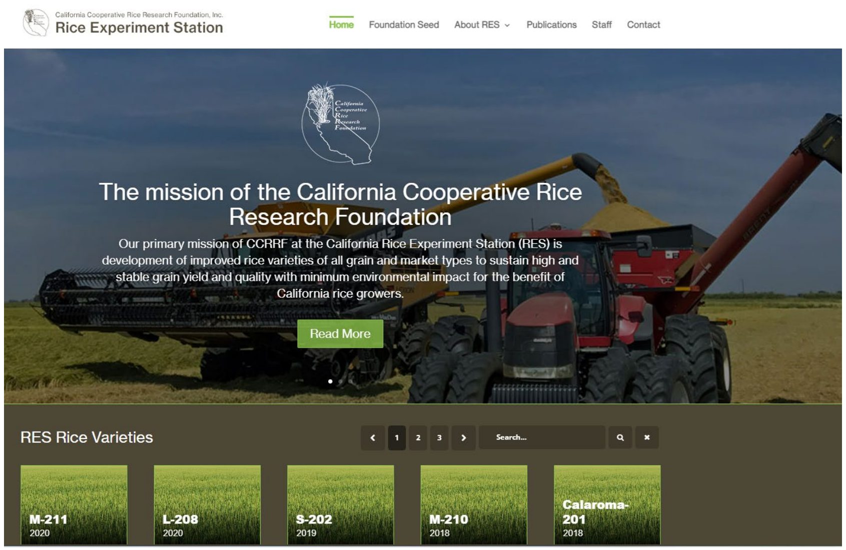
RICE FIELD DAY

Wednesday, August 31, 2022



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

Screenshot of the new California Cooperative Rice Research Foundation – Rice Experiment Station website. The new website was created to make rice variety & research information more accessible to the California Rice Industry across platforms. The new website was launched in April of 2022 and can be found at www.crrf.org

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Dustin Harrell, Ph.D., Director
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Deven Benson, Maintenance and Operator
Ashley Averitt, Maintenance and Operator
Andres Aceves, Maintenance and Operator

ROXY® RPS Partners

Chad Shelton, Albaugh LLC.
Kent McKenzie, ROXY®RPS consultant

UC Rice Research

J. Ray Stogsdill, Staff Research Associate III
Kevin Goding, Staff Research Associate II
Saul Reyes, Junior Specialist
Saul Estrada, Junior Specialist

2022 Rice Field Day Program

7:30 - 8:30 a.m. Registration and Poster Session

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

Welcome by Rob Doornbos, Chairman, CCRRF

CCRRF Business Meeting

- Rice Experiment Station & ROXY® Update
  Dustin Harrell, RES
- Financial Report,
  Kim Gallagher, Treasurer, CCRRF
- Directors Nomination Committee Report,
  Dustin Harrell, RES
- Rice Research Trust Report,
  Steven Willey, Chairman, RRT
- D. Marlin Brandon Rice Research Fellowship
  Dustin Harrell, RES
- California Rice Research Board Report,
  Drew Rudd, Chairman, CRRB
- California Rice Industry Award Presentation
  Kurt Meyer, Vice Chairman, CCRRF

9:20 - 10:45 a.m. MAIN STATION TOUR

Two tours occur simultaneously and repeat.

Blue & Green Groups to Trucks

Long and short grain breeding program & Genome wide selection
Rice Breeding Program
(F. Maulana & N. Sharma, RES)

Rice Agronomy, Fertility, and Insect Management
(B.A. Linquist & Ian Grettenberger, UCD)

Pest Management & Red Rice Update
(L. Espino & W. Brim-DeForest, UCCE)

ROXY® RPS: California's first herbicide tolerant rice
(K. McKenzie, ROXY Consultant)

Medium grain and herbicide tolerant rice breeding
(T. DeLeon, RES)

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

University of California Rice Weed Research Program
(K. Al-Khatib, UCD)

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 under the carport with seating at the tables on the lawns under the canopies.

Continuing Education credit for this 2022 Rice Field Day
has been requested 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.

POSTERS AND DEMONSTRATIONS

1. Commercial Demonstration of a Wireless Smart Technology for Early Detection of Insect Activity in Storage Rice (Zhongli Pan and Ragab Khir)

2. Determination of Fumigant Reduction Potential by Using Wireless Smart Technology for Early Detection of Insect Activity in Rice during Storage (Zhongli Pan and Ragab Khir)

3. Response of California Rice Varieties to Stem rot and aggregate sheath spot (Luis Espino and Whitney Brim-DeForest, UCCE)

4. Insecticides for Armyworm Control (Luis Espino, Troy Clark, Marco Giron, and Consuelo Baez, UCCE)

5. Germination of Stored Rice Seed (Luis Espino, Timothy Blank, and Whitney Brim-DeForest)

6. Rice Seed Midge Response to Conventional Rice Insecticides (Kevin Goding, Eric Bach, Catelyn Bylsma, Morgan Myhre, Luis Espino, and Ian Grettenberger)

7. Managing Tadpole Shrimp with Insecticides (Ian Grettenberger, Kevin Goding, Madi Hendrick, and Luis Espino)

8. Mosquito Fish as a Potential Biological Control Option for Tadpole Shrimp Management (Madi Hendrick, Kevin Goding, Luis Espino, and Ian Grettenberger)

9. Florpyrauxifen-benzyl, Loyant, Applications at Different Growth Stages to Rice and Smallflower Umbrella Sedge (Deniz Inci and Kassim Al-Khatib)

10. California Weedy Rice and Grass Populations' Response to Clethodim (Rasim Unan*, Liberty Galvin, Kassim Al-Khatib)

11. Emergency Drought Relief Latest (California Rice Commission)

12. Public Education & Communications (California Rice Commission)

13. Conservation Programs on California Ricelands (California Rice Commission)

14. Rice Helping Salmon (California Rice Commission)

15. Exploring No-Till Systems in Water-Seeded Rice (Mia Godbey, Bruce Linquist, Whitney Brim-DeForest, Luis Espino)

16. Tracking Herbicide-Resistant Weeds in California Rice Through a Community-Driven Approach (Aaron Becerra-Alvarez, Amar S Godar, Saul Estrada, and Kassim Al-Khatib)

17. Introduction of Upland Soil Conditions Alter Yield Potential in California Rice (Zhenglin Zhang, Daniel C. Olk, Bruce Linquist)

18. 19Y4000, a Blast and Herbicide Resistant Conventional Calrose Rice (Teresa B. De Leon, Kent S. McKenzie, Virgilio C. Andaya, Cynthia B. Andaya, and Dustin Harrell)

19. 17Y2087, a New Improved Premium Quality Short Grain Rice (Teresa B. De Leon, Virgilio C. Andaya, Kent S. McKenzie, and Dustin Harrell)

20. 18Y2070, a Promising California Risotto Rice (Teresa B. De Leon, Virgilio C. Andaya, Kent S. McKenzie, and Dustin Harrell)

21. A Shared Partnership (Chad Shelton and Kent McKenzie)

22. ROXY RPS® 2022 Off-Station Research (Chad Shelton and Kent McKenzie)

23. ROXY RPS® 2021 Off-Station Research (Chad Shelton and Kent McKenzie)

24. RES Genetics Lab: Past, Present, and Future (Gretchen Zaunbrecher and George Yeltatzie)

25. 18Y2070, a Promising California Risotto Rice (Teresa B. De Leon, Virgilio C. Andaya, Kent S. McKenzie, and Dustin Harrell)

26. Control of Watergrass Species (Echinochloa spp.) in California Rice: a Preliminary Survey

27. Weedy Rice Control in a Fallow System (Whitney Brim-DeForest, Taiyu Guan, Troy Clark, Luis Espino)

28. Viability and Dormancy of Weedy Rice Over the Winter: Impacts of Soil Moisture and Burial Depth (Whitney Brim-DeForest, Taiyu Guan, Troy Clark, Luis Espino)

Introduction

By Rob Doornbos

On behalf of the Board of Directors, staff and UC cooperators, I would like to welcome you to the 2022 Rice Field Day. Field Day is our annual opportunity to highlight the research that is underway at the Rice Experiment Station on behalf of the California Rice Industry. It also serves as the annual business meeting for the grower/owners of the California Cooperative Rice Research Foundation.

