RICE FIELD DAY

Wednesday, August 31, 2016

UC Rice Research at RES

(Photo courtesy of Ag One Solutions)

California Cooperative Rice Research Foundation, Inc.
University of California
United States Department of Agriculture
Cooperating

Rice Experiment Station

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

About the Cover

A variety of rice research projects conducted by UC Davis and the UC Cooperative Extension are underway at RES that are not seen in the annual Rice Field Day tours. This drone photo was taken by Ag One Solutions as part of some research activities in cooperation with UC scientists. The photo shows the “Systems Research Area” that includes the following research projects in 2016:

- Nitrogen Management Color Chart Calibration- R.G. Mutters
- Examining Periodic Drainage Events On Rice Yields, Arsenic Uptake And Greenhouse Gas Emissions- BA. Linquist
- Evaluation Of Remote Sensing Tools To Aid Decision Making For A Mid-Season Top Dress N Application- B.A. Linquist
- Understanding Relationships Between Rice Flood Water And The Ground Water- B.A. Linquist
- Tadpole Shrimp- L.A. Espino
- Foliar Stimulants- L.A. Espino

California Cooperative Rice Research Foundation, Inc.

Rice Experiment Station Staff

Administrative

Kent S. McKenzie, Ph.D., Director
Lacey R. Stogsdill, Administrative Assistant

Rice Breeding Program

Virgilio C. Andaya, Ph.D., Director of Plant Breeding
Farman Jodari, Ph.D., Plant Breeder, Long Grains
Stanley O. P.B. Samonte, Ph.D.,Short & Premium Medium Grains
Paul L. Sanchez, Ph.D., Plant Pathologist
Cynthia Andaya, Ph.D., Research Scientist
Matthew Calloway, Breeding Nursery Manager
Baldish K. Deol, Plant Breeding Assistant
Ravinder Singh Gakhal, Plant Breeding Assistant
Christopher Putz, Plant Breeding Assistant
Davinder Singh, Plant Breeding Assistant
Michael Lynch, Plant Breeding Assistant
George Yeltatzie, DNA Lab Technician
Amelia Hettinger, WWP Control Technician

Field Operations and Maintenance

Burtis Jansen, Field Supervisor
Joe Valencia, Mechanic and Operator
Randy Jones, Maintenance and Operator
Shane Odekirk, Maintenance and Operator

UC Rice Research

J. Ray Stogsdill, Staff Research Associate III
Kevin Goding, Staff Research Associate II
Amar S. Godar, Ph.D. SRA III

2016 Rice Field Day Program

7:30—8:30 Registration and Poster Viewing

Posters and Demonstrations

1. Winged Water Primrose Control- (A. Hettinger, RES)
2. Calrose-Lineage Cultivar Improvement By The Rice Experiment Station: I. Yield Increase Rate (S.O.PB. Samonte, V.C. Andaya, F. Jodari, C.B. Andaya, P.L. Sanchez and K.S. McKenzie, RES)
3. Calrose-Lineage Cultivar Improvement By The Rice Experiment Station: II. Resistance To Low Temperature-Induced Panicle Blanking (S.O.PB. Samonte, V.C. Andaya, F. Jodari, C.B. Andaya, P.L. Sanchez and K.S. McKenzie, RES)
4. Alternate Wetting And Drying Reduces Methylmercury In Rice Ecosystems (K. C. Tanner, L. Windham-Myers, J. A. Fleck, and B. A. Linquist, UC Davis)
5. Potassium Fixation In California Rice Fields (J.C. Campbell, R.J. Southard, B.A. Linquist, UC Davis)
6. Evaluating The Effects Of Chemical And Cultural Management Practices On The Population Dynamics Of Tadpole Shrimp (*Triops longicaudatus*) In California Rice (J.B.Bloese, L.Espino, K. Goding and L.D. Godfrey, UC Davis)
7. A Genetic Approach To Reducing Arsenic In Rice (*Oryza sativa* L.) (T.H. Tai, H. Kim, S. Magee, and M.S. Wong, USDA-ARS and UC Davis)
8. Application Of TILLING And Forward Genetics To Identify Rice Mutants With Altered Starch Traits (H. Kim, M. Yoon, A. Chun, and T.H. Tai, USDA-ARS and UC Davis)
9. Discovery Of Functional Nucleotide Polymorphisms In U.S. Rice Varieties Using Exome Sequencing (T.H. Tai, H. Kim, I. Henry, U. Nagalakshmi, M. Lieberman, R. Broy, K. Ngo and L. Comai, UC Davis)
10. Salinity Dynamics in California Rice Fields (M. Marcos, H. Sharifi, S. Grattan and B. Linquist, UC Davis)
11. DNA Marker Profile and Morphological Characterization of Red Rice Samples Collected in California (C.B. Andaya, G. Yeltatzie, P.L. Sanchez, A. Hettinger, W. Brim-DeForest, K.S. McKenzie and V.C. Andaya, RES and UCCE)
12. Elucidating The Interactions Between Rice Cultivation And Groundwater In California (G.T. LaHue, H.E. Dahlke, S. Sandoval-Solis, and B.A. Linquist, UC Davis)
13. Influence Of Infrared Radiation Drying On Sensory Properties Of Rice (C. Ding, R. Khir, Z. Pan, K.L. Bett-Garber and J.M. Lea UC Davis)

14. Rice Waste Discharge Requirement: Pesticide Monitoring Requirements Under the Order and Compliance Reporting for Growers (R. Firoved, California Rice Commission)
15. Rice Pesticide Program- Thiobencarb Monitoring Results and Potential Changes to Management Practices (R. Firoved, California Rice Commission)
16. Thiobencarb Management Practices & Permit Conditions per DPR Enforcement Compendium and Registrant Stewardship Materials (R. Firoved, California Rice Commission)
17. Rice Pesticide Use Matrix: Summarizes Rice Pesticide use in CA (R. Firoved, California Rice Commission)
18. Herbicide Resistance Stewardship Chart and Handout (UC Davis Researchers & Farm Advisors)
19. Intrepid 2F Section 18 for Armyworm Control. Materials and Information Growers Must Provide to Resubmit Section 18 in 2017 (R. Firoved, California Rice Commission & UC Farm Advisors)
20. Weedy Red Rice in California: Identification and Best Management Practices (W. Brim-DeForest, L. Espino, R. Mutters, B. Linquist and K. Al-Khatib, UCCE and UC Davis)
21. Resistant Weed Seed Testing: A Free Service to California Rice Growers (W. Brim-DeForest, A. Godar and K. Al-Khatib, UCCE and UC Davis)
22. Rice Weed Herbicide Susceptibility Chart : The 2016 Version (A. Godar and K. Al-Khatib, UC Davis)
23. Response Of Walnuts To Simulated Drift Of Rice Herbicides (M. Gallo, K. Al-Khatib and B. Hanson, UC Davis)
24. Rice Herbicide Symptoms On Fruit Tree Crops (M. Gallo, K. Al-Khatib and B. Hanson, UC Davis)
25. Biology and Management of Johnsongrass (*Sorghum halepense*) (A. Ceseski, K. Al-Khatib and J. Dahlberg, UC Davis)
26. Yield Increase Rate of Calrose Cultivars Developed by the Rice Experiment Station from 1976 to 2015 (S.O.PB. Samonte, V.C. Andaya, F. Jodari, C.B. Andaya, P.L. Sanchez, and K.S. McKenzie, RES)
27. Is The Tadpole Shrimp Becoming Tolerant To Pyrethroid Insecticides? (L. Espino, UCCE)
28. Using Remote Sensing To Determine The Midseason Nitrogen (N) Status Of A Developing Rice Crop And The Need For Additional N Inputs To Achieve Maximum Yields (T. Rehman, A. Froes de Borja Reis, N. Akbar and B. Linquist, UC Davis)

8:30 - 9:15 a.m. **GENERAL SESSION**

Welcome by Bert Manuel, Chairman, CCRRF

CCRRF Business Meeting

- Financial Report,
  Lance Benson, Treasurer, CCRRF

- Directors Nomination Committee Report,
  Kent McKenzie, RES

- Rice Research Trust Report,
  Steven Willey, Chairman, RRT

- California Rice Research Board Report,
  Jason Bowen, Chairman, CRRB
  Tu Tran, Asso. VP, UC Ag. & Natural Resources
  Presidential Chair for California Grown Rice

- California Rice Industry Award Presentation,
  Gary Enos, Vice Chairman, CCRRF

9:20 - 10:45 a.m. **MAIN STATION TOUR**
Two tours occur simultaneously and repeat.

Blue & Green Groups to Trucks

Rice Variety Development
(V.C. Andaya, F. Jodari, S.O. Samonte, and P.L. Sanchez, RES)

Rice Insecticides: Maximize Use of IPM Tactics to Conserve These Products (L.D. Godfrey, K. Goding, J. Bloese, UCCE & UCD)

10:30 - 10:45 a.m. **Refreshments – Under Carport**

10:45 - Noon **Repeat Station Tour with Red & White Groups**

9:20 - 10:45 a.m. **HAMILTON ROAD TOUR**

Two tours occur simultaneously and repeat.

Red & White Groups to Buses

Weed Control in Rice: Herbicide Programs for Different Rice Growing Systems, and New Weed Control Products
(K. Al-Khatib, A.S. Godar, A. Ceseski, J.R. Stogsdill, M.F. Galla, W. Brim-DeForest, B.A. Linquist, L. Espino and R.G. Mutters, UCD & UCCE)

10:30 - 10:45 a.m. **Refreshments – Research Building Canopy**

10:45 - Noon **Repeat Hamilton Road Tour with Blue & Green Groups**

Noon **Luncheon Concludes Program**

Lunch will be served in the New Research Building with seating at the tables on the lawns under the canopies

2.0 hours of Continuing Education credit for this 2016 Rice Field Day has been granted from Cal/EPA Department of Pesticide Regulation

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Disclaimer

Trade names of some products have been used to simplify information. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Introduction
By Bert Manuel

On behalf of the Board of Directors, staff and UC cooperators, welcome to Rice Field Day 2016. Field Day is our annual opportunity to highlight the research that is underway at the Rice Experiment Station for the California Rice Industry. It is also the annual business meeting for the grower/owners of the California Cooperative Rice Research Foundation.

