
§Head rice yields are from solid seeded stands for all entries.

Table 14. Quality characteristics of aromatic experimental 11Y1049 (A-202) as compared with A-301and A-201.

ID	Aroma content	Dimension					Cook type	RVA			
	2AP ppb	Area mm^2	Length mm	Width mm	Wt/100 k g	Amylose	Gel type	Peak	Hold	Final	Set back
A-301	1221	12.8	7.39	2.17	2.15	23.1	Int	299	178	312	13
A-201	844	12.3	7.40	2.07	1.95	24.8	Int	225	140	286	61
11Y 1049	1051	13.2	7.36	2.27	2.26	23.8	Int	277	159	292	16
L-206	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.

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 2013, 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. In 2013, 1 entry was tested in statewide tests and 18 in preliminary tests with a range of SR resistance. 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.

Entry 10Y1008 is a stem rot resistant line that compared favorably with L-206 grain and milling yield in 2013 (Tables 18 and 21). This line was scored as the most resistant entry in 2013 statewide disease screening tests. Preliminary yield tests in 2013 also showed very high yields, within long-grain nursery, from a number of stem rot resistant populations. ◆

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 2566 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 (500 rows plus greenhouse SS screening). Surviving materials will 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 4168 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 6215 rows in the 2013 SR nursery.

This year, 2900 rows in the stem rot nursery were drill seeded. This resulted in less seed drift, establishment of a more uniform stand, and allowed use of higher nitrogen without inducing lodging. Increased nitrogen results in greater disease severity and better screening.

Promising long and short grain resistant lines are emerging, but progress has been slow with the medium grains.

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, 1019 BC_3F_4 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 2012 were again resistant in solid seeded plots, but not in rows (except for the resistant line 87Y550). Apparently, as backcrossing progresses, a shift in plant type away from 87Y550 may make row screening less effective. 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.

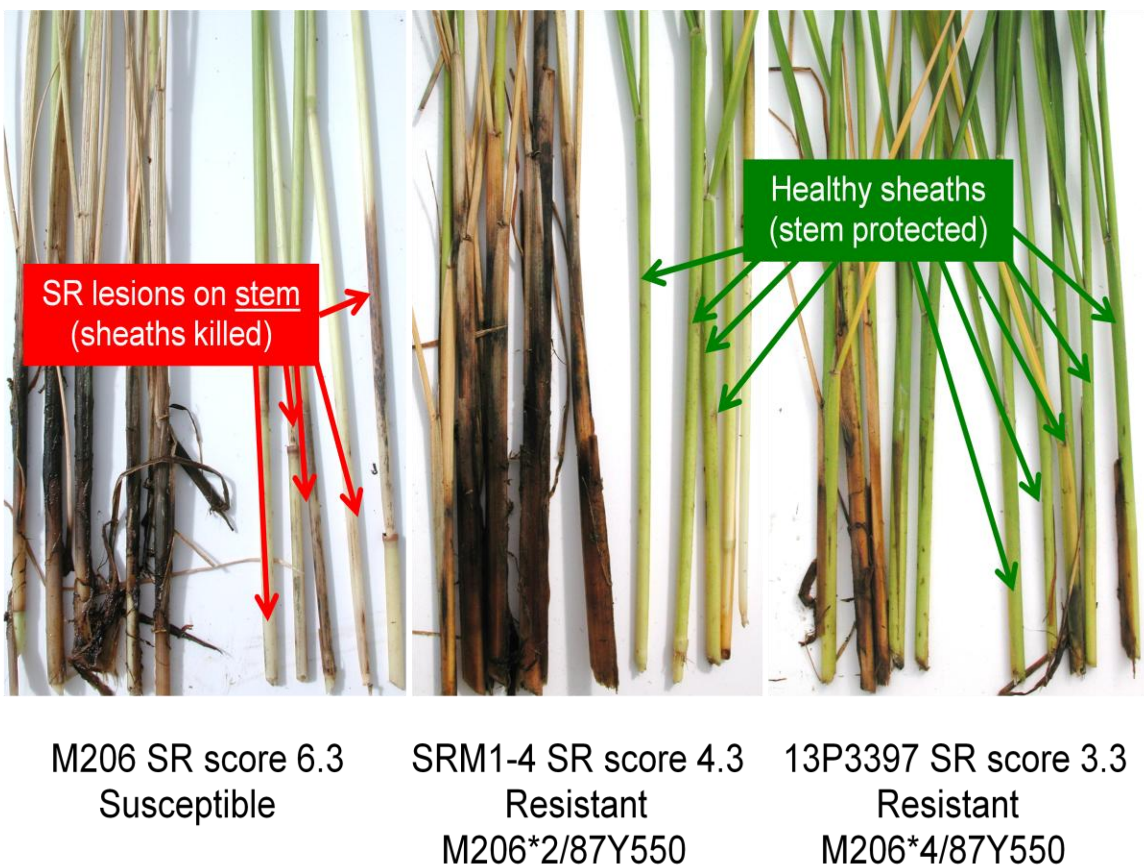
Molecular markers would enable selection for disease resistance without having to perform biological screening and the uncertainties of environmental fluctuations that come with it. Such markers would allow early generation identification of resistant seedlings before crossing, thus greatly speeding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