The 2022 growing season has been challenging for the California rice industry to say the least. We have faced an unprecedented drought, severe water restrictions in many of our water districts, a 50% decline in rice acres, and increased fuel, fertilizer, and chemical costs. As a grower, weather conditions and inflation are not something that we can control directly; however, we can do our part to help maintain the viability of the California rice industry into the future by investing in rice research and rice variety development.

The Rice Experiment Station breeding program has played a key role in maintaining the viability of the California rice industry by developing high quality Calrose varieties. The most recent release from the Station, M-211, not only has a premium Calrose quality but also has a yield advantage over previous Calrose varieties. On the field tour today, you will hear about 2 new potential variety releases from the Station in the coming year. They include a new Calrose variety with the ROXY® herbicide resistant trait and a new premium quality short grain. This has been possible due to the financial support from the California Rice Research Board, the Foundation and the Rice Research Trust, as well as a committed Rice Experiment Station staff.

The highlight of the day's activities are the field tours where you are able to hear from the researchers and see the breeding nurseries on the main station as well as weed control research at the Hamilton Road site.

Drs. Frank Maulana and Nirmal Sharma will provide an update on the long and short grain breeding programs at the RES.

Dr. Teresa De Leon will provide an update on the medium grain and herbicide tolerant breeding programs at the RES.

Dr. Kent McKenzie will provide an update on the ROXY Rice Production System research.

Drs. Bruce Linquist, and Dr. Ian Grettenberger will provide an update on rice agronomy and insect management research.

Drs. Luis Espino and Whitney Brimm-DeForest will provide an update on pest management and red rice research.

Dr. Kassim Al-Khatib will provide a walking tour of the weed research nursery at the Hamilton Road site.

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. We are now further strengthening our seed program for all RES varieties by licensing all seed growers of our varieties. The certified seed program is an essential part of maintaining genetic purity in our varieties and ensuring the highest quality seed is available to the industry, as well as stemming the spread of weedy red rice. The seed program is self-supporting and is not funded by the Rice Research Board.

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. Lastly, thanks to all of the RES staff and UC that work very hard to make Rice Field Day successful.

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 Board or the 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. Thirty-two fellowships have been issued from 2000 to 2021.

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
Johnny Campbell	2017
Alex Ceseski	2017
Telha Rehman	2017
Katie Driver	2018
Luke Salvato	2018
Henry Perry	2019
Aaron Becerra-Alvarez	2021

POSTER ABSTRACTS

Commercial Demonstration of a Wireless Smart Technology for Early Detection of Insect Activity in Storage Rice

Zhongli Pan and Ragab Khir, UCD

Early detection of insect activity in stored rice can maintain the product quality, reduce chemical fumigation and associated costs, and mitigate food safety, health, and environmental concerns. The objective of this study was to demonstrate a wireless smart technology for the early detection of insect activity in commercial rice storage. A wireless technology consisting of a smart insect catching device, a cloud server, and a user interface was developed and demonstrated in nine different commercial storage facilities in California. The new detecting system was programmed to take images based on schedules or on-demand. Data and images were processed in a cloud servicer. The server processed the images and counted the insects captured with an insect-counting algorithm. The system also recorded temperature and relative humidity. The user interface displayed images of insects, insect numbers, temperature, and relative humidity. The results showed that the wireless technology was able to early detect insect activities in all tested storage facilities and simultaneously monitor temperature and relative humidity. The first insect was detected the next day after the trap installation in all of the tested storage facilities in late April 2021. The number of insects continued to increase during the test periods. However, the human inspection in all tested storage facilities did not find any insects during the entire test period. Additionally, the new technology was able to catch and detect different types of insects. The findings of this study confirmed that the implementation of the new technology can make a significant impact in the rice industry, including eliminating the labor and costs from human inspection, preventing insect damages to the products and economic losses, and reducing food safety risks, and fumigation chemical use and related cost.

Determination of Fumigant Reduction Potential by Using Wireless Smart Technology for Early Detection of Insect Activity in Rice during Storage

Zhongli Pan and Ragab Khir, UCD

Reducing the chemical use for insect control and associated cost is very important for the rice storage. In the past four years, with the support from the California Rice Research Board, we have successfully demonstrated a smart wireless early detection technology to catch insects in stored rice when insects emerge. It is believed that insect infestation generally starts from the top layer of rice and then gradually moves down to the bottom. Therefore, only the top layer of rice in storage, instead of the entire product, needs to be treated if the insects are detected early. The objective of this study was to investigate the movement behavior and mobility of insects in rice and control method. Two insect catching devices equipped with video cameras and the sensors of temperature and relative humidity were installed in a silo. A top layer treatment practice based on the new insect detection technology was applied. The obtained results indicated that the insect

infestation and activities can be controlled in the top layer of the rice by applying surface treatment using insecticides. The new practice reduced chemical use by 65%. It was concluded that the adoption of the new wireless technology for early detection of insect activity and application of top layer treatment can maintain the product quality, reduce treatment costs, and mitigate food safety, health, and environmental concerns.

Response of California Rice Varieties to Stem Rot and Aggregate Sheath Spot
Luis Espino and Whitney Brim-DeForest, UCCE

Stem rot (Sclerotium oryzae) and aggregate sheath spot (Rhizoctonia oryzae-sativae) are common diseases of rice in California. Before the 2000s, burning crop residue after harvest was the main management method for both diseases. Since the phase out of straw burning in 2000, the two diseases have become more important and, in some cases, cause yield reductions. A field experiment comparing the response of eight common California rice varieties to each disease was conducted. For stem rot, results showed that varieties with longer development time to maturity had lower incidence and severity. Treatment with the fungicide azoxystrobin reduced disease severity by 30% and resulted in a 4% yield increase in all varieties. For aggregate sheath spot, most varieties had similar incidence and severity, with only one long grain variety showing reduced incidence and severity. Treatment with the fungicide azoxystrobin reduced disease severity 66%; however, a yield increase was observed only in a short grain variety. The implications of these results on disease management in California rice will be discussed.

Insecticides for Armyworm Control
Luis Espino, Troy Clark, Marco Giron, and Consuelo Baez, UCCE

Insecticides are an important tool for managing armyworms (Mythimna unipuncta), an emerging pest of rice in the Sacramento valley. To evaluate the efficacy of insecticides, a field trial was established in a commercial rice field in Butte County. Insecticides tested were Dimilin (diflubenzuron) at 4 or 8 oz/a, , Leprotec (Bacillus thuringiensis) at 1 pt/a in combination with SpearLep (GS-omega/kappa-Hxtx-Hv1a) at 1 or 2 pt/a in combination with Leprotec (Bacillus thuringiensis) at 1 pt/a, Intrepid (methoxyfenozide) at 7 or 10 oz/a, Xentari (Bacillus thuringiensis) at 1 or 2 lb/a, and Sevin (carbaryl) at 1.5 qt/a. Larval population in the field was high, averaging 7 true armyworm larvae/ft2. Larval populations were evaluated 0, 3, 5, 7, and 11 days after treatments were applied. Intrepid and Dimilin provided the best control. Intrepid reached 90% control 5 days after the application while Dimilin reached 84% 7 days after application. Both products reached more than 90% control 11 days after treatment.

Germination of Stored Rice Seed
Luis Espino, Timothy Blank and Whitney Brim-DeForest, UCCE

With the reduced rice acreage in 2022, there are concerns regarding the availability of fresh rice seed for the 2023 season. A field trial was established with varieties M-206, M-211, and CH-202 to evaluate the viability of seed that had been stored for a year at ambient temperature and compare it with the viability of fresh seed. Stand establishment of stored and fresh seed was similar, reaching over 30 plants/ft2. Germination tests for both stored and fresh seed were similar as well, over 88%. Additionally, the establishment of variety S-202 on the statewide variety trials was evaluated. This variety had been stored for a year at ambient temperature. Establishment of S-202 was poor, with stands that ranged from 4 to 16 plants/ft2. Germination of this seed was 86%.

Rice Seed Midge Response to Conventional Rice Insecticides
Kevin Goding, Eric Bach, Catelyn Bylsma, Morgan Myhre, Luis Espino and Ian Grettenberger, UCD

Rice seed midge are a multi-species complex with high damage potential, especially to late-planted rice. Late-planted rice is especially vulnerable as these rapidly reproducing midges can increase in population in a very short time and overwhelm germinating rice. In this study, we are evaluating the effectiveness of conventional rice insecticides against these midges to determine if injury to rice seeds can be prevented. We tested materials typically used early in the season in rice, including pyrethroid and growth regulator modes of action. Rice was seeded into one meter diameter metal rings approximately ten days after the last rice in the area was planted. Treatments were applied one day after planting. A mesh bag containing roughly one hundred seeds was also placed into each ring to evaluate percent damage. We also conducted substrate sampling at seven and fourteen days in each ring to evaluate midge populations. We evaluated stand counts I the rings to assess damage. Results from this study will help inform management of early season rice.