The California rice industry has survived a severe drought and is recovering only to be faced with new challenges; weed control including weedy red rice and also winged water primrose in Butte County. The Rice Experiment Station has been actively engaged addressing these issues with the UC, CRC, the industry and the Agricultural Commissioners. I want to recognize BUCRA, Richvale Seed Growers, and Lundberg Family Farms for providing matching funds to support the winged water primrose control program. We have been able to do these activities without any reduction in our breeding and research. This has been possible with the continued financial support from the California Rice Research Board as well as the Foundation and the Rice Research Trust.

The highlight of the day's actives are the field tours where you are able to hear from the researchers and see the nurseries on the main station as well as weed control research at the Hamilton Road site. Dr. Virgilio "Butz" Andaya, Director of Plant Breeding, is overseeing the medium grain program and will be reporting on that project. Dr. Farman Jodari will update you on his long grain program and varieties. Dr. Stanley Samonte will present his work on premium quality and short grain varieties. Dr. Paul Sanchez joined the team as our rice pathologist in 2015 and will be speaking to you on the tour. Dr. Larry Godfrey, UC Cooperative Extension will also present the ongoing work on rice insect pests on the main station tour.

Dr. Kassim Al-Khatib, UC Davis Professor, heads the UC rice weed control project and will be speaking to you on a walking tour of the weed research nursery at the Hamilton Road site.

Dr. Cynthia Andaya and Mr. George Yeltatzie have our DNA marker lab in full operation to support the RES Breeding Program.

The Rice Experiment Station remains committed to the production of clean, weed and disease free foundation seed for the California rice growers. We continue work in cooperation with the Foundation Seed and Certification Services and the California Crop Improvement Association. The certified seed program is an essential part of maintaining genetic purity in our varieties and insuring the highest quality seed is available to the industry. The seed program is self-supporting and is not funded by the Rice Research Board. A new long grain variety, L-207, was released to seed growers in 2016.

I would like to acknowledge the many businesses and growers who support Rice Field Day through financial donations, agro chemicals and use of trucks for our tours. This year we have also included equipment displays from several sponsors. This industry support is very important to the success of the Field Day. The supporters are listed in your program and we thank them again for their assistance.

Thank you for attending Rice Field Day and supporting our research programs. If you have any questions about Field Day or the Rice Experiment Station, please take the opportunity to talk with the Directors and his staff. There is a great deal of useful information on display today and I invite you to visit the displays and posters as well as taking the field tours.

D. Marlin Brandon Rice Research Fellowship

In 2000, a memorial fellowship was established to provide financial assistance to students pursuing careers in rice production science and technology as a tribute to Dr. D. Marlin Brandon, past Director and Agronomist at the Rice Experiment Station. The California Rice Research Board made a one-time donation to the Rice Research Trust of $52,500 with $2,500 used for the 2000 fellowship. The Rice Research Trust contributed an additional $50,000 and established a fellowship account. Interest from investments on the $100,000 principal is used to provide grants to the D. Marlin Brandon Rice Scholars. Twenty-five fellowships have been issued from 2000 to 2016.

D. Marlin Brandon Rice Scholars

William Carlson	2000
Nicholas Roncoroni	2001
David P. Cheetham	2002
Jennifer J. Keeling	2002
Kristie J. Pellerin	2003
Michael S. Bosworth	2003
Kristie J. Pellerin	2004
Leslie J. Snyder	2004
Gregory D. Van Dyke	2004
Leslie J. Snyder	2005
Louis G. Boddy	2006
Rebecca S. Bart	2006
Jennifer B. Williams	2007
Mark E. Lundy	2007
Louis G. Boddy	2008
Monika Krupa	2008
Cameron Pittelkow	2009
Charles Joseph Pfyl	2009
Maegen Simmonds	2009
Mark E. Lundy	2010
Cameron Pittelkow	2011
Whitney Brim-DeForest	2011
Matthew Espe	2015
Mathias Marcos	2015
Gabriel T. LaHue	2016

SUBMITTED POSTER ABSTRACTS

WINGED WATER PRIMROSE CONTROL

❖ A. Hettinger (RES)

Winged Water Primrose (WWP) (*Ludwigia decurens*) is an invasive, aquatic plant that has been monitored in Butte County since 2011. The local population has increased and was classified as a Category A Pest with a seed rating of P by the California Department of Agriculture in 2016. This classification sets strict parameters on local producers by disqualifying seed fields and could create phytosanitary issues in regards to storing and transporting rice. Local industry agencies responded to this classification by forming a coalition and funding staff at the Rice Experiment Station (RES). The focus area of RES is that where WWP has been found historically. RES has put into place a proactive monitoring and treatment program to help local growers and agencies stay on top of and aware of WWP. Butte County Ag is monitoring the peripheral areas of the historical sites in an attempt to locate new populations. Agencies and growers continue to make a concerted effort to control and hopefully eradicate this pest.

CALROSE-LINEAGE CULTIVAR IMPROVEMENT BY THE RICE EXPERIMENT STATION: I. YIELD INCREASE RATE

❖ S.O.PB. Samonte, V.C. Andaya, F. Jodari, C.B. Andaya, P.L. Sanchez, and K.S. McKenzie (RES)

The Rice Experiment Station (RES) at Biggs, California, has been breeding for high yielding and high quality rice cultivars since 1912. Prominent cultivars produced by RES include the tall traditional Calrose and the semi-dwarf (sd-1) Calrose 76, which is a mutant selected from Calrose after irradiation. The semi-dwarf stature of RES-released cultivars can be traced back mostly to Calrose 76 (released in 1976) or IR-8 (released by IRRI in 1966). To evaluate the success of the breeding program or the presence of a yield plateau, the estimation of grain yield increase rates due to cultivar releases was essential. The objective of this study was to determine the yield increase rate due to the release of 31 semi-dwarf cultivars by the Rice Experiment Station from 1976 to the 2015.

Thirty-one semi-dwarf cultivars developed by RES from 1976 to 2015, including new releases medium grain M-209 and waxy short grain Calmochi-203, were evaluated in replicated yield tests conducted in 2014 and 2015. Yield increase rates were estimated from the 2014, 2015, and the combined 2014 and 2015 data.

There were significant differences among the grain yields of 31 semi-dwarf cultivars in the 2014, 2015, and the combined 2014 and 2015 yield tests. When averaged across 2014 and 2015 data, Calrose 76 yielded 7,690 kg/ha, while CM-203 and M-209 (both released in 2015) averaged 10,160 and 10,520 kg/ha, respectively. Grain yields increased by at least 2,470 kg/ha. Grain yield increase rates were estimated to be 36, 54, and 42 kg/ha/year from the 2014, 2015, and combined 2014-2015 yield tests, respectively. The positive yield increase rates indicated the success of the rice breeding program of RES in continuously improving grain yields of semi-dwarf cultivars. This perennial study is useful in tracking the performance of RES-released cultivars and in planning and breeding rice for the future.

CALROSE-LINEAGE CULTIVAR IMPROVEMENT BY THE RICE EXPERIMENT STATION: II. RESISTANCE TO LOW TEMPERATURE-INDUCED PANICLE BLANKING

❖ S.O.PB. Samonte, V.C. Andaya, F. Jodari, C.B. Andaya, P.L. Sanchez, and K.S. McKenzie (RES)

Low temperatures (<18^{o}C) have negative effects on rice plants at various growth stages from germination (low seedling vigor) to maturity (high panicle blanking), and these ultimately reduces grain yield. The objective of this study was to evaluate the panicle blanking percentages of 31 semi-dwarf cultivars released by the Rice Experiment Station (RES) from 1976 to 2015.

Each of the 31 cultivars were planted in rows and replicated two times in the Cold Tolerance Nursery at San Joaquin in 2015. The rows were evaluated at maturity for panicle blanking percentage, and the maximum blanking percentage of each cultivar was used in the analyses.

Panicle blanking percentages were 50% for Calrose 76 (released in 1976) and 7% for both Calmochi-203 and M-209 (released in 2015). Average maximum panicle blanking percentages were 26% for cultivars released from 1976 to 1985, 12% from 1986 to 1995, 7% from 1996 to 2005, and 5% from 2006 to 2015. RES has improved its cultivars' resistance to low temperature-induced panicle blanking, and consequently reduced the risk of low grain yield.

ALTERNATE WETTING AND DRYING REDUCES METHYLMERCURY IN RICE ECOSYSTEMS

❖ K.C. Tanner, L. Windham-Myers, J.A. Fleck and B.A Linquist (UC Davis)

In flooded soils, such as those found in rice fields, microbes convert inorganic mercury to its more toxic form, methylmercury (MeHg). MeHg can then be transported in rice drainage water to downstream ecosystems where it negatively impacts wildlife. We tested the effectiveness of Alternate Wetting and Drying (AWD) water management as a methylmercury management tool. We conducted a plot experiment at the Rice Experiment Station comparing AWD to conventional continuous flood (CF) water management, with three replicates. Soil, water and plant samples were collected throughout the year and analyzed for MeHg and total mercury (THg). MeHg concentrations were low throughout the experiment, with a number of samples being at or below the detection limit. Rice grain from AWD plots had 50% lower MeHg concentration that CF. Soil MeHg concentrations were similar at the beginning of the growing season, but at the end of the growing season MeHg concentrations were significantly lower in AWD compared to CF. At the end of the fallow season AWD and CF soil MeHg concentrations became similar again. Soil THg remained constant throughout the year and did not differ significantly between treatments. Surface water MeHg concentrations were higher in CF plots than AWD, and fallow season surface water MeHg concentrations were higher than growing season. These results suggest that AWD may be an effective way to reduce MeHg levels in rice ecosystems.