The following figure shows what SR resistance looks like. M-206 (on the left) has a score of 6.3, meaning that all leaf sheaths around the stem are killed, and the fungus has penetrated the stem. Stems on the left are not stripped, while all dead sheaths are stripped on the right. SRM1-4 and 13P3397 are resistant lines from the original (BC_1) and the fine mapping (BC_3) populations, respectively. Note that healthy leaf sheaths enclose the stem. Resistance protects leaves responsible for grain filling, and these leaves remain green through grain maturity. It also decreases or prevents formation of sclerotia, which cause disease in future crops.

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 are now being 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.

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 and 2013. 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 for the first time 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.

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 2012-3, 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 M208 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 M208 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 M208 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). Farm Advisor Chris Greer has indicated he would like to have DNA of selected isolates sequenced by UC Davis facilities. Hopefully, the segments of DNA which make IG1 and IB1 races different can be identified. In this way, races could be determined by DNA tests in the same way that blast resistance genes are now identified.

				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

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

The DNA Marker Lab performs activities in support of the different breeding projects and spearheads the implementation of special projects. The DNA lab is involved in the following activities: (1) marker-aided selection (MAS) for the different grain types (2) fingerprinting activities of various materials, (3) pyramiding of blast resistance genes, (4) genetic mapping of stem rot resistance gene(s), (5) herbicide resistance screening, and (6) mutagenesis.

The main goal of the DNA marker laboratory is to assist the breeders in their selection work by using DNA marker technologies. Other activities listed above are done as time and resources permit.

Marker-Aided Selection

In 2013, the DNA Laboratory devoted its efforts in performing MAS for the breeders, especially on blast resistance and grain quality. A total of 4,200 breeding lines were screened for the Calrose project using the 4 blast resistance markers, generating 16,840 data points (Table 15). Around 7,300 plants were screened for blast resistance in the short grain project (Table 16) generating around 29,000 data points. About 530 plants evaluated from the SG project were transplanted in the greenhouse after marker evaluation to recover seeds for breeder's use. The markers help identify plants that contain the resistance genes and thereby precluding the laborious blast inoculation tests in the greenhouse. Around 2,000 long grain breeding lines and 152 short grains were evaluated using 5 DNA markers for grain quality (Table 17). Using the grain quality markers: gt-alk, RM 190, and Waxy SNPs Intron1, Exon6, and Exon10, about 10,160 data points were generated. The genotype scores for these markers give the breeder a predicted quality scores in terms of gel temperature, amylose type, 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.

Marker-aided selection for herbicide resistance was also done in the lab this year. Using markers developed to detect mutation in the ALS gene that confers resistance to Newpath (Clearfield), around 100 lines were evaluated using S653 and R653 markers to identify the plants containing resistance to imazethapyr. The resistant lines identified through marker work were grown by the plant breeders to maturity for further use.

Table 15. Marker-Aided Selection (MAS) for blast resistance in the medium-grain project.

