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PROCEEDINGS. . .

Thirty-Third Rice Technical Working Group

Biloxi, Mississippi: February 22 – 25, 2010

Edited by: **Michael E. Salassi, Timothy W. Walker, and Randall G. Mutters**

The Agricultural Experiment Stations and Agricultural Extension Services of Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas; and the Agricultural Research Service, the Economic Research Service, the National Institute of Food and Agriculture, and other participating agencies of the U.S. Department of Agriculture; and cooperating rice industry agencies

Louisiana State University Agricultural Center
Louisiana Agricultural Experiment Station

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PROCEEDINGS ... THIRTY-THIRD RICE TECHNICAL WORKING GROUP

RICE TECHNICAL WORKING GROUP

Organization and Purpose

The Rice Technical Working Group (RTWG) functions according to an informal memorandum of agreement among the State Agricultural Experiment Stations and the Agricultural Extension Services of Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas, and the Agricultural Research Service, the Economic Research Service, the National Institute of Food and Agriculture, and other agencies of the United States Department of Agriculture. Membership is composed of personnel in these and other cooperating public agencies and participating industry groups who are actively engaged in rice research and extension. Since 1950, research scientists and administrators from the U.S. rice industry and from international agencies have participated in the biennial meetings.

Pursuant to the memorandum of agreement, the Association of Agricultural Experiment Station Directors appoints an administrative advisor who represents them on the Executive Committee and in other matters. The administrator of the USDA-ARS designates a representative to serve in a similar capacity. The Directors of Extension Service of the rice growing states designate an Extension Service Administrative Advisor. The Publication and Website Coordinators also are on the Executive Committee.

Other members of the Executive Committee are elected biennially by the membership of the RTWG; they include a general chair who has served the previous term as secretary, a secretary-program chair, a representative from each of the seven major rice-growing states (Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas), the immediate past chair, and an industry representative. The rice industry participants elect an Executive Committee member, on a rotational basis, from the following areas: (1) chemical, (2) seed, (3) milling, (4) brewing industries, (5) producers, or (6) consultants.

Several weeks prior to the biennial meeting, panel chairs solicit and receive titles and interpretative summaries of papers to be presented. They work with the secretary-program chair in developing the program including joint sessions as desired. RTWG program development includes scheduling of papers and securing persons to preside at each panel session. Each panel chair is in charge of (1) election of a successor and (2) updating of the panel recommendations.

Committees, which are appointed by the incoming chair, include: Nominations and Location and Time of Next Meeting, Members of the Nominations and the Location and Time of Next Meeting Committees are usually selected to represent the different geographical areas.

The RTWG meets at least biennially to provide for continuous exchange of information, cooperative planning, and periodic review of all phases of rice research and extension being carried on by the States, Federal Government, and cooperating agencies. It develops proposals for future work, which are suggested to the participating agencies for implementation.

Location and Time of the 2010 Meeting

The 33rd RTWG meeting was hosted by Mississippi and held at the Beau Rivage Casino and Resort in Biloxi, Mississippi from February 22 to 25, 2010. The Executive Committee, which coordinated the plans for the meeting, included Randall (Cass) Mutters, Chair; Timothy W. Walker, Secretary; and Garry McCauley, Immediate Past Chair. Geographic Representatives were Karen Moldenhauer (Arkansas), Chris Greer (California), Ronald Rice (Florida), Eric Webster (Louisiana), Jason Bond (Mississippi), Gene Stevens (Missouri), Rodante Tabien (Texas), and Frank Carey (Industry). Administrative Advisors were David Boethel (Experiment Station - Louisiana), Joe E. Street (Extension Service - Mississippi), and Anna McClung (USDA-ARS). Publication Coordinator was Michael Salassi (Louisiana). The Industry Representative was Frank Carey (Mississippi). Website coordinator was Chuck Wilson. The Local Arrangements Coordinators for Mississippi were Jason A. Bond, Nathan W. Buehring and Timothy W. Walker.

Location and Time of the 2012 Meeting

The Location and Time of the 2012 Meeting Committee recommended that the 34th RTWG meeting be held by the host state Arkansas. The meeting will be held from February 26 to 29, 2012, at the Hot Springs Convention Center and Embassy Suites Hotel in Hot Springs, Arkansas.