POTASSIUM FIXATION IN CALIFORNIA RICE FIELDS

❖ J.C. Campbell, R.J. Southard and B.A. Linquist (UC Davis)

In 2016, there are about 500,000 acres of rice planted in the Sacramento Valley of California, valued at more than $700 million. Productivity per hectare in this region has historically been higher than average, but yield growth has slowed in recent years. One important factor related to limits to rice productivity is soil potassium (K). As the soils in this area have historically been high in K, growers have not needed to apply it to their fields. However, after years of harvest without K replenishment, growers are beginning to observe K deficiencies. In attempts to correct them by supplying the soil with K fertilizers, growers are seeing little or no response from the crop. The reason for this lack of response to K amendments is likely K fixation, in which K ions are trapped in between soil particle interlayers and unavailable to plants. Preliminary data of soils sampled in rice fields across the Sacramento Valley shows that there is no clear relationship between a field's K budget and the extractable potassium in the soil or with the amount of K in the plant tissues, indicating that there is likely K fixation occurring. Preliminary data also shows that soils low in exchangeable K are also frequently K-fixing soils. The distribution of K fixation in the Sacramento Valley is suspected to be related to soil mineralogy, as the two sides of the valley have distinct mineral compositions, each with different K fixation capacities. Soil mineralogical analysis will help to elucidate the relationship between soil mineralogy and available soil potassium. Data from lab analyses and web soil survey will allow us to understand which areas are likely to have K fixation. Better understanding the relationship between soil type and K dynamics will help growers better manage their fertility and increase yields.

EVALUATING THE EFFECTS OF CHEMICAL AND CULTURAL MANAGEMENT PRACTICES ON THE POPULATION DYNAMICS OF TADPOLE SHRIMP (*TRIOPS LONGICAUDATUS*) IN CALIFORNIA RICE

❖ J.B. Bloese, L. Espino, K. Goding and L.D. Godfrey (UCCE and UC Davis)

Tadpole shrimp (*Triops longicaudatus; TPS*) is a vernal pool crustacean, native to the western hemisphere. Historically, population levels seldom caused economic damage in rice. However, mandatory changes in cultural cultivation practices have coincided with the shift of TPS from a periodic pest to a significant pest. The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 mandated that rice straw burning in the Sacramento Valley be phased down to a maximum of 25% of total acreage burned by 2001 (Bird et al., 2002). The effects of cultural and chemical management practices were evaluated on their impact on the population dynamics of TPS.

A GENETIC APPROACH TO REDUCING ARSENIC IN RICE (*ORYZA SATIVA* L.)

❖ T.H. Tai (USDA-ARS, UC Davis), H. Kim (UC Davis), S. Magee (USDA-ARS, UC Davis), and M.S. Wong (UC Davis)

We are currently employing two complementary strategies to identify rice mutants with reduced uptake and accumulation of arsenic. The first approach involves Targeting of Induced Local Lesions in Genomes (TILLING), a reverse genetics method in which chemically mutagenesis is used to generate mutants from which DNA is extracted and sequenced to identify changes in specific gene targets. For arsenic, three rice genes have been shown to be involved in uptake by the plants (Lsi1 and Lsi2) and accumulation or localization in the grain (OsABCC1). We have used TILLING to identify mutations in these genes are currently characterizing the plants containing these mutations. The second approach involves forward genetics screening of a mutant population using germanium which is chemically similar to silicon but which causes the formation of lesions in rice seedlings and can lead to death. Germanium has previously been shown to be effective in identifying rice mutants with reduced silicon uptake. These mutants also take up less arsenic. Using this germanium assay, we have identified a number of possible mutants with altered uptake and are currently confirming the results. Together, the reverse and forward genetics strategies are expected to yield rice germplasm for use in fundamental studies on arsenic transport and accumulation in rice and for breeding of improved varieties.

APPLICATION OF TILLING AND FORWARD GENETICS TO IDENTIFY RICE MUTANTS WITH ALTERED STARCH TRAITS

❖ H. Kim (UC Davis), M. Yoon (RDA, South Korea), A. Chun (RDA, South Korea), and T.H. Tai (USDA-ARS, UC Davis)

Rice (Oryza sativa L.) is unique among major cereal crops as the vast majority is used directly for human consumption, primarily in the form of whole milled kernels. Climate change and consumer demand pose significant challenges to rice breeders with regard to maintaining and improving various grain quality traits that influence appearance, eating, cooking, and utilization of rice. Using Targeting of Induced Local Lesions in Genomes (TILLING) and forward genetics approaches, we have identified a number of rice mutants with altered starch traits and putative mutations in starch biosynthesis-related genes. We have conducted preliminary analysis of several of these mutants including scanning electron microscopy, physicochemical tests, and DNA sequencing to confirm the presence of mutations in target genes identified by TILLING. Several fixed mutants and mutations are being used to develop rice germplasm exhibiting novel grain quality and to gain a better understanding of the genetic control of these traits for breeding applications.

DISCOVERY OF FUNCTIONAL NUCLEOTIDE POLYMORPHISMS IN U.S. RICE VARIETIES USING EXOME SEQUENCING

❖ T.H. Tai (USDA-ARS, UC Davis), H. Kim (UC Davis), I. Henry (UC Davis), U. Nagalakshmi (UC Davis), M. Lieberman (UC Davis), R. Broy (UC Davis), K. Ngo (UC Davis) and L. Comai (UC Davis)

Targeted sequencing is an approach in which specific genomic regions of interest are sequenced in order to reduce costs and increase the depth of sequencing coverage compared to whole-genome sequencing. In exome sequencing, the targets are protein-coding regions of the genome (i.e., the exome) which are selectively captured and sequenced. This enables more cost-effective detection of sequence variation that may correspond to functional differences in genes. In this study, three ancestral varieties (Caloro, Lady Wright, and Colusa) of Calrose-type rices were subjected to exome sequencing to identify single nucleotide polymorphisms (SNPs). For comparison, some modern California (L-202, M-204, M-205, and M-206) and southern U.S. long grains (Cypress, Dixiebelle, and Sabine) were also sequenced. SNPs that may impact gene function and can be converted to low-cost DNA markers have been identified. Efforts to validate these SNPs are underway and the distribution of SNP alleles that may affect gene function is being examined in California rice varieties.

SALINITY DYNAMICS IN CALIFORNIA RICE FIELDS

❖ M. Marcos, H. Sharifi, S. Grattan and B. Linquist (UC Davis)

Less high quality water available for rice production will increase salinization and may lead to reductions in yield. Presently, salinity dynamics in rice fields are insufficiently understood. This study aims to elucidate the spatial and temporal salinity dynamics in California rice systems, and to assess current yield thresholds. In this two-year study, water and soil salinity concentrations of 11 field sites were monitored weekly, with 9 sampling points being established in the top, middle and bottom basins of each field. There was a consistent water salinity pattern throughout all fields: an increase in water salinity occurring during week 1 to week 7, ranging from 0.39 to 6.06 dS/m, and being greatest further from the irrigation inlet and in positions with high soil salinity. A model to predict water salinity within a field was developed. Averaged over an entire growing season, position within a field contributed to roughly 79% of the explained variation in the model (R^2=0.59), while soil salinity contributed to roughly 21%. Soil salinity significantly influenced water salinity, especially early in the season; however, it was a poor metric for predicting yield loss. For water salinity, the threshold concentration when yield reductions occurred was 0.88 dS/m, well below the previous report. These results showcase the ability to predict water salinity in a rice field with few parameters while highlighting the importance of focusing on field water salinity as the salinity metric for rice systems.

DNA MARKER PROFILE AND MORPHOLOGICAL CHARACTERIZATION OF RED RICE SAMPLES COLLECTED IN CALIFORNIA

❖ C.B. Andaya, G. Yeltatzie, P.L. Sanchez, A. Hettinger, W. Brim-DeForest, K.S. McKenzie, and V.C. Andaya (RES and UCCE)

Red rice is a type of weedy rice that has red-pigmented pericarp and considered as one of the most troublesome and economically damaging type of weedy rice. It complicates weed control management, seed processing, and grain quality operations. While it is not yet considered as a critical problem in California as compared to the Southern USA, their occurrence has been annually observed in CA rice production system. Seeds of red rices throughout the years have been collected and stored at the Rice Experiment Station. The red rice collection is by no means complete, but there is a need to develop a red rice submission system and procedures for collection, sampling, morphological characterization, data handling, and DNA and phylogenetic analysis. These systems and procedures are needed to gather data for analysis to better understand the type of red rices present, their relation with other weedy red rices, their approximate location, and manner or degree of their distribution.

To understand the relationship and distribution of red rices in CA, weedy rice samples collected from different counties were analyzed genetically using microsatellite markers and characterized morphologically. This study reports how these red rice samples are classified into distinct DNA clusters with the intent of assembling DNA markers for routine use in new red rice samples submitted for curation. Submission procedures and systems recommendation are also discussed.

ELUCIDATING THE INTERACTIONS BETWEEN RICE CULTIVATION AND GROUNDWATER IN CALIFORNIA

❖ G.T. LaHue, H.E. Dahlke, S. Sandoval-Solis, and B.A. Linquist (UC Davis)

Rice (*Oryza sativa*) is unique from other agronomic crops in that it is typically cultivated under flooded conditions, which creates the potential for more complex interactions between irrigation water and groundwater. Aboveground water flows (inflow, outflow, and evapotranspiration) have been well quantified for California rice systems by recent research, but much less is known about subsurface water flows – namely, lateral seepage and deep percolation. This was illustrated by the recent California drought, with anecdotal evidence suggesting increased water input requirements per unit area, likely due to increases in either lateral seepage or deep percolation. Our ongoing research seeks to measure or calculate inflows, outflows, evapotranspiration, lateral seepage, and deep percolation for three rice fields that are typical of the majority of California rice fields. Deep percolation and lateral seepage will both be measured directly with infiltration rings or frames, and head gradients that indicate the direction of water flow within the saturated soil profile are also being monitored. Preliminary results show that the apparent groundwater connects to the floodwater at some sites, whereas at other sites an unsaturated zone persists between the floodwater and the groundwater for much or all of the growing season. Head gradients show downward flow at sites where the entire profile is saturated, whereas in sites where an unsaturated zone exists, the head gradients show flow toward this zone from the groundwater below and the floodwater above. However, these flows are likely very small given the small head gradients observed and the very small saturated hydraulic conductivity that is usually associated with these heavy clay soils. Our future work will continue to quantify these water flows in individual fields and begin to analyze the landscape level relationships between rice area, water input requirements, and groundwater levels.