Type	No. of Lines	Date of Selection	No. Data Points
Blast Pyramids	1342	January 2013	5368
F_1's	800	January 2013	1600
Blast Pyramids	2068	February 2013	8272
TOTAL	4210		16840

Table 16. Marker-Aided Selection (MAS) for blast resistance in the short-grain project.

Type	No. of Lines	Date of Selection	No. of Plants Transplanted	No. Data Points
F_1's	416	May 2013	0 (Field materials)	1664
F_2's	2305	July 2013	275	9220
F_2's	4613	Oct- Nov 2013	255	18,452
TOTAL	7334		530	29,336

Table 17. Marker Aided Selection (MAS) for grain quality traits.

Breeding Project	No. of Lines	No. of Markers	No. of Data Points	Date of Evaluation
Long Grain	2032	5	10,160	Jan- March 2013
Short Grain	152	5	760	April 2013
TOTAL	2,184		10,920	

DNA Fingerprinting

An important component of the DNA lab is to provide assistance in variety identity and purity. In 2010, we started building a database of marker data using simple sequence repeats (SSRs) or microsatellite markers and DNA fingerprint of all California rice varieties released at RES as well as other rice variety introductions. To date, data for 177 markers run against the 50 released varieties where available. We will continue to add DNA markers to our database since fingerprinting success depends largely on markers that can distinguish one variety from another. We also have a panel of 11 DNA markers that can distinguish the CA medium-grain varieties from one another. These markers were fluorescently labeled to facilitate faster analysis of materials for fingerprinting. We will develop a similar panel for the long-grain and short grain-varieties.

Fingerprinting requests vary from year to year depending on the needs of the breeding program. This year, the short grain project requested the DNA lab to verify if 42 lines in Calmochi-101 head rows that showed variability in heading days are true-to-type. Using 6 markers namely: RM3689, RM72, RM333, RM7076, RM44 and RM279, the 42 lines were confirmed to be Calmochi-101. From these results, the SG breeder isolated two mutants he found interesting for future evaluation. These Calmochi-101 mutants arose spontaneously.

In the medium grain project, around 700 entries were fingerprinted in the month of July and August of 2013. These M-202 and M-401 mutants were evaluated using 15 DNA markers. Fingerprint data assures the breeder of the identity and purity of his materials. Variety identification was also performed on commercial rice (non-RES samples) to answer seed contamination questions.

Mapping Stem Rot Resistance

An advanced backcross recombinant inbred line mapping population from the cross 87Y550/M206*2 was used to map the stem rot resistance from *O. rufipogon*. In the first replicated trial in Biggs in 2010, stem rot resistance QTLs were reported in Chromosomes 4, 6, and 10. Using the data in the second year of replicated trial in two locations (Biggs and Glenn County) in 2011, seven QTLs were identified to contribute to stem rot resistance. QTLs were detected in Chromosomes 1, 2, 3, 4, 5, 6 and 10. In 2013, we added polymorphic markers in the chromosomes lacking coverage particularly in Chromosomes 7, 8, 9 and 11 and repeated the genetic analysis.

Using composite interval mapping of Qgene 4.3.7 and using untransformed stem rot scores in our current analysis, six QTLs were identified to contribute to stem rot resistance. The QTLs in chromosome 6 (qSR6.1) and 10 (qSR10) were both observed in both locations and years. These chromosome regions were also identified in previous analyses to contribute to stem rot resistance. Combined together, the two QTLs accounted for approximately 30% of the phenotypic variance. A QTL on Chromosome 5, qSR5, was observed in both locations in 2011 and accounts for 7% of the phenotypic variance.

In this particularly analysis, three more QTLs were identified to be highly significant in Glenn County only. The second QTL detected in Chromosome 6 (qSR6.2) accounts for 15% of the phenotypic variance. QTLs in Chromosomes 7 and 8 (qSR7, qSR8) explain 12% and 11% of the phenotypic variance, respectively. Clearly, there are several genes controlling stem rot resistance but we have found two QTLs in Chromosomes 6 and 10 that were both detected in both years and locations irrespective of the QTL analysis method employed. We will continue to look at our data using other available QTL analysis method as we also start our fine mapping of the region of interest.