Managing Tadpole Shrimp with Insecticides
Ian Grettenberger, Kevin Goding, Madi Hendrick and Luis Espino, UCD

Tadpole shrimp are the key invertebrate pest in rice early in the season. Management relies heavily on insecticides. Currently, pyrethroids are the most-used mode of action, but additional materials have been employed in some cases. Because tadpole shrimp can be difficult to detect when they are small and because they can grow very quickly, the timing of applications can vary widely. This likely will affect efficacy for some materials. We evaluated a number of different insecticides for managing tadpole shrimp. We tested insecticides from multiple modes of action due to the threat of resistance to pyrethroids. In addition, we tested multiple rates and application timings to address the economics of management and different scouting situations. We used two methods. In the first, we used one-meter diameter metal rings and natural infestations of tadpole shrimp. We evaluated management success by performing visual counts of tadpole shrimp in the rings at multiple time points, as well as a final destructive assessment by netting and counting the shrimp. We also are evaluating stand establishment and yield. We also used an “inner ring” method. Here, we placed a metal trash can within the larger ring and then added 10 shrimp to each ring before making the insecticide application. We then counted the shrimp to evaluate mortality at multiple time points. Through this work, we are identifying alternatives to pyrethroids and establishing best practices for their application that can factor in both economics and efficacy. Managing shrimp with multiple modes of action will be critical for preventing insecticide resistance from spreading more broadly.

Mosquito Fish as a Potential Biological Control Option for Tadpole Shrimp Management
Madi Hendrick, Kevin Goding, Luis Espino and Ian Grettenberger, UCD

Tadpole shrimp (Triops longicaudatus; TPS) are the key, early season pest of rice in California. TPS have desiccation resistant eggs that begin hatching within 24-48 hours after flooding under the right conditions. Because California rice is planted after the fields are flooded, their biology gives them a unique advantage. By the time rice is planted, many TPS are already large enough to begin damaging the plants. They feed on the roots of young rice seedlings, which causes them to float to the surface and results in stand loss. TPS are a severe pest with few control options, and growers are typically limited to chemicals such as pyrethroids to treat. Because there are so few management options, alternative control methods could be vital to managing insecticide resistance. We conducted field trials testing different densities of mosquitofish (Gambusia affinis) as a control agent. $100ft^2$ rings were built in fields and flooded before fish were added. Trials were conducted in two different fields with known differing TPS densities. The results of these trials demonstrate the potential of mosquitofish as a control agent. Since mosquitofish can be acquired from vector control agencies, they could serve as an accessible means of alternative pest control. Rice as a crop is incredibly valuable to California's economy, and severe infestations of TPS can threaten this crop before it is even planted, thus highlighting the need for additional management tactics.

Florpyrauxifen-benzyl, Loyant, Applications at Different Growth Stages to Rice and Smallflower Umbrella Sedge.
Deniz Inci and Kassim Al-Khatib, UCD

Smallflower umbrella sedge (SMF) is a troublesome sedge weed in California (CA) rice fields. The continuous use of the same modes of action and the lack of crop rotation have resulted in herbicide-resistant SMF. Florpyrauxifen-benzyl, LoyantÒ, will be registered for rice in the near future. Loyant provides excellent control of broadleaf, grass, and sedge weeds. The application timing of Loyant is from the two-leaf rice growth stage until 60 days before harvest. Two field research experiments were conducted during the 2021 and 2022 growing seasons at the Rice Experiment Station to elucidate rice and SMF response to Loyant when applied at different growth stages. In the first study, Clomazone at 12 lb/A was applied to all plots that excluded untreated control (UTC). Loyant was applied at 1.33 pt/A to 1-leaf, 4-, 6-, 8-, and 10-inches height SMF. In the second study, Loyant was applied at 1.33 and 2.66 pt/A after the rice panicle initiation to determine rice phytotoxicity, including blanking and late-season weed control. All Loyant treatments included methylated seed oil at a 0.5 pt/A rate. Both studies were conducted as a randomized complete block design, where experimental units were 10X20 ft treatment plots. All plots were evaluated for weed control and crop injury at 7, 14, 21, 28, 35, and 42 days after treatments (DAT). Weeds were counted at 28 DAT within two randomly selected areas in each plot, and plots were harvested at the end of the season, and the yield was measured. The first study showed that the highest chlorosis, 12%, and the highest necrosis, 10%, were observed at 7 DAT of 1-leaf SMF stage application. Loyant at the 1-leaf stage was the most effective treatment for watergrass (WTG) at 42 DAT with 100% control, rice field bulrush (BLR), and SMF at 28 DAT with 98% control. All treatments achieved 100% control of ducksalad (DKS) at 42 DAT. Six inches SMF growth stage application adequately controlled 100% of redstem (RDS) at 42 DAT. The highest yield at harvest was achieved as 11,092 lb/A at 10-inches growth stage application, which is the latest application timing of this study. In the second study, after rice panicle initiation applications, the highest necrosis, 32%, was observed at 7 DAT of Loyant 2.66 pt/A treatment. Rice gradually recovered from all the injuries by the 42 DAT. Loyant at 2.66 pt/A was the most effective treatment as follows. The highest BLR and sprangletop control were observed at 35 DAT at 83% and 95%, respectively. Similarly, the highest SMF and WTG control was observed at 42 DAT at 96% and 93%, respectively. Nevertheless, the highest yield at harvest was achieved as 8,583 lb/A at Loyant 1.33 pt/A treatment. While 1.33 and 2.66 pt/A Loyant treatments caused 8% grain blanking in rice panicles, UTC showed 14% blanking. Seeds per panicles were observed as 86, 83, and 82 for Loyant treatments at 1.33, 2.66 pt/A, and UTC, respectively.

California Weedy Rice and Grass Populations' Response to Clethodim
Rasim Unan, Liberty Galvin and Kassim Al-Khatib, UCD

Weedy rice (Oryza sativa f. spontanea Roshev.), barnyardgrass (Echinochloa crus-galli), late watergrass (Echinochloa oryzicola), early watergrass (Echinochloa oryzoides) and sprangletop (Leptochloa fascicularis) are important weeds in California and are difficult to control with herbicides. The aim of this study was to determine the response of California weedy rice types and grasses to clethodim herbicide applications. Clethodim is an ACCase-inhibiting cyclohexanedione herbicide. Clethodim was applied at 8 rates (0, 9.4, 18.8, 37.5, 75, 150, 300 and 600 g ai ha-1) on 5 weedy rice types, and 5 grasses which jungle rice, barnyardgrass, late watergrass, early watergrass, sprangletop and M105 rice variety. The experiment was conducted on complete randomized block design with 6 replications in the greenhouse. The herbicide was applied with 0.25% nonionic surfactant (v/v). Dose–response curves based on the log-logistic model were used to determine the effective dose that provides 90% control (GR90 values). All weeds and a rice cultivar had different response to herbicide treatment. Clethodim GR90 doses ranged from 43-87 g ai ha-1 for both weeds and cultivated rice variety as well. While barnyardgrass was determined as the most sensitive, M105 was determined as the most resistant in tested plants. In addition, M105 was 2.02-folds resistant compared to barnyardgrass. GR90 values are 58, 61, 59, 50, 74, 54, 43, 46, 75, 80, and 87 g ai ha-1 for weedy rice type 1, 2, 3, 4, 5, jungle rice, barnyardgrass, late watergrass, early watergrass, sprangletop and M105, respectively. These findings indicated that clethodim has a great potential to be used as a spot treatment for the management of weedy rice and grass species.

Emergency Drought Relief Latest
California Rice Commission

The CRC has been working to secure state and federal relief for our suppliers, mills, dryers, and communities so significantly impacted by the drought.

Public Education & Communications
California Rice Commission

Highlighting the unique connection between California Rice, the communities we farm and mill in, and our industry's ongoing environmental efforts and benefits.

Conservation Programs on California Ricelands
California Rice Commission

Detailing the variety of wildlife conservation programs currently available to growers to help provide additional habitat for birds and fish, especially important during drought.