2010 RTWG Awards

The Distinguished Rice Research and Education Award honors individuals achieving distinction in original basic or applied research, creative reasoning and skill in obtaining significant advances in education programs, public relations, or administrative skills, which advance the science, motivate the progress, and promise technical advances in the rice industry. Only one individual and team award can be given at an RTWG meeting. The individual award was presented to Dr. Eric P. Webster for his contributions to rice weed management.

The Distinguished Service Award honors individuals who have given distinguished long-term service to the rice industry in areas of research, education, international agriculture, administration, and industrial rice technology. This award usually requires a whole career to achieve, and thus, it can be argued that it is our toughest award to win. But, since more than one can be given at a RTWG meeting, it is our fairest award granted to all worthy of such distinction. This award was presented to Dr. John Kendall, Dr. Theodore (Ted) Miller, and Mr. James Thompson.

Publication of Proceedings

The LSU AgCenter published the proceedings of the 33rd RTWG meeting. Dr. Michael Salassi of Louisiana served as the Publication Coordinator for the 2010 proceedings. The 2010 proceedings were edited by Michael E. Salassi, Timothy W. Walker (Secretary), and Randall (Cass) Mutters (Chair). They were assisted in the publication of these proceedings by Darlene Regan (LSU AgCenter Rice Research Station) and the panel chairs.

Instructions to be closely followed in preparing abstracts for publication in the 34th RTWG (2012 meeting) proceedings are included in these proceedings.

Committees for 2012

Executive:

Chair:	Tim Walker	Mississippi
Secretary:	Chuck Wilson	Arkansas

Geographical Representatives:

Karen Moldenhauer	Arkansas
Chris Greer	California
Ronald Rice	Florida
Xueyan Sha	Louisiana
Nathan Buering	Mississippi
Won Kyo Jung	Missouri
Lee Tarpley	Texas

Immediate Past Chair:

Randall (Cass) Mutters	California

Administrative Advisors:

David Boethel	Experiment Station
Joe E. Street	Extension Service
Anna McClung	USDA-ARS

Publication Coordinator:

Mike Salassi	Louisiana

Web Page Coordinator:

Chuck Wilson	Arkansas

Industry Representative:

Frank Carey	California

2012 Local Arrangements:

Rick Cartwright - Chair	Arkansas
Karen Moldenhauer - Co-chair	Arkansas

Location and Time of 2014 Meeting:

Steve Linscombe	Louisiana
Michael Salassi	Louisiana
Eric Webster	Louisiana

Nominations:

Steve Linscombe (Chair)	Louisiana
Rick Norman	Arkansas
Luis Espino	California
Ronald Rice	Florida
Jason Bond	Mississippi
Won Kyo Jung	Missouri
Fugen Dou	Texas

Rice Crop Germplasm:

Georgia Eizenga, Chair	USDA-ARS
Jim Correll	Arkansas
Karen Moldenhauer	Arkansas
James Gibbons	Arkansas
Farman Jodari	California
Jim Oard	Louisiana
Xueyan Sha	Louisiana
Dwight Kanter	Mississippi
M.O. Way	Texas
Billie Woodruff	RiceTec, Inc.
Ex Officio:	
Harold Bockleman	USDA-ARS
Mark Bohning	USDA-ARS
Kay Simmons	USDA-ARS
Anna McClung	USDA-ARS
Clarissa J. Maroon-Lango	USDA-ARS
Wengui Yan	USDA-ARS

National Germplasm Resources Laboratory:

Mark Bohning	USDA-ARS
Gary Kinard	USDA-ARS

Rice Variety Acreage:

Johnny Saichuk, Chair	Louisiana
Chuck Wilson	Arkansas
Kent McKenzie	California
Nathan Buering	Mississippi
Donn Beighley	Missouri
Garry McCauley	Texas

2012 RTWG Panel Chairs:

Breeding, Genetics, and Cytogenetics:
Wengui Yan — USDA-ARS

Economics and Marketing:
Brad Watkins — Arkansas

Plant Protection:
Craig Rothrock — Arkansas

Processing and Storage:
Rolph Bryant — USDA-ARS

Rice Culture:
Nathan Slaton — Arkansas

Rice Weed Control and Growth Regulation:
Bob Scott — Arkansas

RESOLUTIONS
33rd RTWG – 2010

The 33rd meeting of the RTWG held at Biloxi, Mississippi, February 22 to 25, 2010, provided the time and location for the exchange of information among rice research and extension scientists, rice growers, rice industry representatives, and users of rice products. This exchange of knowledge was beneficial to all concerned and has accomplished the aims of the RTWG.