Dr. Virgilio Andaya and Mr. Jeff Oster developed a fine mapping population by crossing the most resistant line in our mapping population to M-206. Around 322 lines from our fine mapping population were planted in the field this planting season. Tissues were harvested and DNA extractions were performed. We have started the genotyping work using select markers. We will continue with our marker work until we have enough data for genetic analysis.

Mr. Oster also obtained stem rot scores on the fine mapping population this year. The phenotype scores that he obtained will be analyzed together with the DNA Lab's genotype scores to determine if a consistent conclusion can be made. As phenotype scores are highly affected by the environment (location or seasons) across year and across location, replicated stem rot evaluation will be set-up.

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.

Pyramiding of Blast Resistance Genes

Rice blast disease caused by the fungal pathogen *Magnaporthe oryzae* causes considerable damage to rice. Although rice blast is not prevalent in California, it could pose a serious concern. M-208, released in 2005 contains a major blast resistance gene Pi-z has been observed to have blast in some fields.

Mr. Oster initiated a backcrossing program in 2005 to incorporate several blast resistance genes into M-206 background. M-206 was chosen because of its good combining ability and commercial importance. In 2012, thirty-six plants out of approximately 6,000 F_2 plants screened from the medium grain program were identified to contain all four-blast resistance genes using DNA markers (AP5930, RM224, RM331 and RM7102). These materials have resistance genes from four blast resistance sources namely: Drew (*Pita2*), C101LAC (*Pi33*), Cocodrie (*Pikh*) and IR65482-4-136-2 (*Pi40*).

The blast resistant pyramids were turned over to the breeders and are now being used by the breeders in their crossing work. The different breeders in their respective programs will mention the extent to which these materials are being used. Participation of the DNA Lab in creating blast resistance gene pyramids in the breeder's preferred genetic background will be continued as needed by the different breeding programs.

EMS Mutagenesis

Another special project at the RES is to generate materials that breeders can use in the breeding projects. Ethyl methane sulfonate (EMS) mutagenesis is one of the most widely used methods of generating mutations. EMS changes the structure of the guanine bases of the DNA causing it to pair with the wrong base. An alkylated guanine will pair with thymine instead of cytosine base. This ultimately results in an amino change or deletion.

In 2010, we started generating EMS-treated materials for the medium-grain and short- grain projects. The MG program identified interesting M-202 and M-401 mutants from this mutagenesis work. Dr. Virgilio Andaya reported on the progress of these selected materials (see Calrose Medium Grain). EMS lines that were not chosen by the breeder will be passed on to the DNA Lab for selection to herbicide tolerance. Additional mutagenesis will be done this coming year to generate materials that will be used for herbicide resistance project. ◆

BREEDING NURSERIES

Seeding of the 2013 breeding nursery began May 2nd, and was completed May 24th. In 2013, 1274 crosses were made at RES for rice improvement, bringing the total number of crosses made since 1969 to 43,824. 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 2013, thereby accelerating the breeding process.

The 2013 RES breeding nursery occupied approximately 76 acres. Water-seeded yield tests included 3536 small plots and 3215 large plots. The nursery included about 67,000 water-seeded and 29,580 drill-seeded rows and plots. F_2 populations from 2011 and 2012 crosses were grown in precision drill-seeded plots on 5 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 2014.

Headrows (1600) of M-402, M-401, Calmochi-101, and 01Y1049 were grown for breeder seed production in 2013. 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 2012-13 winter nursery was completed and seed returned to RES and planted in April. The 2013-14 winter nursery of 9281 rows was planted November 5-7, 2013, and 600 F_1 populations were transplanted to the nursery December 2, 2013. Selection and harvest will occur in April, and seed returned for processing and planting in the 2013 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 2013 Statewide Yield Tests were conducted at seven locations in commercial fields by Mr. Raymond L. Wennig, Dr. Randall G. Mutters, Dr. James E. Hill, Dr. Chris Greer, and Dr. Luis Espino. Advanced selections were tested in one of the three maturity groups: very early, early, or intermediate to late with standard check varieties included for comparison. Each maturity group was subdivided into an advanced and preliminary experiment. The advanced entries and checks had four replications and the preliminary entries had two replications. Plots were combine-size (10 by 20ft) and the experimental designs were randomized complete blocks.