Rice Helping Salmon
California Rice Commission

Outlining Phase II of the Pilot Salmon Project with UC Davis and California Trout.

Exploring No-Till Systems in Water-Seeded Rice
Mia Godbey, Bruce Linquist, Whitney Brim-DeForest and Luis Espino, UCD

No-till agriculture is becoming a widely adopted conservation agriculture management system that can lead to reductions in soil erosion, increases in overall soil health, lower production costs, and ultimately, sustainable long-term crop productivity. However, it has not been widely adopted in rice systems. Previous studies have produced variable yields, so further research is needed to improve our understanding of the limiting factors so that we can improve future management decisions. In this study, we are not looking at a strict no-till system, but rather a system where the tillage and field preparation is done during the summer when the field is fallow. Many growers take the opportunity to till and level the fields when the field is fallow. Here, we are testing if it is possible to simply flood and plant these fields in the following year without any further tillage. This would allow growers the ability to plant sooner and also reduce costs related to tillage. There may also be some benefits related to weeds and pests, which we are evaluating. In this project, we marked off a 1-acre portion of a field at three on-farm locations – Robbins, Biggs, Nicolaus – to determine the feasibility of planting and growing rice in fallowed soils that were tilled and leveled in the previous growing season. This no-till area was compared to an adjacent area that was conventionally tilled. Nitrogen rate trials were set up as well as monitoring areas for weeds and pests. While we are only midway through the season, the most prominent so difference so far between the till and no-till treatments at the beginning of the season was related to stand establishment. The average number of established seedlings ranged between 13 and 32 plants per square foot for no-till and between 15 and 48 plants per square foot for till. This difference may be attributed to the windier than normal April/May months when the crop was being established. Since the no-till fields were leveled the previous season, they did not have roller grooves (as did the conventional till) for the young seedlings to establish in, and thus high winds easily dislodged the seedlings. Other preliminary results suggest that weed and pest pressure may be different between these systems. In future studies, we suggest rolling the field following tillage and leveling in the previous year to minimize this issue. Yield and N response data will be available at the end of the season. Results from this research will allow for quantification of no-till soil effect on yields, N requirements, pest management, and weed pressure.

Tracking Herbicide-Resistant Weeds in California Rice Through a Community-Driven Approach

Aaron Becerra-Alvarez, Amar S Godar, Saul Estrada and Kassim Al-Khatib, UCD

The continued use of herbicides along with minimal to no crop rotations, has led to a large incidence of suspected herbicide-resistant weeds in California rice. The Herbicide Resistance Screening Survey was developed by the University of California to assist rice growers make proper weed management decisions. Survey data from 2015 to 2021 provide an overview of herbicide resistance among California rice weeds. Weed seed samples are received from growers, farm advisors and crop consultants that collect suspected herbicide-resistant samples at the end of every growing season, then, the weed samples are tested against all herbicides labeled for any particular species and reported back to the growers before the next growing season. The total number of seed samples submitted for testing was 661, including, 189 smallflower umbrella sedge, 173 barnyardgrass, 110 bearded sprangletop, 107 late watergrass, 49 early watergrass, 18 ricefield bulrush and 15 redstem. Observed resistance was above 82% for the acetolactate synthase-inhibitors. Similarly, 88% of samples submitted were resistant to propanil. Thiobencarb and cyhalofop-butyl recorded 43% and 59% resistant samples, respectively. While benzobicylcon+halosulfuron-methyl, carfentrazone, clomazone, and triclopyr recorded equal to or less than 12% resistant samples. Multiple resistance was observed on all species. Smallflower umbrella sedge and barnyardgrass observed 25% and 34% resistant samples to three modes of action, respectively, while late watergrass recorded 53% resistance to four modes of action and 3% to five modes of action. The community-driven approach from this survey provides an active weed management decision-making framework for growers and allows researchers to track herbicide-resistant weeds.

Introduction of Upland Soil Conditions Alter Yield Potential in California Rice
Zhenglin Zhang, Daniel C. Olk and Bruce Linquist, UCD

Rice in California represents a sizeable proportion of U.S. harvest. The default growing strategy of yearly monocropping rice without upland rotations or fallows has shown signs of yield gaps in other rice-growing regions in the world likely due to an accumulation of lignin-derived phenols that limit N fertilizer availability. In this experiment, we investigate the effect of fallow on rice yield. Rice after fallow will be compared to a control of continuous rice to determine differences in yield potential and crop N uptake. Soils will be analyzed for soil phenol content and degree of mineral N binding. The results will assist in creating guidelines for yield prediction and optimal N fertilizer application rates when rice cultivation differs from the default of continuous rice.

RES Genetics Lab: Past, Present, and Future
Gretchen Zaunbrecher and George Yeltatzie, RES

Since its establishment in 2008, the RES Genetics Lab's primary role has been to assist the breeders in their selection work by using DNA marker technology. This continues to be our main goal. In addition to traditional marker technologies, new methods such as CRISPR and capillary electrophoresis are currently being implemented or will be introduced in the near future. Through the years, principal investigators, Cynthia B. Andaya and Teresa B. De Leon, with the help of DNA lab technician, George B. Yeltatzie, and other RES support staff have developed essential DNA fingerprinting protocols for the identification of all grain types as well as assisting in the generation and purification of many released varieties. In February of 2022, Gretchen M. Zaunbrecher became the new RES Genetics Lab Director. The lab is continuing with its main goal and is currently analyzing approximately 2,400 F1 plants to verify true crosses and genotyping over 4,100 Head Row entries using 5-10 markers per entry. The lab is also developing a Purity Certified Assay for future Roxy Foundation seed which will give farmers additional assurance in the quality of their seed. Future work will continue to assist the breeders using current technologies but will incorporate new methods such as CRISPR gene modification and capillary electrophoresis to further the efficiency of marker assisted selection and the advancement of varietal improvement.

19Y4000, a Blast and Herbicide Resistant Conventional Calrose Rice
Teresa B. De Leon, Kent S. McKenzie, Virgilio C. Andaya, Cynthia B. Andaya, and Dustin Harrell, RES

19Y4000 (Oryza sativa L.) is a conventional medium grain rice cultivar developed by the California Cooperative Rice Research Foundation Inc., a planned release in 2022. 19Y4000 is a blast resistant semidwarf inbred variety with a high tolerance to oxyfluorfen. Agronomic characteristics, grain attributes, cooking and eating qualities of 19Y4000 are similar to M-206 and M-210 which can be traced back to its M-206 parent. Over the three-year statewide yield evaluations, 19Y4000 had an average yield of 8958 lbs. per acre, fully headed at 87 days, with very good seedling vigor, lodging potential, and cold tolerance like that of M-206. At 18-20% MC harvest moisture, 19Y4000 had an averaged milling yield of 67% headrice and 71% total. The original herbicide resistance donor of 19Y4000 was derived through chemical mutation. 19Y4000 was developed through pedigree method coupled with marker-assisted selection and is considered a non-GMO rice.

17Y2087, a New Improved Premium Quality Short Grain Rice
Teresa B. De Leon, Virgilio C. Andaya, Kent S. McKenzie, and Dustin Harrell

A rice cultivar with an experimental line ID of 17Y2087 is planned for release in 2023 by the California Cooperative Rice Research Foundation Inc. for the premium quality short grain market. 17Y2087 is a semidwarf, early maturing, non-pubescent, high yielding variety. From 2018 to 2021 Statewide Yield Trials, Calhikari-203 had an average yield of 9118 lbs./acre, flowered at 88 days, cold tolerant, and lodging resistant. 17Y2087 has excellent milling yield of 66% headrice, 71% total when harvested at 18-20% MC. Based on rice marketing companies and Japanese blind test evaluations, the grain appearance, cooking, and eating qualities of 17Y2087 is closely similar and acceptable to the premium quality short grain market class of Koshihikari and Calhikari-202.

18Y2070, a Promising California Risotto Rice
Teresa B. De Leon, Virgilio C. Andaya, Kent S. McKenzie and Dustin Harrell, RES

An experimental line designated as 18Y2070 was developed to accommodate the niche market for risotto rice. The line is currently in headrow purification and seed increase for possible variety release in 2024. With pedigree that traced back to Arborio, Carnaroli, Faro, and 89Y235, the 18Y2070 has the signature bold kernels with white belly typical of risotto rice varieties. Three-year multi-location statewide yield testing indicated a very good yield potential and favorable agronomic characteristics for 18Y2070. Overall, 18Y2070 is a semidwarf glabrous rice, flowers at 89 days, lodging resistant, and with grain yield of 9136 lbs./acre. With positive external blind evaluations for grain appearance, cooking and eating characteristics, the 18Y2070 may be released as the first risotto rice variety of California Cooperative Rice Research Foundation Inc.