Therefore, the Executive Committee, on behalf of the RTWG, expresses its appreciation to the following individuals and organizations that contributed to the success of the 33rd meeting.

1. Randall (Cass) Mutters, RTWG Chair, and all other members of the Executive Committee who organized and conducted this very successful meeting. We recognize Timothy Walker and his cooperating staff for the timely completion of organizational details to include notification correspondence, program preparation, specific paper presentation standards, and all other tasks involved with the RTWG.

2. The staff of The Beau Rivage Resort and Casino, Biloxi, Mississippi, for their assistance in arranging lodging, services, and hospitality before and during the RTWG meeting.

3. The Local Arrangements Committee chaired by Timothy Walker for the site selection and overseeing arrangements. To Jason Bond and Nathan Buehring for their time and assistance in locating and securing arrangements with the hotel. To Harriet Greenlee for conducting all aspects of pre- and on-site registration, and other conference planning details. To Doreen Muzzi for the design and operation of the 33rd RTWG website, publicity, printing of the program, and gift bag organization. We appreciate all the aforementioned efforts to make sure everything was in place so the meeting ran smoothly.

4. To all other Mississippi State University staff who contributed time and effort for numerous vital tasks that made sure this meeting was a success.

5. The Panel Chairs Dwight Kanter, Steve Martin, Tom Allen, Elaine Champagne, Dustin Harrell, and Jason Bond and moderators for planning, arranging, and supervising the technical sessions. Special recognition is due for the efforts of the chairs and Michael Salassi to collect, organize, and edit abstracts for the Website posting and final publication.

6. The paper/poster presenters for sharing results and new ideas at the meeting.

7. The Certified Crop Advisor Training Session, General Session, and Applied Genomics Workshop speakers for sharing their knowledge and wisdom.

8. Michael Salassi, and the LSU AgCenter staff, for editing and publishing the RTWG proceedings.

9. We gratefully recognize our many sponsors that made the 33rd Rice Technical Working Group meeting possible.

RTWG Conference Sponsorship

Diamond
BASF
Bayer CropScience
Dow AgroSciences
RiceTec, Inc.
Syngenta Crop Protection
Valent U.S.A. Corporation

Gold
FMC Corporation
Horizon Ag, L.L.C.
Mosaic Company
RiceCo, L.L.C.

Silver
Agrotain International, L.L.C.
Dupont Crop Protection
Helena Chemical Company
Riceland Foods Foundation

Bronze
Mississippi Farm Bureau Federation
United Phosphorus, Inc.

Distinguished Rice Research and/or Education Award

Eric Webster

Dr. Webster, in his short tenure with the LSU AgCenter, has developed an outstanding record of research and outreach accomplishments. He has developed a very ambitious research program that is one of the most extensive in the USA. Eric has displayed the ability to foresee the issues and thus be proactive in addressing questions before they arise. His applied research program is intense, yet he also conducts more basic research as well.

Even though his area of research is highly competitive, he continues to recruit high quality graduate students into his program. His successful program is very reputable for being an excellent environment for graduate students. Dr. Webster is very skilled at being able to adjust the amount of guidance given based on each individual's unique needs to create a productive learning environment.

Dr. Webster has demonstrated the ability to be a team player by his collaborative efforts within the LSU AgCenter and in other rice producing states. His professionalism and personal skills foster long-term, productive collaborations.

Recently, Eric accepted the responsibilities of coordinating rice extension weed science work within the LSU AgCenter. He has performed exceptionally in technology transfer. He has the ability to apply research-based knowledge in diagnosing specific field problems and communicate findings and solutions across a wide array of audiences.

Dr. Webster's publication record is exemplary. The mix of publications is very appropriate for his appointment as a Land-Grant scientist. In 2008, Dr. Webster and his co-workers authored a publication titled *Schematic Diagram for Seeding Weed Identification in Rice*. Over 8000 copies have been distributed among extension personnel, producers, researchers, and teachers in the USA rice industry and abroad. In addition to his publication record, he has generated over $2 million in funding in the last decade.