All 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 Stam80df® were applied for weed control and one application of Silencer® was applied for rice water weevil control.

Tables 18 through 23 contain a summary of performance information from the 2012 Statewide Yield Tests. Yields are reported as paddy rice in pounds per acre at 14% moisture. Combine harvest was delayed due to muddy soils from rain and harvest moistures were very low (<12%) and believed to have lower yields. 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 2014. Complete results of the UCCE Statewide Yield Tests can found on the web at http://ucanr.edu/sites/UCRiceProject/Research/Agronomy_Progress_Reports/.

Table 18. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
10	11Y1005	L	4.7	85	104	1	4.9	10980	9730
5	08Y3269	M	4.9	91	102	2	5.2	10860	9790
15	09Y2036	S	5.0	82	104	25	5.8	10440	9710
8	L-206	L	4.8	81	91	6	6.0	9970	9210
9	10Y1008	Lsr	4.7	83	97	2	5.1	9960	8980
1	M-104	M	4.9	78	99	22	6.2	9710	9200
16	11Y2022	MPQ	4.9	83	102	9	6.7	9630	9410
7	10Y3286	M	4.8	83	97	11	6.3	9580	9300
6	08Y3126	M	4.7	84	102	14	6.0	9490	9480
2	M-105	M	4.8	80	102	4	6.3	9150	9240
12	S-102	S	4.9	79	99	7	5.2	9120	8690
14	CH-202	SPQ	4.8	81	94	55	5.3	8880	8880
13	CH-201	SPQ	5.0	84	94	40	6.5	8700	8710
4	M-206	M	4.9	82	102	20	7.0	8610	9130
11	CM-101	SWX	4.8	81	94	24	4.8	8580	8110
3	M-202	M	5.0	89	99	7	6.1	8380	8940
Mean			4.8	83	99	15	5.9	9500	9160
LSD(0.05)			0.1	2	5	20	0.7	780	260
CV %			1	2	4	90	8	6	4

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

Table 19. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
43	10Y2043	S	4.9	80	102	1	5.1	10610	10290
52	11Y2223	S	4.8	80	94	3	6.0	10610	9730
46	09Y2122	S	4.9	85	104	6	5.7	10400	9820
37	12Y20	L	4.8	85	104	1	5.3	9880	9790
30	12Y113	M	4.7	83	104	15	6.6	9850	9600
42	09Y2141	SWX	5.0	82	107	8	5.4	9560	9930
51	11Y2160	SWX	4.8	83	102	6	5.6	9550	9380
45	12Y2010	SPQ	5.0	80	89	1	6.1	9340	9220
38	11Y1008	L	4.8	83	94	1	6.6	9310	9490
49	12Y2107	SWX	4.9	84	97	3	5.4	9250	9210
34	M-206+Pi-9	MB	4.8	83	56	25	6.3	9160	9000
27	11Y3209	M	4.7	81	94	3	5.8	9150	9220
32	M-206+Pi-kh	MB	4.9	84	102	5	6.3	9090	9320
44	10Y2037	S	4.8	83	104	3	6.8	9070	9020
19	11Y3532	M	4.8	79	97	3	6.0	9050	8950
17	M-205	M	4.9	92	99	1	5.3	9030	9050
31	12Y3097	MB	4.8	82	99	5	6.5	8910	9170
23	11Y3573	M	4.7	81	91	1	5.8	8900	9310
18	M-208	M	4.9	84	97	6	6.3	8810	9180
26	11Y3411	M	4.8	84	99	1	5.7	8700	8810
47	12Y2087	SPQ	5.0	81	99	3	5.5	8690	8850
36	M-206+Pi-33	MB	4.8	84	99	3	6.4	8650	9270
29	11Y3693	M	4.8	84	97	3	6.4	8620	8680
24	10Y3477	M	4.9	82	104	8	6.0	8610	9220
25	11Y3376	M	4.9	86	97	1	5.1	8600	9030
50	11Y2229	SLA	4.7	85	91	16	5.7	8550	8780
21	11Y3305	M	4.7	80	107	3	5.6	8520	8810
20	11Y3241	M	4.7	82	99	3	5.7	8370	8920
28	11Y3638	M	4.7	84	102	1	5.9	8080	8850
41	M-402	MPQ	5.0	112	112	1	5.6	8070	8290
35	M-206+Pi-ta2	MB	4.8	83	99	10	5.9	8020	8950
33	M-206+Pi-40	MB	4.8	83	102	20	6.2	7900	8870
22	11Y3406	M	4.8	81	102	1	6.0	7860	8530
48	12Y2093	MPQ	4.8	86	102	3	5.7	7790	9150
39	13Y39	L	4.9	86	102	1	6.1	7700	8880
40	CA-201	SLA	5.0	84	99	8	6.3	6970	7300
Mean			4.8	84	97	5	5.9	8870	9110
LSD(0.05)			0.1	1	NS	11	0.7	1410	430
CV %			2	1	11	114	8	8	5