FIELD TOUR ABSTRACTS

RES Rice Breeding Program

T.B. De Leon, F. Maulana, N. Sharma, Gretchen Zaunbrecher and D.L. Harrell, RES

The RES Breeding program has released fifty-one improved rice varieties since 1969 and it continues its effort in developing excellent rice varieties for all grain types and market classes of rice for California rice growers. The program is divided to medium grains, short grains, and long grains projects. For all grain types, the program aims to develop superior rice varieties with 1) high and stable grain yield potentials, 2) superior milling yield and grain qualities including grain appearance and cooking characteristics relative to market and consumers preference, 3) improved cold tolerance and seedling vigor, 4) early maturity and statewide adaptability, 5) improved straw strength for lodging resistance, 6) blast and stem rot disease resistance, and more recently, 7) herbicide tolerance. The medium grains project includes development of regular and premium Calrose rice. The short grains project includes development of regular short grain (S), premium quality short grain (SPQ), waxy or sweet rice (SWX), low amylose-type (SLA) and short bold grain or Arborio-type rice (SBG). In the long grains, the project includes conventional or regular long grain, aromatic, Jasmine-type, and Basmati-type rice.

Breeding efforts in 2021 were approximately 39% medium grain, 31% short grain, and 30% long grain. The program was broken down roughly to 50% conventional and 50% specialty market classes. A total of 525 crosses were made in the spring and 625 crosses during the summer of 2021, bringing the overall total of crosses made since 1969 to 53,566. Overall, the RES breeding program evaluated at least 86,490 entries in 2021. Crosses made during early spring were planted in the RES F1 nursery while the F1 seeds made during summer were planted in the Hawaii Winter Nursery to accelerate the breeding process. The combined F2 populations generated from the 2021 F1 nurseries at the RES and Hawaii were planted for selection at the RES and San Joaquin nurseries in 2022.

Medium Grain Breeding

The medium grain breeding project entered 40 advanced breeding lines in the Statewide Yield (SW) Tests in 2021 where, 25% were regular Calrose (M), 22% were premium quality Calrose (MPQ), 25% were blast resistant Calrose (MB), 12% were stem rot resistant medium grain (MSR), 8% were herbicide-resistant medium grain (MH), and 8% were fragrant medium grain (MF). The replicated multi-location testing brought a combined total of 188 statewide yield plots, including the medium check varieties.

Current medium grain check varieties performed well in 2021 with an average yield of 9,546 lb/A at RES and 9,129 lb/A in the statewide yield trials. M-105 had an average yield of 8,841 lb/A at RES and had a SW yield average of 8,992 lb/A.

M-206 yielded 9,452 lb/A at RES and 9,141 lb/A at SW yield tests. The blast-resistant M-210 yielded 8,852 lb/A at RES and 9,138 lb/A across SW trials. Lodging resistant M-209 performed well at the RES with an average yield of 10,078 lb/A and a SW average yield of 9,042 lb/A. The most recent premium Calrose variety M-211 was the highest yielding among all medium grain varieties with yields of 10,505 and 9,333 lb/A, at the RES and SW yield trials, respectively. On average, all medium check varieties had milling yield of 65% head rice (whole grain) and 70% total (whole and broken grains) at 21% moisture content during harvest.

Seedling vigor score was very similar across all check varieties and ranged from 4.8 to 4.9. Days to 50% heading after planting was 78 days for M-105, 81 days for M-206, 82 days for M-210, 84 days for M-209, and 86 days for M-211. Check varieties had an average plant height of 82 cm. No lodging was observed in 2021. All check varieties were susceptible to stem rot disease with stem rot scores ranging from 3.0 (M-211) to 4.3 (M-105). Cold-induced panicle blanking was very low at the San Joaquin cold nursery and ranged from 1 to 6 % across medium grains. However, the greenhouse cold tolerance experiment had very high panicle blanking that ranged from 20 to 68%. M-206 showed the highest cold tolerance among the varieties with 20% panicle blanking. M-209 came in second with 28% blanking while M-105 and M-211 had 68% and 55% blanking, respectively. M-210 was moderately cold tolerant with 41% panicle blanking.

In the pipeline for regular Calrose, Line 18Y3130 had a 6, 13, and 21% yield advantage over M-209, M-206, and M-105 at the RES, respectively. On average, 18Y3130 yields 10,714 lb/A at RES and 9,486 lb/A at SW tests. In the premium quality Calrose, Line 19Y3127 had an 8.7% yield advantage over M-211. 19Y3127 reached 50% heading one day later (87 days) than M-211 but with average yield of 10,293 lb/A at the RES and 10,153 lb/A in the statewide yield trails.

The 19-Y-4000 will be proposed for variety release in January 2023 in line with ALB2023 (oxyfluorfen) registration. 19Y4000 is a regular Calrose with blast resistance and herbicide tolerance to oxyfluorfen. 19Y4000 was developed from a cross made in the summer of 2015, designated as RM3447, and with a pedigree of M206*8/97Y315vE(Pi-b)//M-206-G9. Based on UCCE statewide yield tests from 2019 to 2021 under conventional herbicide program, 19Y4000 had an average yield of 8,958 lb/A (Table 1). Evaluation of milling yield at the RES indicated the grain stability and quality of 19Y4000 like M-206. At 18-20% moisture content during harvest, 19Y4000 had an average milling yield of 67% head rice, 71% total. The seedling vigor, days to heading, plant height, lodging potential, and cold tolerance of 19Y4000 are similar to M-206 and M-210. Evaluation of grain qualities and cooking attributes also indicated the very close similarity of 19Y4000 to M-206. Line 19Y4000 is stem rot susceptible but expected to have blast resistance due to the presence of *Pi-b* resistance gene. The 19Y4000 was developed through pedigree method and marker-assisted selection, and thus a non-GMO Calrose rice.

Table 1. Agronomic characteristics and grain qualities of 19Y4000, M-206, and M-210 from 2019-2021 data.

TRAIT	3-year Mean Performance			SOURCE
	M-206	M-210	19Y4000	
Agronomics				
Grain Yield (lb/A)	9054	9057	8958	SW Tests
% Head Rice/Total at 18-20%MC	67/ 70	68/ 72	67/ 71	Milling Tests
Seedling Vigor (1-5)	4.8	4.8	4.8	SW Tests
Days to 50% Heading	87	87	87	SW Tests
Height (cm)	97	96	96	SW Tests
Lodging (%)	38	30	31	SW Tests
Blanking (%)	2	1	1	San Joaquin
Grain Qualities				
Head Rice Length (mm)	5.84	5.84	5.84	Milling Tests
Head Rice Width (mm)	2.74	2.74	2.70	Milling Tests
Head Rice L/W Ratio	2.13	2.14	2.17	Milling Tests
Head Rice 1000-grain Wt. (g)	21.59	21.70	21.28	Milling Tests
Head Rice Chalk Kernel (%)	1.99	1.20	3.36	Milling Tests
Head Rice Whiteness	132	133	132	Milling Tests
Head Rice Vitreousness	124	125	123	Milling Tests
Head Rice Protein (%)	5.7	5.8	6.3	Milling Tests
Apparent Amylose Content	18.6	19.0	20.5	Milling Tests
Pasting Temp (°C)	90	89	91	Milling Tests
Disease Reaction				
Stem Rot (1-5; 5 as highly susceptible)	3.9	3.9	3.6	Disease Nursery

Short Grain Breeding

The breeding effort of the short grain breeding project is divided into 37% regular California short grain (S), 33% premium quality short grain (SPQ), 16% sweet or waxy rice (SWX), 8% for low amylose (SLA), 6% for Arborio (SBG), and 2% for herbicide-resistant (SH).