INFLUENCE OF INFRARED RADIATION DRYING ON SENSORY PROPERTIES OF RICE

❖ C. Ding, R. Khir, Z. Pan, K.L. Bett-Garber and J.M. Lea (UC Davis)

Infrared (IR) drying has been proven by our research team to have high moisture diffusivity corresponding to high drying rate for rough rice. Simultaneously, an effective disinfestation, disinfection, and stabilization could be achieved without milling quality loss. Additionally, extended shelf life with maintained physicochemical properties for rough and brown rice could be achieved by using IR drying. However, the effect of IR drying on sensory properties for rough and brown rice need to be further investigated. The aim of this study was to study the impact of IR drying on the sensory quality of rough and brown rice. Samples of freshly harvested medium grain rice variety M206 with initial moisture content of 25.03±0.21 % (d.b.) were used. They were dried using IR, hot air at 43 °C, and ambient air for comparison. For IR drying, rice were heated to temperature of 60 °C followed by 4 h tempering and natural cooling. The dried samples were divided into two portions, which were respectively used as rough and brown rice for storage at 35±1 °C with relative humidity of 65 ±3 % for 7 months. Fourteen descriptive texture attributes at different phases of sensory evaluation were determined by a trained panel, beginning with the feel surface evaluation of the rice when it was first placed in the mouth and ending with residual characteristics after swallowing. The IR dried rice showed higher springy (4.1±1.6) and hardness (6.3±1.0) intensities than the springy (3.2±1.0) and hardness (5.7±1.3) of rice dried with ambient. The intensity of initial starchy coating intensity, slickness, stickiness to lips and intensity of cohesiveness of the cooked rice kept decreasing during storage. However, these attributes of IR dried rice showed less decrement after 7 months of storage. It is concluded that IR drying could be used as a feasible efficient drying technique for rice with better maintained sensory quality.

FIELD TOURS OF RESEARCH

RICE VARIETY DEVELOPMENT

The RES breeding program consists of four research projects. Three rice breeding projects focus on developing adapted varieties for specific grain and market types and are each under the direction of a RES plant breeder. The rice pathology project, under the direction of the RES plant pathologist, supports the breeding projects through screening and evaluating varieties for disease resistance, rice disease research, and quarantine introduction of rice germplasm for variety improvement. All projects also linked with the DNA marker laboratory and are involved in cooperative studies with other scientists from the UC, USDA and industry, including off station field tests, nurseries, quality research, and biotechnology. Brief highlights of the RES breeding program are discussed here and will be presented during the field tour of the breeding nursery.

Medium Grain
(V.C. Andaya, Plant Breeder, RES)

The predominant rice varieties planted in California are medium grains famously known as Calrose. The Calrose brand is well-known for quality and was awarded the 2015 “World’s Best Rice” during the 7th TRT World Rice Conference in Kuala Lumpur, Malaysia.

The breeding goals in the medium grains project are to develop varieties with high and stable grain yield, superior milling yield, excellent grain quality, with tolerance to cold temperature induced blanking, good seedling vigor, and resistance to rice blast and other diseases. Most of the breeding materials such as F2 populations, early generation progenies, and advanced breeding lines are planted at the RES progeny and yield nurseries. A cold location nursery in San Joaquin is used to screen for cold tolerance, specifically cold-induced sterility or blanking, to complement refrigerated greenhouse low temperature screening at the station. The most promising selections are planted in the winter nursery in Lihue, HI, for seed increase, generation advance, and additional screening for blanking. The medium grains project employs both traditional and marker-based breeding methods. The DNA markers used for marker-assisted selection are mostly microsatellite markers, and effectively used for fingerprinting and purity testing, breeding for blast resistance and grain quality.

Commercial medium grain varieties are routinely used as check varieties in preliminary yield trials and UCCE Statewide Tests. Included in these tests are varieties still in production in California. M-202 was no longer used as check in 2016. Its overall grain yield was about 10% lower compared to newer cultivars, and registers low head rice yields. M-205 and M-206 are widely grown varieties known for their excellent milling and high grain yield, and served at standard check varieties in yield trials. M-105, a new very early maturing variety, was released as an alternative to M-104. M-105 registers superior and higher milling yield. M-208 is a blast resistant early maturing Calrose, carries the Piz gene, which confers resistance to IG-1 but not the IB-1 blast pathogen now present in California. Its acreage is limited due to lower yield potential and sensitivity to cold. The newest variety is M-209, an early maturing variety released in 2015. It has higher yield potential and bigger grains and is adapted in areas where M-205 is grown.

In 2015, based on the overall agronomic and yield performance of the check varieties RES location, M-209 registered the highest average yield of 9,610 lbs./acre compared to M-205 with average yield of 9,080 lbs./acre, a 5.8% yield advantage. Both of these varieties registered the best lodging percentage of 3%. M-206 remained among the top yielders reaching an average yield of 9,560 lbs./acre.

Update on M-209

M-209 (formerly 08-Y-3269) was approved for release by the CCRRF Board of Directors in early 2015. It is a high yielding, early maturing, semi-dwarf, glabrous, lodging-resistant Calrose medium grain. The five-year average of M-209 at RES tests was 10,010 lbs./acre with 2.9% and 4.1% yield advantage over M-205 and M-206, respectively. In Butte, Colusa, West Sutter and East Sutter Counties, its registered grain yield advantage over M-205 is 3.7%, 6.1%, 3.9%, and 5.5%, respectively. Though it out yielded M-205 by 17.9% in San Joaquin, M-209 is not recommended for planting in colder rice growing areas. Overall, M-209 is slightly earlier and taller than M-205 and has similar lodging score as M-205.

The milled rice grains of M-209 are larger, heavier and slightly longer compared to M-205 and M-206. The length/width ratio is 2.13, 2.09, and 2.17 for M-209, M-205, and M-206, respectively. M-209 is best harvested above 18% grain moisture content, and unlike M-205, M-105, and M-206, milling yield may drop when harvested at drier moisture levels. The average milling yield of M-209 at 18% moisture is 68/73 (head/total), compared to 67/73 and 69/72 for M-205 and M-206, respectively. The percent chalkiness of M-209 is slightly lower than M-205 and M-206, and is similar in clarity and whiteness to both. Based on the results of the RVA, M-209 has a similar profile as the other medium grains, including in the apparent amylose and protein content. Milled rice samples of M-209 were evaluated by milling and marketing organizations for visual, cooked rice, and taste quality and was judged to be superior in grain quality and acceptable to the rice market.

A 3-year blanking score in San Joaquin, unseasonably warmer in the past years, is actually lower for M-209 than M-205 and M-206. Nonetheless, M-209 may sustain greater damage from cold temperatures thus not recommended for planting in cooler rice areas of California.

M-209 reaction to stem rot and aggregate sheath spot was comparable to M-205 but better disease reaction compared to M-206. However, M-209 may be slightly sensitive to blast compared to M-205 and M-206.

M-209 is recommended in areas where M-205 is normally grown and was cultivated by select seed growers for the first time in 2015. The grain yields on a dry weight basis recorded in their seed production fields were better than expected, with yields ranging from 98 to 108 cwt/acre. These seeds will be available for planting by the commercial rice growers in 2016.

Promising Medium Grain Lines

A blast resistant line, 12Y3097, is an advanced derived from the marker-assisted backcrossing work using M-206 as the genetic background, and thus has most of the agronomic attributes of M-206. It contains the Pi-b blast resistance gene that can withstand the IG-1 and IB-1 blast isolates found in California. In 2015, the grain yield of 12Y3097 ranged from 9,470 to 9,960 lbs/acre at RES yield tests, and 9,000 to 9,890 lbs/acre in statewide yield tests. The average yield advantage over M-208 was 8% and 4% at RES and statewide tests, respectively; while yield advantage over M-206 is 1.4% at RES but 0.5% lower yield than M-206 statewide. The grain attributes of 12Y3097 is comparable with M-206 in terms of chalkiness, seed weight, milling yield and grain dimension, though sometimes the grain may be slightly longer and lighter. 12Y3097 is currently in headrows for purification and being evaluated for yield in all locations of the UCCE Statewide Test. A closely-related blast resistant line is 16Y18, having one additional dose of M-206. This line is being fast-tracked in statewide test in 2016 as well as in purification headrows. Compared to 12Y3097, 16Y18 heads two days later but has a better seedling vigor score. Side by side comparison with M-206 and M-208 will be available later this year. As an additional note, 12Y113 as reported in previous field day was dropped from further tests because of its low head rice yield. It is being kept in cold storage as a germplasm source and parent for crossing.

There has been an effort to study the genetics of stem rot resistance using molecular markers and genetic mapping populations using cross between M-206 and 87Y550. The 87Y550 is a long grain rice whose stem rot resistance came from the wild rice relative *Oryza rufipogon*. Studying the genetics of stem rot resistance had been a very challenging work because of issues in phenotyping or disease screening both in the greenhouse and in the field. Equally challenging is the breeding portion because of the linkage drag and the undesirable agronomic traits associated with the wild rice resistance donor, which are oftentimes very hard to break even with several crossing and backcrossing work.

A rice line, 14Y3060, was isolated during the genetic studies that appear promising agronomically. The level of stem rot resistance is better than M-206 but far less than the resistance level desired. This line is currently evaluated in the statewide tests.