† L = long grain, 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.
§ Days to 50% heading.
¶ SR = stem rot score, where 0 = no damage and 10 = plant killed. # Paddy rice yield in lb/acre at 14% moisture,
# Paddy rice yield in lb/acre at 14% moisture.
NS = not significant.

Table 20. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
68	09Y2179	S	4.8	87	102	1	5.2	9960	9430
59	10Y3703	M	4.6	86	97	13	5.1	9890	9480
70	11Y2183	MPQ	4.6	90	94	1	6.3	9470	9460
62	09Y1122	L	4.8	83	91	1	5.6	9400	9920
54	M-205	M	4.7	88	91	1	5.1	9230	9190
63	11Y1008	L	4.7	82	97	1	6.0	9180	10100
56	08Y3269	M	4.8	87	94	1	5.3	9070	9260
61	12Y83	L	4.5	83	102	1	5.2	8990	9370
69	09Y2159	SLA	4.4	93	94	1	7.2	8660	8530
65	S-102	S	4.8	80	97	45	5.9	8640	8450
57	08Y3126	M	4.5	83	102	68	6.6	8610	9280
66	CH-201	SPQ	5.0	86	94	86	5.9	8490	8050
67	CH-202	SPQ	4.7	84	94	83	5.3	8480	8330
60	L-206	L	4.6	81	86	39	7.6	8420	9410
58	10Y3690	M	4.6	88	94	1	5.3	8360	8860
55	M-206	M	4.8	82	99	53	5.6	8160	9150
64	CM-101	SWX	4.7	80	94	69	6.1	7950	7660
53	M-202	M	4.9	85	99	79	5.7	7640	8400
Mean			4.7	85	94	30	5.8	8810	9020
LSD(0.05)			0.2	1	3	18	0.7	870	340
CV %			3	1	3	42	9	7	5