In 2021, a total of 370 crosses were made. Including the check varieties, the project evaluated 383 F_1's in the greenhouse, 385 populations of $F_{2-3,}$ generations, and 16,720 F_3-F_6 progeny rows. There were 291 entries entered in the preliminary yield trial (PYT), 75 entries in the advanced yield tests (AYT), and 19 entries in SW yield tests. Selected progeny rows of short grains were entered in the Hawaii Winter Nursery to increase seed and advance the generation of the lines. In total, at least 23,582 breeding lines (replicated) or 13,931 entries were evaluated for the short grain project in 2021.

Commercially grown short grain check varieties included in the 2021 experiments were S-102 and S-202 for regular short grain (S), Calhikari-202 for premium short grain (SPQ), Calmochi-101 and Calmochi-203 for sweet or waxy rice (SWX), 89Y235 for Arborio or short bold grain (SBG), and Calamylow-201 for short grain low amylose (SLA). These check varieties were used for the comparison of trait improvements in the short grain type for all experiments and evaluations. Compared to medium grains, short grains on average are lower yielding with the exception of S-202. The average short grain yield was 8,140 lb/A at SW, and

8,317 lb/A at RES. Most short grains reach 50% heading at 80 days, are semi-dwarf, are cold tolerant with low panicle blanking in San Joaquin, and generally susceptible to stem rot. An exception among short grains is S-202, which had an average yield of 11,002 lb/A at RES and a SW average yield of 10,535 lb/A. In contrast, S-102 had an average yield of 8,451 lb/A (SW) and 9,273 lb/A (RES). Both S-102 and S-202 have high seedling vigor. However, S-202 reached 50% heading 2 days later, had a 2% higher lodging potential and was more resistant to stem rot than S-102.

Calhikari-202, the premium short grain, had a SW average yield of 8,144 lb/A and RES yield of 8,849 lb/A, which was higher than the 2020 yield average by 147 lbs. In 2021, Calmochi-101 yielded 6,046 lb/A at RES and 7,202 lb/A at SW. Calamylow-201 had the lowest yield of 6,700 lb/A, both at RES and the SW yield tests. The Arborio short grain line 89Y235 yielded 7,805 lb/A (SW) and 8,004 lb/A at RES. The 89Y235 line reached 50% heading at 81 days and had an average height of 77 cm. It had a low lodging potential (1%) and was cold tolerant at SJ. All short grains had reduced plant height in 2021 (78 cm) as compared to 2020 (93 cm) in the RES trials. Despite the average 15 cm height reduction grain yield was higher in 2021.

Line 17-Y-2087 has been in the SW yield tests for a total of four years and it continues to outperform the Calhikari-202. Line 17Y2087 had a 14% yield advantage over CH-202. The average SW yield of 17Y2087 was 9,118 lb/A compared to 7,985 lb/A for CH-202. Except in the Yuba test site, the four-year SW yield testing of 17Y2087 showed its wide adaptation with average yield of over 9,000 lb/A at each location. Among the test locations, 17Y2087 had the highest mean yield at the Yolo site (9,619 lb/A) indicating its cold tolerance.

17Y2087 is an early maturing, non-pubescent, high yielding semi-dwarf premium short grain rice. Its F1 cross (RS2095) was made in the spring of 2012 with a pedigree that traced back to 10Y2049/04Y177/4/Kosh*2/S-101//Kosh/S-101/3/Hitome. The 17Y2087 is genetically an improved Koshihikari or Calhikari-202 that is early flowering, semidwarf, and lodging resistant. In over four years of testing, 17Y2087 out yielded CH-202 which may be attributed to its bigger and heavier grains (L/W ratio of 1.8 vs 1.7 in CH-202, 18g/1000 grains vs 17.2g in CH-202). Milled grains of 17Y2087 appeared very similar to CH-202 with a lesser number of chalky kernels (1.4% vs 2.3%, Fig. 6). 17Y2087 has similar kernel starch characters (RVA profile) to CH-202 but is slightly more viscous (final viscosity of 234 vs 225) and requires 1ºC higher pasting temperature (90ºC vs 89ºC). Like CH-202, 17Y2087 does not have a blast resistant gene and is also susceptible to stem rot. Based on external evaluations of visual grain appearance, cooking, and taste qualities by various milling, marketing companies, and individuals (including some Japanese evaluators), 17Y2087 was determined to have excellent cooking and taste qualities for the premium short grain market.

Long Grain Breeding

The long grain breeding program continues its research and breeding efforts to develop superior long grain varieties of four major classes for California, including: 1) conventional long grain, 2) Jasmine, 3) Basmati, and 4) aromatic classes. Milling and cooking quality improvements of conventional and specialty long grains are a high priority objective in this program as is improving yield potential and agronomic performance and introducing important traits like resistance to disease and resistance to cold-induced blanking.

Test materials in the 2021 statewide tests were compared to the long grain check varieties L-207, L-208, Calaroma-201, Calmati-202 and A-202 for grain yield and agronomic performance. Milling characteristics, grain quality, blanking, and disease reaction of these checks were also analyzed. L-207 is a conventional long grain variety released in 2016 with higher yield, intermediate height, early-maturing date, and Southern US long grain cooking quality. L-207 is adapted to most rice-growing areas in the state except the cold area of San Joaquin. Physicochemical testing of L-207 by the USDA Rice Quality Lab confirms its similarity to southern long grains with intermediate amylose, intermediate gel type, and moderate RVA profile. L-208 is the newest conventional long grain and was released in 2020. Agronomic characteristics, adaptation, milling, and cooking qualities of L-208 are similar to L-207.

Based on pooled averages of very early, early, and intermediate-late group statewide experiments, L-208 and L-207 had higher yield at Rice Experiment Station (RES) compared to other statewide locations. The average yield at RES/statewide was 10,817/10,565 lb/A for L-208 and 10,070/10,019 lb/A for L-207. The new variety, L-208, had approximately a 5.2% yield advantage over L-207 in 2021. The variety L-208 performed better and had higher yield in nine out of eleven statewide experiments except for Yuba and South Butte locations. L-208 was 78 cm tall, 7 cm shorter than L-207. L-208 reached 50% heading around 81 days, two days earlier than L-207. The average head rice of L-208 was 62.5%, which was similar to L-207.

Calaroma-201 is a Jasmine-type long grain variety released in 2018 which has an aroma like typical aromatic long grains, but the taste characteristics are closer to Thai Jasmine quality. Calaroma-201 has a similar adaptability as L-207 and should be avoided in colder growing locations. It has low gel type and thus cooks softer than a typical long grain. Calaroma-201 had higher yield at RES compared to other statewide locations in 2021. The average yield was 10,055 lb/A at RES and 9,177 lb/A in the statewide trial. Calaroma-201 was 72 cm tall and headed around 85 days. Percent head rice of Calaroma-201 was 58.5.

Calmati-202 is a true basmati variety released in 2006. It is an early maturing, semi-dwarf, pubescent, aromatic, and elongating long grain. Grain and cooking qualities of Calmati-202 is considerably closer to imported basmati. However, milled rice kernels are slightly shorter than imported basmati rice available in the US market. Timely harvest and proper handling is recommended to preserve milling as well as cooking quality of this variety. Due to the slender grain shape and pubescent hull and leaf, the drying rate of the grain at harvest is significantly faster than standard varieties. Recommended harvest moisture is 18 percent. Calmati-202 had higher yield at RES compared to other statewide locations in 2021. The average yield was 6,408 and 6,779 lb/A for the statewide and RES locations, respectively. The variety reached 50% heading in 85 days and the height was 63 cm in 2021.

A-202 is a conventional aromatic variety that was released in 2014 as a replacement for A-301. A-202 is earlier, taller, and has a significantly higher seedling vigor score than A-301, but still has the same flavor sensory profile as A-301. The RVA profile is typical of conventional long-grain types like L-206 and L-207. Areas of adaptation for A-202 include Butte, Colusa, Yuba, Glenn, and Sutter counties. A-202 is not recommended to be grown in the colder rice areas. A-202 had higher yields at other statewide locations as compared to the RES location. The average yield was 9,070 lb/A at RES and 9,709 lb/A at other statewide test locations in 2021. A-202 was 87 cm tall and reached 50% heading in 83 days. Percent head rice of A-202 was 53.1%. None of the varieties had lodging at the RES location in 2021.