Eric has been recognized by his peers by receiving numerous research awards throughout his career. He is the epitome of what a research scientist should strive to be and is very deserving of this prestigious award.

Distinguished Service Award

John Kendall

John Kendall has contributed 37 years of service to the U.S. rice industry through a long and effective career in private industry with Riviana Foods, Inc. located in Houston, Texas. He received his B.S., M.S. and Ph.D. degrees from Louisiana State University with his graduate degrees being achieved in Food Science and Technology. After completing his education, he worked for a few years with Borden, Inc. before joining Riviana Foods, Inc. in 1973. Through the years that he has worked with Riviana Foods, he has advanced from a Food Technologist to the position of Director of Research and Development, Process Development that he has held for the last 20 years. He led the team that established an internal system for monitoring rice milling, parboiling, and instantizing quality and developed Good Manufacturing Practices that have been implemented by the Quality Control and Corporate Quality Assurance Departments in Riviana's world-wide operations. He was the leader in development of parboiling and instantizing technologies that have led to construction of more efficient processes for Riviana products such as "Success Rice," "Gourmet House parboiled and instant Wild Rice," and most recently, "Minute Rice." He is the inventor, or co-inventor, of a number of U.S. and world-wide patents relating to rice and grain processing.

Dr. Kendall has always maintained close contact with the rice research community, ranging from breeders to cereal chemists. He has worked closely with researchers to be aware of the development of new rice cultivars and explore their potential and suitability for various food products. As an innovator, he has always been interested in how rice genetic diversity coupled with processing technology could be used to develop new and improved products for the market place. He was quick to understand how novel technologies like molecular markers could help not only in breeding efforts for the development of new varieties but also in quality control of industrial products. Although there have been many changes and challenges to the rice industry over Dr. Kendall's career, he has been helpful in providing feedback to researchers to make them aware of industry concerns and marketing opportunities that have helped to assure a steady stream of new, high quality rice food products that has helped the U.S. rice industry to grow and diversify.

Distinguished Service Award

Theodore (Ted) Miller

Theodore Miller received his M.S. and Ph.D. from Louisiana State University. Upon his hire in 1976, he moved his family to Leland, MS, where he made his career in rice research and extension for Mississippi State University. Dr. Miller conducted rice research from 1976 to 1981. In 1981, the Mississippi Cooperative Extension Service hired Dr. Miller to be the Mississippi Rice Extension Specialist. He served the citizens of Mississippi in this capacity until his retirement in 1997. Typical of Dr. Miller's work ethic, he did not rest in his retirement; rather, he began Tri-M Agronomics where he was a successful independent rice consultant for several rice growers in Mississippi. After the fall of 2008, Dr. Miller finally "stored" his boots for good and retired from his consulting business. He now is spending time with his wife Sally, enjoying his hobbies which include carpentry and auto-mechanics.

Dr. Miller's hire by MSU was at a very critical time. Acreage allotments had just been expanded by the USDA and thus rice acreage increased substantially in Mississippi in the 1970s and 1980s. Mississippi State was considered a center for cotton production expertise; however, few native Mississippians possessed knowledge of rice production. Dr. Miller's knowledge and his ability to communicate with growers proved to be valuable to the growth of the rice industry in Mississippi. Many of his efforts were recorded in the 60+ publications that addressed many of the basic issues for successful rice production. His publications included information from variety trial results, fertilization, pest control measures, water management, and grain storage and handling. In addition to his publications, Ted spent countless hours in the field assisting growers and training county agents so they could assist rice growers of Mississippi make informed decisions to maximize profitability.

Dr. Miller's research, extension, and independent consulting efforts are worthy enough of recognition. Moreover, the intangible qualities of Ted's life should also be highlighted. Ted is a veteran of the Vietnam War. However, many do not know that he earned a Purple Heart for being wounded in combat. The helicopter that Dr. Miller was piloting encountered enemy fire and went down. As a result of the injury, Dr. Miller lost his leg from just below the knee. He was rehabilitated and spent 33 years walking rice with a prosthetic. There are many people today that did not know this about Ted because he is not the kind to bring attention to himself. He never complained, rather he reported to work daily and did what was necessary to excel in his work regardless of his circumstances. This is why Ted is the epitome of class, character, bravery, and toughness. He dedicated his life to rice and the people who make the USA rice industry what it is today.