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

Table 21. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
104	12Y2167	SPQ	4.9	84	97	31	5.4	10170	9020
105	12Y2175	MPQ	4.6	89	97	1	5.7	9890	9990
102	11Y2230	SPQ	4.9	85	97	85	5.4	9710	9260
101	09Y2141	SWX	4.7	81	104	75	6.1	9170	9900
82	12Y3097	MB	4.6	83	99	36	5.8	8850	9040
100	M-402	MPQ	5.0	109	102	1	5.5	8680	7460
87	12Y82	L	4.8	89	91	1	6.0	8660	9540
75	11Y3441	M	4.8	84	97	26	6.6	8620	9210
80	10Y3394	M	4.6	82	99	65	6.5	8590	9330
88	10Y1008	Lsr	4.6	83	94	3	5.6	8570	9490
81	12Y113	M	4.7	82	99	88	6.0	8500	9390
73	10Y3737	M	4.6	88	94	1	5.6	8440	9300
91	11Y106	LJ	3.8	94	104	68	4.4	8410	7630
78	11Y3636	M	4.7	82	91	16	6.3	8310	9090
90	12Y1010	L	4.8	83	94	3	5.4	8290	9300
71	M-208	M	4.9	84	97	36	5.3	8270	8880
92	12Y87	LJ	4.9	93	91	1	5.8	8160	7810
96	11Y1049	LA	4.6	85	97	13	6.0	8150	9060
86	12Y81	L	4.7	84	104	1	6.4	8050	9090
79	10Y3332	M	4.5	86	99	1	5.2	7980	8860
77	11Y3344	M	4.6	82	99	65	6.1	7970	8870
76	11Y3334	M	4.5	82	94	45	5.5	7850	8720
72	M-105	M	4.7	79	97	8	6.4	7820	9130
99	89Y235	BG	4.4	83	99	70	6.0	7750	7930
103	12Y2085	MPQ	4.7	83	99	38	5.6	7740	8860
95	12Y1022	LA	4.8	84	97	1	5.5	7730	8810
74	10Y3512	M	4.4	85	94	1	5.3	7550	8760
97	11Y1096	LA	4.7	85	99	1	5.9	7480	8630
85	A-301	LA	3.7	94	81	1	5.8	7290	7310
89	12Y84	L	4.3	85	102	1	5.3	7280	9390
83	A-201	LA	5.0	89	89	1	6.2	7020	7600
106	11Y2111	BG	4.7	84	99	1	5.9	6950	8080
98	CA-201	SLA	4.9	83	94	45	7.0	6590	6380
84	CT-202	LB	4.9	84	94	1	5.9	5700	5970
93	12Y1054	LB	4.9	77	89	3	5.4	5440	5810
94	11Y158	LB	4.7	93	76	6	5.7	3790	4600
Mean			4.6	85	94	23	5.8	7930	8490
LSD(0.05)			0.2	2	5	36	0.7	760	410
CV %			3	1	3	76	9	5	5

†BG = bold or Arborio grain, L = long grain, LA = long grain aromatic, LB = long grain basmati, LJ = long grain jasmine, Lsr = long grain stem rot resistant, M = medium grain, M = medium grain blast resistant, MPQ = premium quality medium grain, SLA = short grain low amylose, SPQ = premium quality short grain, and SWX = short grain waxy.
‡ SV = seedling vigor score, where 1 = poor and 5 = excellent.
§ Days to 50% heading.
¶ SR = stem rot score, where 0 = no damage and 10 = plant killed.
# Paddy rice yield in lb/acre at 14% moisture.

Table 22. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
110	08Y3269	M	4.8	86	102	1	5.8	10100	8910
116	11Y2183	MPQ	4.7	90	102	1	5.6	9970	9470
113	M-402	MPQ	4.9	109	97	1	5.4	9830	8560
108	M-205	M	4.7	88	102	1	5.7	9730	8890
115	CH-202	SPQ	4.7	80	86	55	5.4	9700	8700
112	12Y1176	L	4.6	85	104	1	6.0	9600	9050
109	M-206	M	4.8	81	102	41	5.9	9570	9260
111	L-206	L	4.7	80	89	13	7.3	9460	9020
114	CH-201	SPQ	4.9	84	91	60	6.1	8950	8520
107	M-202	M	4.8	85	102	1	5.9	8700	8290
Mean			4.7	87	97	18	5.9	9560	8870
LSD(0.05)			0.1	2	8	38	0.8	620	370
CV %			1	2	5	151	10	5	5

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

Table 23. 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 2013.