Genomic Selection: Improving Rice Breeding Efficiency and Reducing Costs

Pedigree breeding based on phenotypic selection is time-consuming and costly. It takes about 10-12 years to develop and release a new rice variety and it requires a lot of resources. Marker-assisted selection (MAS) is suitable for simple traits, such as amylose content, aroma, blast resistance and herbicide resistance, controlled by a single gene with large effect, but it is less suitable for complex traits, controlled by many small-effect genes, including grain yield and milling quality. Genomic selection (GS), another form of MAS, has shown to overcome this drawback. GS uses prediction model to estimate DNA marker effects from a training population (TP-with genotypes and phenotypes) to predict the performance of the lines that have been genotyped but not phenotyped. GS can reduce breeding cycle by earlier selection of potential parents for crosses with improved chance of obtaining superior lines, reduce phenotyping costs by predicting the performance of lines before field testing and increase genetic gain over time. The objectives of this project are: 1) to develop the TP for GS model training and optimization, and 2) to integrate GS in rice breeding programs at the Rice Experiment Station (RES) to speed up the development of new varieties and reduce expenses. A population of 360 lines, including advanced breeding lines and RES released rice varieties of all grain types, are currently being evaluated for grain yield and quality in the field at RES. In addition, we plan to genotype the population with genome-wide DNA markers for GS model training. Our long-term plan is to integrate GS, as one of the breeding strategies, in RES rice breeding programs to improve overall breeding efficiency.

DNA Marker Laboratory

Since its establishment in 2008, The DNA Marker Lab's primary goal has been to assist the breeders in their selection work using DNA marker technology. MAS has become an essential tool for increasing the efficiency of the breeding program by identifying potential lines that possess superior agronomic traits, allowing the breeder to advance these lines sooner thereby reducing costs and the time needed to eventual variety release. In addition to the MAS work identifying traits such as blast resistance, grain quality, aroma and herbicide tolerance, the DNA lab is responsible for genetic fingerprinting and purity testing of advanced lines for quality assurance of our released varieties. Through the years the DNA lab has played important roles in the genetic mapping and validation of stem rot resistance and oxyfluorfen herbicide tolerance traits in our advanced lines as well as the generation of new mutant populations through traditional irradiation and chemical mutagenic protocols.

The DNA lab is currently verifying over 2,830 F1 entries for true crossing and fingerprinting 4,120 short, medium, long, and specialty advanced lines with 6-12 markers each. Approximately 5,000 lines will be analyzed for the presence of both oxyfluorfen and blast tolerance. Every year off-type field samples that are submitted by our breeders and commercial producers are fingerprinted and identified by the lab. The lab is also developing a Purity Certification Assay for future ROXY® foundation seed which will give producers additional assurance in the quality of their seed. Future projects include the implementation of the new gene modification protocol, CRISPR, to develop rice varieties with valuable traits that will further enhance grain quality, productivity, and overall performance of future varieties.

ROXY® RPS (Rice Production System)
Kent McKenzie, ROXY® RPS Consultant

Efforts continue to bring non-GMO herbicide tolerant rice to California rice growers. through the ROXY® RPS and our partnership with Albaugh, LLC. Albaugh has also engaged the California Rice Commission in support of the EPA and Concurrent Review by the California Department of Pesticide Regulation.

Albaugh's Commercialization plan will be driven by four major components:

- **Patented Trait**
  ROXY® Trait
  Canadian Plant Novel Trait Approval Process (for market approval)
- **Branded Herbicides**
  ALB2023 & ALB2024 (Herbicides to be named in 2022)
  Anticipate EPA Approval 4th QTR 2022
- **CA Elite Germplasm**
  19Y4000 – Proposed naming as RXM21 and release 2023
  (Calrose line with M-210 Blast resistant)
- **Industry Stewardship**
  Grower, Seed Industry & Ag Chem Industry
  Stewardship will be implemented to prolong the performance and utility of the ROXY® RPS

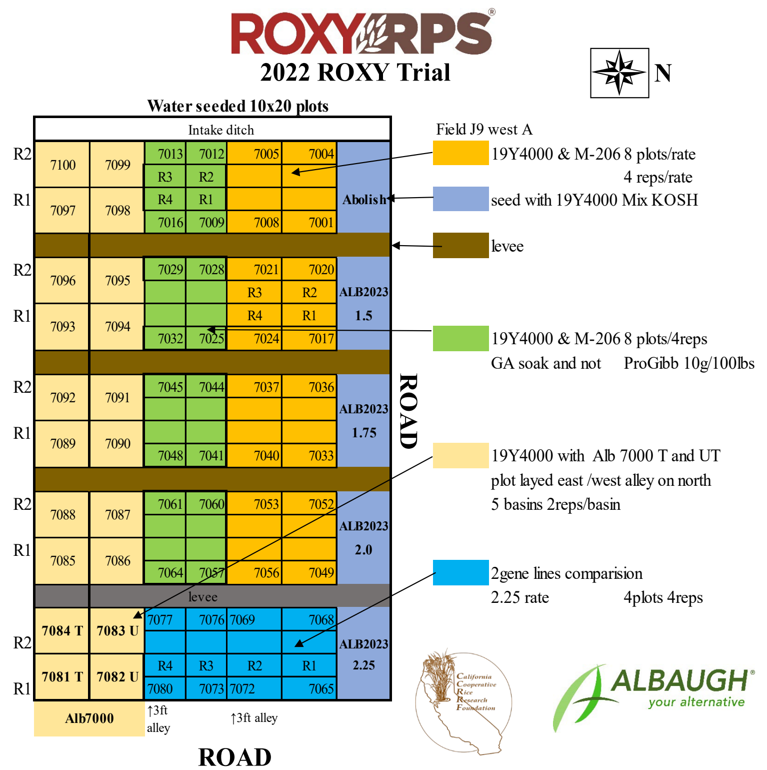
The ROXY® trait is a non-GMO rice trait that provides herbicide tolerance to ALB2023 and ALB2024 (oxyfluorfen) and was recovered in the variety M-206, California's most widely grown Calrose variety. Rice Experiment Station scientists have shown the trait is controlled by a single recessive gene, identified, and confirmed that gene, and the new mechanism for the herbicide tolerance. The ROXY® trademark was granted 9/2018 and a US patent was granted 11/23/2021.

The first backcross to M-206 and M-210 have been increased and tested extensively in the ROXY® RPS at RES, in commercial rice fields in 2017-22 as well as the University of California Statewide Yield Tests. 19Y4000 (M-210 + ROXY Trait) is undergoing a 9-acre foundation seed increase in 2022. It has been included in 15 different off-station Albaugh has engaged their commercial go to market partners in commercial testing of the ROXY® RPS and has funded ROXY RPS testing with the UC testing at Hamilton Road over the past four years.

Eight years of research involving multiple locations show that ROXY® RPS and ALB2023 applied preplant in a water-seeded system provides high levels of weed control with the ROXY® RPS. It is also effective in drill seeded rice with a post-plant and preflood application providing a potential in other rice growing regions and a tool to address weedy rice and resistant weed biotypes. Additional ROXY® trait and ROXY® RPS information is available as the poster display area.

The following page contains a figure of the of the Field Day Tour Stop in the ROXY® research nursery. This is the water seeded research and demonstration field. The focus is on tolerance to the herbicide and was planted to 19Y4000 and the susceptible M-206. Four basin are treated with different preflood rates of ALB2023 and one with Abolish as a registered preflood application. Granite SC was also applied to field. The front strip was plant to a mixture of the susceptible Koshihikari that can be visually identified in by its tall height, late maturity, and pubescent leaves as a mimic for weedy red rice infestations. Two additional products were tested to determine if they enhanced the metabolism of ROXY® RPS rice. In this test both ProGib (gibberellic acid) and ALB7000 (biological) were tested. In the last basin some breeding lines are included that two different ROXY mutations.

The other basins in the field include preliminary and advanced yield tests) of ROXY breeding line (2pt./acre ALB2023) as well as drill seeded progeny rows and F_2 populations (3pt./acre pre-flush + 2 pt./acre ALB2024 post emergence).



Optimizing Rice Production in Fields that Have Been Fallowed
Bruce Linquist, Zhang Zhenglin, and Mia Godbey

Over the past decade the amount of fallowed (idled) rice fields in any given year has increased. While there are still years where most rice land is planted, in other years we are seeing anywhere from 20 to 50% of rice land being fallowed. Reasons for fallowing rice land are due mostly to drought, but also to late season rains which prevent land preparation and tillage. Leaving land fallow over a growing season can affect nutrient management, weeds, pests and diseases in the following year. This year we are conducting several studies examining how to optimize rice production in fields that were previously fallowed.