Another advanced medium grain line that performed well in the 2015 statewide yield test in the intermediate late group is 14Y3092. It has high potential yield and matures slightly longer than M-205, has excellent grain appearance and head rice yield. This line is being evaluated in all location of the statewide test.

Future Outlook

The challenge of breeding new varieties that combines better grain quality with superior grain yield is enormous, to say the least. Grain yield and grain quality are both genetically complex, and combining two complex traits is a gigantic magnitude more difficult than tackling each trait individually. It becomes even more challenging if further improvement in seedling vigor and cold tolerance, disease resistance, and better milling yields are added to the mix.

The medium grain project is focused on setting goals that are achievable short term, at the same time keeping sight of more ambitious goals in the long term, like developing new rice varieties with new quality types that may have a potential in the marketplace, or agronomic attributes that has a place in the CA rice production system. These goals can be attained through efficient breeding via innovative approaches, measuring traits faster; handling, analyzing and storing data more efficiently; and improving nursery and yield plot management. There is a need to review the RES breeding program, although there is no urgent need to drastically overhaul the breeding procedures that are proven effective throughout the years.

Premium Quality and Short Grain (S.O.P.B. Samonte, Plant Breeder, RES)

The Premium Quality and Short Grains Project encompasses the improvement of the following rice varietal types:

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

All new rice lines are bred and selected for improved and stable grain yield and yield-related traits, milling and cooking quality, reduced panicle 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 selected lines must possess in order to qualify into a specific grain type. Experimental lines in nurseries and yield tests are compared against their respective grain type check varieties. Selected lines must show improvements over their respective checks.

***Waxy Short Grain**-Calmochi-101 and New Variety Calmochi-203*

The Rice Experiment Station (RES) released Calmochi-203 as a new variety in 2015. It is a stable high yielding, semi-dwarf, early-maturing, glabrous, waxy, short grain rice. Prior to its varietal release, CM-203 had significantly higher grain yields than CM-101 in all 38 Statewide Test (SW) environments from 2010 to 2014. Averaged across environments, grain yields were 9,650 lb/acre for CM-203 and 7,590 lb/acre for CM-101, for a 27% yield advantage. Further comparisons with CM-101 indicated that CM-203 was similar in seedling vigor (SV) rating, taller by about 5 cm, it required one more day to reach heading and 11 more days to reach maturity (20% MC), and it lodged slightly more. CM-203 had higher head rice percentages (65 vs. 63%), larger grain size dimensions, heavier 1000-grain weights, and lower viscosity than CM-101. Panicle blanking, based on the cold tolerance nursery at San Joaquin, was low at 8% for CM-203 and 5% for CM-101.

In 2015, CM-203 continued to show its superior trait parameters. It yielded significantly higher than CM-101 in all 10 SW test locations. Grain yields, averaged across locations, were 10,060 lb/A for CM-203 and 7,660 lb/A for CM-101, for a 31% yield advantage. Compared to CM-101, CM-203 headed a day later, it was taller, lodged less, had higher head rice percentage at 69%, and had similar high SV ratings and low blanking percentages (<7%) at San Joaquin.

In the 2016 SW Tests, there are two SWX lines being evaluated with CM-203 and CM-101 serving as check varieties.

Premium Quality Short Grain- *Calhikari-201 and Calhikari-202*
Calhikari-202, which was released in 2012, has continued to show its advantages over Koshihikari and CH-201 (released in 1999) in yield, agronomic traits, quality, and taste. In the SW Tests from 2010 to 2015, which included 63 test environments, CH-202 had a 6-year yield average of 8,520 lb/A and a 4.3% yield advantage over CH-201, which averaged 8,170 lb/A. In the 2015 SW Tests, when compared to Koshihikari in 2015, CH-202 had a 57% yield advantage, lower SV rating, earlier heading (14 days earlier), shorter plant height (27 cm shorter), 30% less lodging, and higher head rice percentage (2% higher at 69%). In SPQ grain types, lower head rice protein concentration is associated with better taste rating. Head rice samples from milling tests in 2013, 2014, and 2015 showed that CH-202 had lower protein concentrations and higher Satake Taste Analyzer ratings than Koshihikari.

In 2015, four SPQ lines were evaluated in the SW Tests, with 13Y2031 emerging as the top selection. Its average grain yield was 9,400 lb/A, which was 15% and 19% higher than CH-201 and CH-202, respectively. In comparison with CH-202, 13Y2031 had higher SV rating, later heading by 3 days, taller height by 3 cm, and 25% less lodging. It had a 64% head rice percentage, which was similar to CH-201 (63%), but lower than CH-202 (69%). Average Satake Taste Analyzer scores for 13Y2031, CH-202, and Koshihikari were 83, 81, and 79%, respectively. SPQ 13Y2031 has glabrous seed (smooth hull), unlike CH-202, CH-201, and Koshihikari, which are pubescent. SPQ 13Y2031 is currently being purified in the Experimental Seed Increase Nursery and is exhibited in the Short Grain Project Demo Plots.

In the 2016 SW Tests, there are three SPQ lines (including 13Y2031) being evaluated with CH-201 and CH-202 serving as check varieties.

Premium Quality Medium Grain- *M-401 and M-402*

M-401 and M-402, which were released in 1981 and 1999, respectively, are the standard premium quality medium grain varieties. In the SW Tests in 2015, nine MPQ lines were evaluated, and 12Y2175 emerged as the outstanding selection. Based on six SW test locations, 12Y2175 yielded an average of 10,120 lb/A, with yield advantages over M-402 and M-401 at 30 and 9%, respectively. It exhibited high SV ratings, similar to M-401 and M-402. Early heading is a trait essential in saving irrigation water, and 12Y2175 exhibits this by heading at 84 days after sowing, which was at least 8 days earlier than the MPQ varieties. Furthermore, 12Y2175 had a 65% head rice percentage, which was 2 and 8% higher than that of M-402 and M-401, respectively. MPQ 12Y2175 is currently being purified in the Experimental Seed Increase Nursery and it is exhibited in the Short Grain Project Demo Plots.

In the 2016 SW Tests, there are eight MPQ lines (including 12Y2175) being evaluated with M-401 and M-402 serving as check varieties.

Conventional Short Grain- *S-102*

The standard conventional short grain rice variety is S-102 (released in 1996). In the 2015 SW Tests, five SG lines were evaluated, with 10Y2043 at the forefront and being evaluated in both the very early and the early maturity groups. Grain yield of 10Y2043 (averaged across 8 test locations in 2015) was 10,700 lb/A, which was 19% higher than S-102. Its 5-year average from 2011 to 2015 was 10,110 lb/A, which was 18% higher than S-102. Compared to S-102 in 2015, 10Y2043 had slightly lower SV rating, it headed 4 days later, was 4 cm shorter in plant height, and had lower chalky area percentage. Head rice percentage of S-102 was higher than that of 10Y2043 in 2015, but their 3-year average from 2013 to 2015 was 65% for 10Y2043 and 64% for S-102. Furthermore, 10Y2043 is glabrous (smooth hull), unlike S-102 which is pubescent. SG 10Y2043 is currently being purified in the Experimental Seed Increase Nursery in 2016.It is also exhibited in the Short Grain Project Demo Plots.

In the 2016 SW Tests, there are four SG lines (including 10Y2043) being evaluated with S-102 serving as check variety.

Low Amylose Short Grain- *Calamylow-201*

Calamylow-201, which was released in 2006, is the current SLA variety. However, its low grain yield, high lodging percentage, and pubescent seed are unattractive traits that need improvement. This year, two SLA lines 15Y2100 and 15Y2106 are being evaluated in the SW Tests for the first time. Compared to CA-201, based on the 2015 Preliminary Yield Test (PYT) conducted at RES, 15Y2100 and

15Y2106 had grain yield advantages of 54% and 40%, respectively, and headed 3 and 4 days later, respectively. The SLA lines had slightly higher SV ratings and similar final head rice viscosities when compared to CA-201. SLA line 15Y2100 is being exhibited in the SG Project Demo Plots alongside CA-201.

Bold Grain- *87Y235*
Bold grain or Arborio rice types are grown on a small acreage in California. RES has not released a BG variety, but it has released 87Y235 as a germplasm in 1994. The development of improved BG lines is the first step to increase interest in this type of rice. Currently, there is one BG line (15Y2002) being evaluated in the SW Tests. Compared to 89Y235, based on the 2015 PYT, 15Y2002 has similar plant height, SV rating, and number of days to heading, but it has a 4% yield advantage.

Disease Resistance
Disease reactions to stem rot, aggregate sheath spot, and blast by breeding lines entered into the PYT and SW Tests are being evaluated by RES pathologist Dr. Paul Sanchez.

Rice lines of the various grain types are being pyramided for blast resistance genes. Based on DNA marker-assisted analyses conducted by RES geneticist Dr. Cynthia Andaya and on agronomic trait observations, blast resistant lines were selected and are currently being evaluated in this year's 10x10 Yield Tests.

Long Grains
(F. Jodari, Plant Breeder, RES)

The objective of the long grain project is to develop superior conventional long-grain and specialty long-grain varieties for California. Main emphasis in the conventional (southern) long-grain breeding category includes superior cooking quality, yield potential, milling yield, milling yield stability, cold tolerance, seedling vigor, and disease resistance.

Conventional Long Grains
L-206 is a very early to early maturing semi-dwarf, conventional long-grain variety. It has improved cooked grain texture and higher grain yield over earlier long grain varieties. Average heading date in statewide tests at RES is 1 day earlier than M206. Plant height is 14 cm shorter than M-206. L-206 has slightly stronger amylographic profile, as shown by higher cool paste viscosity and RVA setback values. Consequently cooked grain texture of it is less sticky than L-

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

L-206 is adapted to most rice growing areas in California except the coldest locations of Yolo and San Joaquin counties. Average grain yields of L-206 during 2006 to 2015 early statewide trials (RES, Butte, Colusa, Yuba), was 9510 lb/A, as compared to 9400 for M-206. Average head rice yield of L-206, however, is 62 %, which is 3% lower than M-206. Fissuring studies indicate that L-206 is significantly more resistant to grain fissuring than L-204. indicating a better milling yield stability at lower grain moisture contents.