Entry Number	Identity	Type †	Seedling Vigor ‡	Heading (d) §	Height (cm)	Lodging (%)	SR ¶	--- Grain Yield --- (lb/A) #	
								RES	State
128	12Y1155	LA	4.9	81	99	1	6.0	10890	10010
119	11Y3448	M	4.8	82	99	26	5.9	9900	9340
141	11Y2182	MPQ	4.7	88	97	1	6.0	9890	9090
127	12Y1168	L	4.8	80	102	1	5.1	9850	9620
144	12Y2178	SPQ	4.9	92	97	1	6.4	9840	9070
118	M-105	M	4.8	76	102	1	5.9	9820	8730
139	M-401	MPQ	4.9	115	114	1	5.1	9780	8670
136	12Y1128	LA	4.8	79	94	1	5.0	9420	8950
121	11Y3433	M	4.8	86	97	1	5.5	9380	8750
120	10Y3433	M	4.9	86	104	1	5.4	9330	8700
117	M-203	M	5.0	82	109	93	6.0	9200	8590
131	11Y106	LJ	4.7	94	102	1	4.3	9170	8290
143	09Y2173	MPQ	4.9	89	102	26	6.2	9130	8910
124	M-401-ES2a	MPQ	4.8	87	112	73	6.4	9040	9090
125	M-401-ES2b	MPQ	4.8	86	107	93	6.4	9010	9050
137	12Y1037	LA	4.9	80	97	1	5.7	8900	8470
142	09Y2176	MPQ	4.9	86	99	1	6.4	8850	8530
122	11Y3667	M	4.8	86	104	1	5.4	8730	8330
132	12Y135	LJ	4.9	87	94	1	7.2	8650	8530
123	M-401-ES1	MPQ	4.8	86	104	65	6.2	8240	8760
130	12Y133	LJ	4.9	91	91	1	6.3	8160	8100
138	A-201	LA	4.9	85	91	1	6.4	7680	7750
129	12Y1178	LJ	4.8	85	99	1	5.0	6970	7210
135	13Y135	LB	4.9	84	89	1	6.4	6960	6270
126	CT-202	LB	5.0	82	94	1	6.4	6080	6160
140	KOSH	SPQ	4.8	103	122	93	6.7	5650	5700
133	11Y158	LB	4.9	85	84	1	6.4	5500	5000
134	12Y1052	LB	4.9	75	91	1	6.2	5020	5150
Mean			4.8	86	99	17	5.9	8540	8170
LSD(0.05)			0.1	2	8	27	0.8	1070	510
CV %			1	1	4	76	10	6	6

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

PRELIMINARY YIELD TESTS

Preliminary Yield Tests are the initial step of replicated large plot testing for experimental lines. The experimental design, plot size, and production practices are identical to the Statewide Yield Tests grown at RES. Two replications are planted at the early and late seeding date. A summary of the yields of 2013 Preliminary Yield Tests is presented in Table 24. These tests included 610 entries and check varieties.

Results in Table 24 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 2014 Statewide Yield Tests. ◆

Table 24. Summary of Preliminary Yield Tests at RES in 2013.

Test	Type	Number of Entries	All	Highest	Top 5	Check	Standard Check
			----------Average Yield (lb/acre)†----------				
Very Early							
Short grains	Conventional	4	10410	11080	-	8760	S-102
	Specialty rice ++	54	9260	10630	10460	9170	CH-202
Medium grains	Conventional	108	9010	10860	10410	8800	M-105
	Premium	9	10000	11130	10510	10120	M-402
Long grains	Conventional	57	9600	10720	10640	9340	L-206
	Specialty rice	24	8230	11040	10410	7780	A-201
Early							
Short grains	Conventional	0	-	-	-	-	S-102
	Specialty rice #	39	9160	10820	10250	9130	CH-202
Medium grains	Conventional	105	9910	10900	10720	9170	M-206
	Blast Resistant	15	7940	9240	8842	8000	M-206
	Early Mutants	14	7920	8730	9080	6970	M-401
	Premium	25	9440	10630	10280	7070	M-402
Long grains	Conventional	43	9280	10240	10030	9290	L-206
	Specialty rice	38	7430	10200	9970	7090	A-201
Intermediate-Late							
Short grains	Conventional	1	10930	10930	-	9400	S-102
	Specialty rice	9	8870	9820	9280	8940	CH-202
Medium grains	Premium	25	9920	10840	10610	9710	M-402
Long grains	Conventional	12	9820	10280	10180	9090	L-206
	Specialty rice	28	7850	10550	9830	6500	CT-202

† Paddy rice yield at 14% moisture
++ SPQ,SLA,SWX,BG