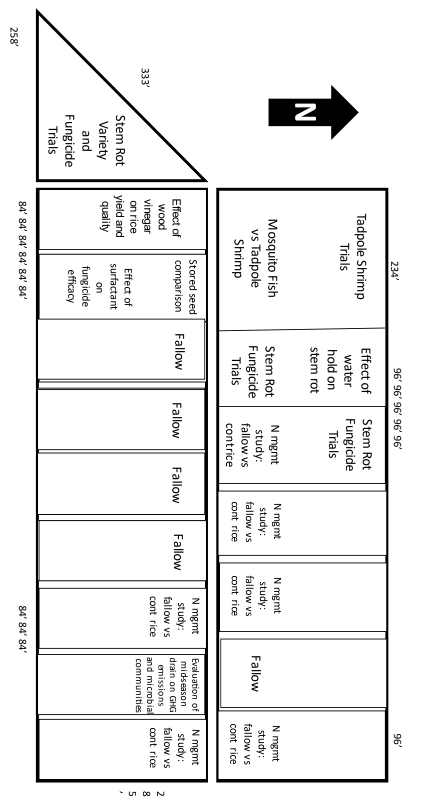
First, we are conducting research to find out if N management is different in fields that have been fallowed compared to fields that had rice grown in it the previous year. There are several reasons why N management might be different. First, fallowed fields have less straw as the straw will have had almost one and a half years to decompose. Less straw means less tie up of fertilizer N. Secondly, we know that in fields which are flooded for most of the year, phenols build up. These phenols can tie up nitrogen fertilizer. Keeping the soil aerated for a long period allows for these phenols to break down. Finally, the yield potential may be higher in fallowed fields - necessitating more N fertilizer.

In an experiment at the RES, we are looking at six N rates (ranging from 0 to 190 lb N/ac) applied as aqua-NH3 in basins that were either fallow or had rice in 2021. In addition, we have plots with labeled-N (15N) fertilizer which allows us to track fertilizer N in the soil and plant. We are taking samples at different time during the season to see when fertilizer N is being taken up. This research will inform us if we need to apply a different rate or time to fields that were fallow.
This is the second year of that study. In 2021, we found that the yield potential in fallowed fields was higher than in continuous rice fields; however, the optimal fertilizer rate required to achieve maximum yields was similar. We also found more soil phenols in continuous rice fields. In addition, stem rot incidence was higher in continuous rice fields.

In addition to N fertility, we are looking at greenhouse gas (GHG) emissions from fields which were fallowed vs fields which had rice in them the previous year. In 2021, fields which were fallowed had lower GHG emissions due to reduced methane emissions. One reason for this may be that there is less straw decomposition in fields which were fallow.

In another area of research, we are exploring no-till opportunities in rice systems. We are not looking at a strict no-till systems, but rather a system where the tillage and field preparation was done during the summer when the field was fallow. Many growers take the opportunity to till and level the fields when the field is fallow. We are testing if it is possible to simply flood and plant these fields in the following year without any further tillage. This would allow growers the ability to plant sooner and also reduce tillage related costs. There may also be some benefits related to weeds and pests, which we are evaluating. This year we are evaluating this at three on-farm locations. Next year, we will be following up on that research here at the RES. Preliminary results from this year's study are available in a poster presented at field day and in an abstract in this pamphlet.

Finally, given the increased limitations on water available for rice production, in 2023, we are going expand our no-till research to look at drill seeding rice into existing soil moisture. With existing soil moisture, it may be possible to forego any irrigation applications until permanent flood (about 4-5 weeks after seeding). This could mean substantial water savings.



2022 RES Systems site plan

Insect Management Update

Ian Grettenberger, Luis Espino, Kevin Goding, and Madi Hendrick

Our lab's research this season is focused on improving management of tadpole shrimp and seed midge. Tadpole shrimp are a key early-season arthropod pest in rice. We are evaluating registered and unregistered insecticides for management of tadpole shrimp. Pyrethroids have been heavily relied upon, so we need to have other tools in the toolbox. We are also testing different insecticide rates and application timings to help clarify the efficacy and economics of different materials and determine when different insecticides can be applied. We are also evaluating if mosquitofish can provide biological control of tadpole shrimp. Mosquitofish are used for vector control but will also consume tadpole shrimp. We are evaluating multiple rates of fish and multiple shrimp pressures given that these variables likely will affect if the fish can suppress tadpole shrimp. For tadpole shrimp, we are also running bioassays to measure levels of resistance to pyrethroids. Insecticide resistance is cropping up in a number of areas, so it is imperative that we identify the scope and severity of resistance.

While not as prevalent as tadpole shrimp, rice seed midge can be a problematic and destructive early-season pest. We are evaluating insecticides normally used early-season to determine what treatment options are available and effective for midge management.

Outside of this work on tadpole shrimp and seed midge, we have continued a minimal amount of work on rice water weevil. We are monitoring rice water weevil populations using a black light at the Rice Experiment Station. We are doing this to track trends through time, likely confirming that rice water weevil populations are remaining low.

Weedy Red Rice Update

Whitney Brim-DeForest

In 2022, research on weedy rice continued in several key areas: the use of a fallow system for management, identification and confirmation of new biotypes, as well as a wrap-up of the use of winter flooding and zero fall tillage as cultural controls.

The use of a fallow system looks promising: preliminary data suggests a reduction in the emergence of weedy rice under a managed fallow (flushing and spraying) after the second year. Flushing and spraying (just once) significantly controlled emerged weedy rice plants. However, it appears that even without an herbicide application flushing alone followed by a dry period is effective in controlling weedy rice. When we go back into rice in 2023, we will be able to determine if the weedy rice has remained dormant in the soil seedbank.

Several suspicious plants were submitted in 2020-2021 that do not appear to be the same phenotypically as our current biotypes (1 to 5). We are in the process of greenhouse testing, which will allow us to determine the level of weediness (shattering and dormancy levels) in comparison to our previously identified biotypes. We will have an update by the winter.

Winter flooding does not appear to significantly improve decay of weedy rice in the soil, in comparison to ambient conditions. This is likely because our winters are normally wet in California. However, further analysis of the data will hopefully indicate whether it would be important to flood weedy rice-infested fields during drier winters. The final analysis will be completed this winter.

Zero tillage in the fall in weedy rice-infested fields increases decay of weedy rice seeds over the winter. This aligns with our recommendation to leave infested fields untilled in the fall, to maximize decomposition rates, and minimize the number of seeds that go back into the soil seedbank. Burying the seeds in the fall increases the percentage of dormant seeds that remain viable in the soil, increasing the amount of time weedy rice will persist in the soil seedbank.

Pest Management Update
Luis Espino

My program is conducting research and outreach into diseases and arthropods that affect rice. Trials conducted during the past few years have shown that the application of the fungicide azoxystrobin (the active ingredient in Quadris) is effective to reduce the incidence and severity of stem rot, aggregate sheath spot, and blast when applied between the mid boot to early heading stages. Unfortunately, there aren't any other fungicide modes of action in the registration pipeline. There are, however, biofungicides and products that induce a defense response in the plant that are already registered or are in the development process. I have tested some of these products, but the results have not been promising. I will continue testing and determine if they have a fit in a disease management program for rice.

In the past few years there seems to be an increase in the incidence of bakanae infection. Bakanae is a seedborne fungal disease that is prevented by soaking seed in a sodium hypochlorite solution before planting. Growers should continue to treat seed with sodium hyproclorite and should follow the recommended soaking and drain times.

Armyworms were problematic this year in some fields. My project tracks moth populations and we have learned that when moth numbers peak, worm populations in the field will peak one to two weeks later. Also, if moth numbers are relatively low at the peak, then the worm infestation will not cause problems. When moth catches are high, monitoring for worms is necessary because the intensity of the infestation can be variable. The insecticides Intrepid and Dimilin provide good control of armyworms.

Research on tadpole shrimp has confirmed that when monitoring for this pest, scouts should look for tadpole shrimp presence and the stage of development of the rice. When fields can be flooded and seeded quickly, rice can outcompete the tadpole shrimp. Once rice has an established root and the spike is present, seedlings are less susceptible to shrimp injury. When this happens, tadpole shrimp will feed on germinating weed seeds and can help reduce the population of weeds that escape herbicides. If tadpole shrimp is present before rice has an established root and the spike is present, the shrimp can reduce stand significantly and therefore a treatment would be needed.

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