Results of a comprehensive study sponsored by USA Rice federation and conducted by Southern US experiment stations and commercial milling companies have indicated that L-206 is highly favored for packaging quality. These results indicated that L-206 was ranked 1st among all US long grain varieties and hybrids for package quality by the participating rice mills. The evaluation criteria were bran streaks, chalk, kernel color, uniform length, and overall appearance. Concerted effort continues in the long grain project to maintain and further improve the marketability qualities of advancing long grain breeding material.

L-207 is a new long grain variety released for production in January 2016. Experimental designation of it was 12Y20 as it entered statewide testing in 2012. L-207 is a high yielding intermediate height, and early maturing variety with Southern US long-grain cooking quality. Detailed performance of these lines is included in RES annual reports (http://www.crrf.org). It is 2 days later in maturity and 6 in. taller than L-206. Average grain yield over all 7 statewide tests, excluding San Joaquin, in 2015 was 10080, 9420, 9330 lb/A for L-207, L-206, and M-206 respectively. Of special importance is the performance of L-207 at Yolo test location during 2013-2015, where it compared favorably with L-206 and M-206. Cooler conditions at Yolo site have been a challenge for long-grain selections and varieties in the past. Consequently, areas of adaptation of this variety will include most areas in the region except San Joaquin.

Milling yield of L-207 is also 3% higher than L-206. During 2012 to 2015, milling yields were tested at sequential harvest moistures. Within a span of 7 to 10 days, head rice yields remained stable ranging between 63 to 67%.

The genetic base of long grain breeding material at RES has been significantly expanded in recent years through the use of germplasm from Southern US and world collection sources. This diversity is being used to incorporate the desirable agronomic and quality traits in the elite RES lines.

Specialty Long Grains

Specialty long grain breeding efforts continue in an accelerated pace, as market demand for these types continues to increase. Currently, efforts are underway to develop soft cooking aromatic jasmine, elongating aromatic basmati, and conventional long-grain aromatic types adapted to California. Specialty long grains currently occupy nearly half of the long grain breeding nursery.

Calmati-202 is an early maturing basmati type variety. Quality improvements in this variety include more slender kernels, higher cooked kernel elongation ratio, and more flaky grain texture. Grain yield of Calmati-202 (CT-202) has averaged 6700 lb/acre. Head rice yield of this variety is considerably lower than standard varieties due to its slender grain shape, averaging 57%. CT-202 has a semi-dwarf pubescent plant type with good seedling vigor. Maturity is 93 days to 50% heading. Milled kernels of this variety are longer and narrower than CT-201 but not as slender as imported basmati.

Grain fissuring studies have shown that CT-202 is susceptible to fissuring at low harvest moistures. Timely harvest and proper handling is recommended to preserve milling as well as cooking qualities of this variety. Due to slender grain shape and pubescent hull and leaf, drying rate of the grain at harvest is significantly faster than standard varieties. Recommended harvest moisture is 18 to 20 %.

New series of basmati lines have been developed, including 7 entries that are currently being tested in 2016 statewide trials. These lines have shown cooking qualities that are nearly indistinguishable from imported basmati types. Grain and milling yields of these lines, however, seem to be similar to or lower than CT-202. Current breeding efforts are directed toward increasing both grain yield and milling yield while maintaining their basmati quality traits. Their adaptability thus far is limited to warmer rice growing region.

Efforts have significantly increased in jasmine type breeding, which currently occupy the largest section of the specialty nursery. Conventional pedigree and mutation breeding methods are being used. In 2016 statewide tests, 7 jasmine type selections are being tested. One entry, 15Y84, is currently being produced as breeder seed.

It has shown good cooking qualities with soft cooking texture and moderate aroma. two additional jasmine selections with similar amylographic profiles to those of imported jasmine are currently being purified as preliminary headrows

Quality testing was further expanded in 2016 for all advanced long grain selections including conventional as well as specialty types. Screening for amylographic profile through RVA was nearly doubled with the acquisition of a second RVA analysis instrument. This is in an effort to match the cooking quality of conventional, jasmine and basmati types to those of the current market.

A-202 is a conventional cooking type aromatic variety was released in January 2014. This variety is intended to be a replacement for aromatic variety A-301. A-202 is early maturing, semi-dwarf, and glabrous. Compared to A-301, A-202 is 9 days earlier, 4” taller, and has significantly higher seedling vigor score. Average yields, in lb/A in 2012 - 2013 ‘early’ statewide tests was 9100 and 7300 for A-202 and A-301, respectively. In 2014 and 2015 it was tested in all 8 statewide locations and averaged 9170 and 9180 lb/A. respectively. Average headrice yields during the same period were 60% and 53% for A-202 and A-301, respectively. Milled kernels of A-202 is slightly bolder than A-301. The recommended ratio of water to rice for cooking of A-202 is 2 to 1. Amylose content, gelatinization temperature type and amylographic profile are similar to A-301. Aroma volatilization of A-202 is slightly less during cooking process. Flavor sensory of this variety, however, is similar to A-301.

Preliminary tests conducted in 2012 have also shown that under organic production system A-202 has considerable yield advantage over A-301 variety. A-202 is susceptible to cold induced blanking and not recommended for production in cold locations. Areas of adaptation for A-202 include Butte, Yuba, Colusa, Glenn, and Sutter Counties.

Stem Rot Resistance

Stem Rot resistance breeding efforts continues in cooperation with RES plant pathologist. In 2016, 15 entries were tested 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.

Rice Pathology
(P.L. Sanchez, RES)

Rice Pathology Project focus on the development of improved disease resistance screening and evaluation for Rice Experiment Station (RES) breeding projects. This is done by developing and applying advanced screening techniques to measure and score breeding lines for selection, advancement, and data on breeding lines. We are producing inoculum in the laboratory and managing disease nurseries for optimal disease development. Advanced entries in yield trials are evaluated for susceptibility to stem rot in the field and aggregate sheath spot and blast in the greenhouse. Several years of testing are required to accurately characterize the level of resistance in these entries.

Germplasm Collection

Pathology Project handles rice germplasm (wild and cultivated rice species) requests by the breeders which must go through quarantine. All seed imported from other countries and received from rice growing states in the US are treated according to a permit issued by the U.S. Department of Agriculture, Plant Protection and Quarantine (PPQ) and subject to inspections by California Department of Food and Agriculture (CDFA) to prevent introduction of new pathogens and pests into California. Materials are then released for use in the breeding program. The plant quarantine procedure ensures that the breeders have access to traits important to the continuing improvement of California varieties.

Blast Resistance

Blast resistance conferred by the large-effect (no disease) *Piz* gene is already available in M-208. However, blast was found in growers' field in 2010 on M-208 and this year on M-209. Other large effect genes have been backcrossed eight times into M-206. Yield trials indicate these materials are very similar to M-206. Four of these genes have been combined in M-206 by conventional screening and use of molecular markers to prevent the fungus from overcoming single gene resistance, as occurred in M-208 and M-209. Available Blast resistant lines were screened and evaluated inside the greenhouse. These pyramided gene materials are being purified for yield testing. Efforts are already under way to transfer these genes to other varieties.

Stem Rot Resistance

Stem rot resistance has been derived from wild species of rice. Currently, the genes responsible for this resistance are being mapped in medium grain materials by the RES Molecular Biology Laboratory. An initial backcross population indicated at least four possible locations for genes, and further backcrosses are being evaluated to determine the location of these genes more precisely. Mapping populations are planted in the field for phenotypic and genotypic evaluation. The intent is to develop molecular markers useful in transferring this hard to evaluate trait. Long grain materials have been in state wide trials for some time, and are among the highest yielding materials.

Sheath Spot Resistance

Sheath spot resistance is also present in some rice germplasm materials derived from the wild species program for stem rot resistance. In this way, it may be possible to have resistance to two diseases simultaneously. Other sources of resistance have also been identified and crossed into M-206.

Ultimately, it is desirable to have resistance to all three diseases (blast, stem rot, and sheath spot) in a single variety. Use of advanced genetics and genomics approach for identifying and transferring blast, stem rot and sheath spot resistance genes will make production of more disease resistant California rice varieties in the future.

Virgilio "Butz" Andaya is Director of Plant Breeding & Medium-Grain Project Leader, Farman Jodari is the Long-Grain Project Leader, Stanley O. PB. Samonte is Premium Quality & Short-Grain Project Leader, Paul Sanchez is Rice Pathologist, and Cynthia Andaya is Research Scientist (DNA Lab) at RES.

Rice Insecticides: Maximize Use of IPM Tactics to Conserve These Products (L.D. Godfrey, UCD)

The California rice industry has a fairly good portfolio of insecticides for use in managing invertebrate pests such as rice water weevil, tadpole shrimp, and midge. These have been realized over the years through cooperation of the agrichemical companies, the rice industry, and the Univ. of California researchers. These materials registered for California rice include pyrethroids (Mustang®, Warrior®), neonicotinoid (Belay®), insect growth regulator (Dimilin®), and carbamate (Sevin®). One additional product is in the registration pipeline, a ryanodine receptor modulators (Coragen®). However, as shown in the 2015 season when armyworms reached unprecedented levels (the highest of the last 25 years) the insecticide choices were limited and all options had some deficiencies in terms of efficacy on armyworms. Fortunately, the California Rice Commission was able to get an emergency exemption (Section 18) for Intrepid® to help with this situation. All these registered insecticides need to be managed carefully so they are available and effective in future years and for future generations. They are insecticides! What could happen to them? The most obvious threats are 1.) development of insecticide resistance and 2.) regulatory actions.

Situation – 2016

These are not new threats but in previous years they were minimized due to new insecticides being developed. The development of new insecticides has greatly slowed in recent years. In the last 2 years, no experimental (new) insecticides have been available for testing against invertebrate pests of rice. That isn't to say that the multinational agrichemical companies are ignoring the California rice industry but rather the number of agrichemical companies developing insecticides for the U.S. market is very limited now. Most recently, two mergers between major companies are proposed/in progress (Dow Agrosciences + DuPont Crop Protection and Monsanto Co. + Bayer CropScience) and one major company is slated for purchase by a Chinese company (Syngenta Crop Protection by China National Chemical). This upheaval has disrupted the long-term planning for research and development of new materials. The number of agrichemical companies has gone from over a dozen to only a "handful" now. Of course, ongoing regulatory actions (the other threat to registrations), especially those associated with the pollinator issue, are also problematic and will be discussed below.

Why are these mergers happening? The belief is there is efficiency in scale, i.e., bigger is better. It is a cost-cutting measure and one of the areas that is often cut after the merger is research and development. One estimate I have seen for the DuPont-Dow merger is that there will be a $1.3 billion cost savings due to "synergies in research and development". This reduction means the possibility of fewer new chemistries being developed (although this could be offset by working more efficiently, more automated processes, etc.). The additional reality is that a significant amount of the effort (and budget) for these remaining agrichemical companies is in biotechnology and not in the development of sprayable/foliar insecticides.

There are still several smaller, U.S.-based companies that concentrate on the U.S. market and are critical for the rice industry, but these are not primary producers of new chemistry. They license active ingredients that have been discovered and developed by other international entities and as such they are at the whims of these companies to develop new chemistries. Especially for rice, the insect pest spectrum for rice in Asia (and insecticides needed to control these pests) does not coincide with the pest spectrum for rice in the

U.S. so there is not always a good fit between insecticides needs in Asia and in the U.S.

Managing Insecticides for Prolonged Use

Insecticide Resistance. Insecticide resistance is a biological process facilitated by selection pressure that renders the insecticide ineffective in terms of killing the pest. What is selection pressure? It the process of exposing the insect pest population to the insecticide via an application to the field. Over time, i.e., applications, a portion of the population becomes tolerant to the insecticide and this proportion eventually becomes the dominant part of the population. In this case, insecticide resistance has developed. Once insecticide resistance has developed, the insecticide cannot be used due to lack of effectiveness. Of course, pesticide resistance can occur with herbicides and fungicides as well as insecticides.

Several methods are available to minimize the development of resistance. Most importantly, minimize the number of insecticide applications, i.e., minimize the selection pressure. Utilize other pest management tactics as much as possible such as cultural control, host plant resistance, biological control, etc. This will achieve the needed level of control, especially when combining tactics, without imposing selection pressure to the small number of available insecticides. Carefully consider if an insecticide application is needed before making an application. This should be based on the level of the pest population and predicted amount of damage/yield loss and not only on the low cost of the insecticide or simple presence of the pest. Carefully sample the pest population. Use border applications as much as possible. Treat the 50-75 feet adjacent to the levee. This area has the highest rice water weevil populations and armyworms tend to be concentrated along the borders. This is a cost-cutting measure, reduces the amount of insecticides going into the field and also helps to maintain susceptibility in the pest population. Studies are ongoing to evaluate the distribution of tadpole shrimp in rice basins to see if border applications could be used. The second way to minimize the development of resistance is to alternate insecticide modes of action such as use a pyrethroid insecticide one year and Belay the next year and perhaps Dimilin the third year (assuming the insecticide is registered for the pest you want to control). This helps to maintain susceptibility in the pest population.

Status of Insecticide Resistance in Rice

Several PCAs have noted that pyrethroid insecticides are not controlling rice water weevil as well as they did at one time. This has not been “proven” scientifically but the magnitude of pyrethroid use makes this entirely possible after ~15 years of intensive use. There is also an indication that some tadpole shrimp populations have a reduced level of susceptibility to pyrethroid insecticides (see poster by Luis Espino). Armyworms exhibit a natural-occurring level of tolerance to many insecticides and in 2015 it was found that the insecticide tools registered are not appropriate to control high populations of armyworms within the heavy rice canopy.

Regulatory Issues

Regulatory issues with insecticides seem to be ongoing and ever-present in California and nationally. Many times these issues do not directly involve the rice industry such as the pollinator issue (the flowers of rice plants are not significantly attractive to bees) but "blanket" regulations are put in place and these have effects on a broad range of industries. Fortunately, the California Rice Commission keeps track of these ongoing issues and is an effective advocate for the industry.

New Pest Management Tactics

To supplement insecticides in IPM programs, my lab strives to develop new pest management tactics for invertebrate pests of rice. These include insecticidal tools as well as non-insecticidal methods. Presently, understanding the upswing in tadpole shrimp populations and developing management tools has been a priority (see poster by Joanna Bloese in poster area). Other studies are studying similar topics on armyworms and rice water weevil. Stink bugs native to California appear to be on the upswing and two species of invasive stink bugs appear to have the potential to be pests of rice and we are monitoring this situation through carefully planned studies.

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Weed Control in Rice: Herbicide Programs for Different Rice Growing Systems, and New Weed Control Products

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The UC Rice Weed Research Program at the Rice Experiment Station, Biggs, CA seeks to assist California rice growers in achieving economic and timely broad-spectrum weed control, preventing and managing herbicide resistant weeds, and complying with personal and environmental safety requirements. The program primarily focuses on the performance evaluation of existing herbicides (in mixtures and sequential combinations) and new herbicides for the common rice growing systems in California.

Here we highlight results from our 2016 field experiments for the major rice growing systems used in California. Weed control efficacy of herbicide programs presented here primarily reflect the visual ratings (average of four replicates) approximately 40 to 60 days after seeding (DAS) of rice. Rice response (stand reduction, stunting and other injury) to the herbicide programs has also been noted wherever relevant.

Continuous Flood System:
This system has been historically the most common rice growing system in California as this system promotes suppression of most competitive rice weeds such as barnyardgrass, watergrass, and sprangletop. In this system, a water depth of 4 inches is maintained throughout the season after seeding rice into a flooded field. When late post-emergence foliar applications are needed, water depth is lowered to expose about two-thirds of weed foliage to the herbicide spray, but fields are never completely drained.

This year, watergrass (early and late) were the predominant weeds, followed by ducksalad, ricefield bulrush, smallflower umbrella sedge, redstem and sprangletop. All weeds evaluated in our program are susceptible to herbicides registered for California rice, but we discuss and give weed management options for fields with population(s) of resistant weed species.

For this system, several granular into-the-water herbicide products are available for controlling weeds in rice including Bolero, Cerano, Granite GR, Halomax, Londax, and Shark H_2O. In addition, League® MVP is a relatively new addition to the California rice herbicide portfolio and Butte® is expected to be available soon. These herbicides can be applied early to provide good to excellent control of labelled (target) weeds. As they vary in the spectrum of weed control, it is often useful to combine two of these herbicides in a program to offer broad spectrum weed control.

POST-applied (foliar) herbicides, in most situations, are indubitably necessary to achieve excellent weed control in rice. The follow-up POST-applied herbicides not only extend the spectrum of weed control, but also may help delay and/or manage herbicide-resistant weeds through overlapping activity on the same target weed species. The choice of POST-applied herbicides is primarily dictated by composition of weed species in the field and the presence or absence of resistant weeds. The common POST-applied herbicide options for California rice include Abolish, Clincher CA, Granite SC, Regiment CA, RiceEdge®, Shark H_2O, Halomax, Londax and propanil products (SuperWham!, Stam 80 EDF etc.).

Butte® -Based Programs

Butte® is expected to be available to California rice growers next year. Butte® is a granular mixture of benzobicyclon and halosulfuron product developed by Gowan Company. The benzobiclyclon component of Butte® adds a new mode of action (HPPD-inhibitor) to the herbicide portfolio for water-seeded rice in California. This year, efficacy of Butte® alone or in a program was tested in two separate studies.

In the first study, Butte® was tested under a continuous flood system with two rates of application, both alone and in a program. An into-the-water application of Butte® at 7.5 or 9 lb/A at 1 lsr provided excellent control of sedges (ricefield bulrush and smallflower umbrella sedge), ducksalad, monochoria, and sprangletop. However, the control of watergrass varied from fair to good, whereas redstem control was poor. Overall, Butte® alone provided a broad spectrum of weed control and offered an exceptional level of crop safety. Inclusion of Cerano (12 lb/A at day of seeding) into the Butte® program (7.5 lb/A at 1 lsr) provided overall greater control of weed species compared to the Butte® applied alone; however, this program caused a significant (~10%) crop stand reduction.

A follow-up application of Clincher (13 oz/A + 2.5% COC) or Regiment (0.67 oz/A + 2.0% v/v UAN + 0.2% v/v NIS) at 1 tiller stage slightly improved watergrass control. A tank-mix of SuperWham! + Grandstand (6 pt/A + 8 oz/A + 1.25% v/v COC) or Granite SC (2.8 oz/A + 2.25% v/v COC) applied at 1 tiller stage provided exceptional control of all weeds, including watergrass and redstem. The choice of the appropriate follow-up application or an inclusion of a granular herbicide (for example Cerano) may largely depend on the weed population density and/or resistance status of the weeds in the field.

In the second study, a single rate and timing of Butte® (7.5 lb/A at 1 lsr) was tested under a continuous flood system with a follow-up application of Granite SC applied at three rates (2, 2.4 and 2.8 oz/A) and three timings (3 and 5 lsr, and 1 tiller stage). As noted in the first study, Butte® at 7.5 lb/A at 1 lsr provided excellent control of sedges (ricefield bulrush and smallflower umbrella sedge), broadleaf weeds (ducksalad and monochoria) and sprangletop. The application of Butte® alone provided only a fair to good control of watergrass and poor control of redstem. All the rates and timings of Granite SC greatly improved watergrass and redstem control, and these applications were reasonably safe to rice. The application at 3 lsr, especially with the highest rate of Granite SC caused slightly more stunting (~10%) of rice compared to Butte® alone or other Granite SC applications. However, redstem control was greater with this early application. The highest rate of Granite SC (2.8 oz/A) may be required in the fields where redstem is a problem weed. In conclusion, Butte® followed by Granite SC program offers broad spectrum of weed control and excellent crop safety in continuously-flooded rice system.

Bolero-, Cerano- and Granite GR-Based Programs

Bolero-based programs [applied at the 2 leaf stage of rice (lsr)] provided good control of watergrass, and excellent control of sprangletop and smallflower umbrella sedge. Inclusion of SuperWham! at 6 qt/A + 1.25% v/v Crop Oil Concentrate (COC) at 1 tiller stage or Regiment (0.8 oz/A + 2% v/v UAN + 0.2% v/v NIS) at 5 lsr in this program slightly improved control of watergrass. A follow-up application of SuperWham! (6 qt/A + 1.25% v/v COC) at 2 tiller stage after the Regiment application resulted in excellent control of all weed species, including watergrass. Bolero-based programs offer an excellent solution for controlling ALS- and/ or propanil-resistant smallflower umbrella sedge and Clincher- and Cerano-resistant sprangletop.

Cerano-based programs [12 lb/A, at the day of seeding (DOS)] provided good control of watergrass and excellent control of sprangletop. Cerano caused severe crop injury (bleaching and stunting) and stand reduction following its application. The crop recovered most of the injury by six weeks after rice seeding. A foliar application of SuperWham! (6 qt/A + 1.25% v/v COC) at 1-tiller stage following Cerano application was exceptionally effective in controlling watergrass (98% control), however, the control of ricefield bulrush and smallflower umbrella sedge was poor (less than 70% control). Addition of Shark H_2O (8 oz/A) at 1 lsr followed by Granite SC (2.8 oz/A, 5 lsr) or Abolish + Regiment (1.5 qt/A + 0.67 oz/A + 0.2% v/v NIS + 2% UAN) at 5 lsr to the Cerano-based program provided good control of sedges and an excellent control of grasses and broadleaf weeds. Cerano followed by Butte® (7.5 lb/A, 1 lsr) was the most effective among the Cerano-based programs in controlling weeds, however, this programs caused remarkable level of initial/transitory crop injury and some stand reduction.

Application of Granite GR (15 lb/A) at 3 lsr, in general, controlled a broad spectrum of weeds; however, by itself, it was not excellent for controlling smallflower umbrella sedge and also it lacked efficacy on sprangletop and redstem control. While a follow-up foliar application of SuperWham! (6 qt/A + 1.25% v/v COC) at 5 lsr or 1 tiller stage or Abolish + Regiment (1.5 qt/A + 0.67 oz/A + 0.2% v/v NIS + 2% UAN) at 5 lsr improved overall weed control (including smallflower umbrella sedge), sprangletop control was still poor.

League® MVP

League® is a granular formulation of thiobencarb and imazosulfuron developed by Valent USA. Efficacy of Leauge® MVP alone (35 lb/A at 2 lsr) and in a program involving a follow-up application of SuperWham! (6 qt/A + 1.25% v/v COC) applied at 1-2 tiller stage. League® MVP alone provided a very good control of watergrass (>90%) and an exceptional control of sprangletop, sedges and broadleaf weeds while providing excellent crop safety. The League® MVP plus SuperWham! program improved watergrass control compared to League® alone program. League® MVP-based program, especially in a rotation with Butte®-based program, holds a promise for successfully managing Cerano- or Clincher-resistant sprangletop.

RiceEdge®

RiceEdge® is a dry flowable mixture of propanil and halosulfuron product from RiceCo, LLC, for use in rice as a better alternative to SuperWham! (propanil alone). Although this product can be use in pinpoint flood system, this year, it was tested only under a continuous flood in Granite GR-based program. RiceEdge® (10 lb/A, 1-2 tiller stage) following Granite GR (15 lb/A) at 3 lsr provided excellent control of most weeds (watergrass, sedges and broadleaf weeds), but sprangletop.

Pinpoint Flood:

In this system the field is completely drained during the period of foliar application of herbicides (at about the 2-4 leaf stage of rice). The complete drainage of the field is intended to expose weed foliage to herbicide applications, thus allowing the opportunity to achieve the best efficacy of POST-applied herbicides. The pinpoint drainage in this system may induce better establishment of sprangletop.

The Clincher-only application (13 oz/A + 2.5% v/v COC at 5 lsr) was excellent in controlling all grasses including sprangletop. A tank-mix application of Clincher and Granite SC (13 oz/A + 2.3 oz/A + + 2.5% v/v COC at 5 lsr) was very effective in controlling all the weed species except smallflower umbrella sedge. Weed control was similar with a sequential application of Granite SC at 5 lsr and followed by Clincher application at 1 tiller stage. Clincher-only, or Clincher + Granite SC applications applied late at 1 tiller stage were not as effective as the early or sequential applications for controlling grasses. These programs will not control certain ALS-inhibitor-resistant ricefield bulrush and Clincher-resistant watergrass and sprangletop populations; however, it is a good alternative for fields with Cerano- or thiobencarb-resistant sprangletop populations.

Not surprisingly, a remarkable reduction in the efficacy of grass and smallflower umbrella sedge control was observed with a tank-mix application of Clincher (13 oz/A) and SuperWham! (6 qt/A) with 2.5% v/v COC applied at 5 lsr or 1 tiller stage.

A follow-up tank-mix application of SuperWham! and Grandstand (6 qt/A + 8 oz/A + 2.5% v/v COC) at 1 tiller stage after the early tank-mix application of Clincher and Granite SC provided the best (~100% control of all weeds) weed control. Grandstand effectively controls ricefield bulrush and redstem. Thus, addition of Grandstand in the program is particularly important for controlling of ALS-inhibitor- and/or propanil-resistant ricefield bulrush, and redstem.

Drill-Seeded Rice:
While drill-seeded rice system offers flexibility for herbicide use when proximity to the sensitive crops restricts aerial applications, this system divests major herbicides developed for continuously-flooded rice. As seeding depth of rice might affect relative emergence of rice to weeds, there may be a potential for using non-selective and economically more feasible herbicides such as glyphosate. In the search of this promise, a preliminary study was conducted in which rice was planted at three depths (0.5, 1.5 and 2 inches) and glyphosate was applied just before the first leaf of rice reached the soil surface to evaluate weed control and crop safety of glyphosate alone or in combination with other common herbicide programs for drill-seeded rice.

As expected, weeds adapted to dryland seedbeds such as barnyardgrass, sprangletop, watergrass and smallflower umbrella sedge were better established, whereas aquatic weeds such as ricefield bulrush, ducksalad, and redstem were less favored or almost eliminated in this system compared to continuously-flooded system.

Emergence time of rice varied with the depth of planting. Rice planted at deeper depths (1.5 and 2 inches) emerged much later (5-7 days) than that of planted at shallower depth (0.5 inch), which allowed delayed application of glyphosate with deeper planting. As per the hypothesis, this year's preliminary data suggest that a high majority of initial flush of weeds could be controlled without a significant damage to the crop with glyphosate when rice is planted deeper (1.5-2 inches). Additionally, the results indicate that the greater initial weed control with glyphosate at deeper depth help improve the efficacy of follow-up applications of contact herbicides (low translocation index) such as Clincher, SuperWham! or Granite SC. While these results are encouraging, future studies with adjustment in field plot setup with respect to irrigation management is needed to validate the conclusions.

Herbicides used and their active ingredient

Herbicide	% ai	lb ai/gal
Abolish 8EC (thiobencarb)	84	8.0
Bolero Ultramax (thiobencarb)	15	NA
Butte (benzobicyclon + halosulfuron)	3 + 0.64	NA
Cerano 5 MEG (clomazone)	5	NA
Clincher CA (cyhalofop-butyl)	29.6	2.4
Grandstand (triclopyr)	44.4	3.0
Granite GR (penoxsulam)	0.24	NA
Granite SC (penoxsulam)	24	2.0
Glyphosate WeatherMax	48.8	5.5
Halomax 75 (halosulfuron)	75	NA
Londax (bensulfuron-methyl)	60	NA
Prowl H_2O (pendimethalin)	42.6	3.8
Regiment (bispyribac-sodium)	80	NA
RiceEdge (propanil + halosulfuron)	60 + 0.64	NA
Sandea (halosulfuron)	75	NA
Shark H_2O (carfentrazone)	40	NA
Strada CA (orthosulfamuron)	50	NA
Wham! CA (propanil)	41.2	4.0
Stam 80 EDF	81	NA

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EQUIPMENT DISPLAY

Valley Truck and Tractor
Holt Ag Solutions
N&S Tractor
Peterson Cat
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SWECO

Certified Seed and Rice Experiment Station Varieties

Planting certified rice seed provides great benefits to California rice growers and the California Rice Industry as a whole. Its purpose is to assure availability of pure, weed free, and high quality seed of rice varieties for California rice growers and consequently the California rice market. This has been an effective program for California, providing pure seed for the industry and preventing establishment of weedy red rice, providing varietal identity, and protecting the California Rice Industry from contamination issues like and the Liberty Link GM contamination experienced in the southern US. The production and maintenance of foundation seed of California Cooperative Rice Research Foundation (CCRRF) rice varieties is one of the major missions carried out at the Rice Experiment Station. The RES foundation seed program is a cooperative effort between CCRRF and the California Crop Improvement Association.

The rice varieties released from the Rice Experiment Station since the early 1990's are protected under the US Plant Variety Protection Act (PVP) and are to be grown and approved for sale for seed by variety name only as a class of certified seed, and restricted to California. Sale of these protected varieties as grade seed defeats the benefits of planting certified seed and is a violation of Article 9 of California Seed Law.
(https://www.cdfa.ca.gov/plant/pe/nsc/docs/seed/SeedLaw_2014.pdf)

Thanks for your cooperation,

Kent S. McKenzie

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Director and Plant Breeder