Distinguished Service Award

James (Jim) Thompson

Mr. Jim Thompson is a member of the Department of Biological and Agricultural Engineering at the University of California, Davis, with specific responsibilities for post harvest technology. Jim's early work was on problems of burning rice straw in the 1970s. His collaborative research on burning techniques was widely adopted by the California Air Resources Board and resulted in the industry's ability to continue burning rice straw as an inexpensive and practical method of disposal and disease sanitation.

Jim's more recent contributions that have centered on post harvest handling of rice grain have proven extremely valuable to the California rice industry. Jim introduced automated aeration technology, now widely adopted in rice drying. His collaborative efforts also impacted the industry by changing sample milling techniques. Furthermore, more collaborative efforts led to the development of a precise understanding of the interaction between rice moisture content at harvest, weather conditions, and rice quality. This work showed that dew following drying north winds negatively impacts head rice yield. In addition, a critical rice moisture content at which California medium grain becomes susceptible to head rice loss after rehydration was determined. These findings have been disseminated at the Rice Quality Workshop, which is a popular event for post harvest management information.

A pattern of energy conservation and improvements in harvest handling, drying, and storage can be seen with Mr. Thompson's efforts. He is very deserving of this honor.

Minutes of the 33rd RTWG Meeting

Opening Executive Committee Meeting

In attendance: Cass Mutters (Chair), Anna McClung (USDA-ARS Rep.), Chuck Wilson (Website Coordinator), Chris Greer (California Rep.), Nathan Buehring (Mississippi Rep.), David Boethel (Experiment Station Admn. Advisor), Jason Bond (Local Arrangements), Tim Walker (Secretary), Gene Stevens (Missouri Rep.), Frank Carey (Industry Rep.), Joe Street (Extension Service Admn. Advisor), Steve Linscombe (Louisiana Rep.), Karen Moldenhauer (Arkansas Rep.) and Garry McCauley (Past Chair).

Chair Cass Mutters called the meeting to order at 8:30 a.m. on February 22, 2010, at the Beau Rivage Resort in Biloxi, Mississippi.

Old Business

The gavel donated by Texas at the last meeting was presented by Cass Mutters.

Cass Mutters asked if any corrections to the minutes of the 2008 RTWG were needed. Hearing none, he entertained a motion to dispense with the reading of the minutes. The motion was approved unanimously by the executive committee.

The RTWG financial report from 2000 to 2008 was presented to the executive committee for their review. Anna McClung asked about the different registration income amounts, and registration tallies for the 2010 RTWG meeting. According to Secretary Tim Walker, 290 registrants were prepaid for 2010 meeting, with 325 to 350 total registrants expected. The average number of registrants since the 2000 meeting has been just below 400.

Cass Mutters asked whether Missouri is currently in the rotation to host the RTWG meeting. Gene Stevens indicated that Missouri would probably not be in the rotation to host the RTWG meeting. In addition, it was noted that Florida not does have a contingency at the 2010 meeting.

New Business

Cass Mutters asked if there were any revisions to the RTWG Manual of Operating Procedures. Tim Walker proposed eliminating the requiring of a hard copy of abstracts be mailed to the panel chair and substituting that requirement with the exclusive use of e-mail. Tim Walker's motion was seconded by Garry McCauley, and hearing no opposition, the motion carried.

A motion was made by Jason Bond that instead of the February 1 deadline for oral presentations to be submitted to panel chairs that it be changed to at least seven days prior to the beginning of the RTWG meeting. Tim Walker seconded the motion. Steve Linscombe asked if the due date should be left to the discretion of the current RTWG secretary. A second motion made by Cass Mutters proposed adding an amendment allowing for the due date for presentations to be at the discretion of the current secretary. The motion was seconded by Karen Moldenhauer, and with no further discussion, the motion was unanimously approved.

Garry McCauley asked for written procedures regarding the use of RTWG contingency funds. Steve Linscombe commented that the request of the funds could go to the meeting chair but said there is nothing in the manual that refers to that subject. Mutters requested volunteers to draft proposed procedures. Steve Linscombe and Garry McCauley said they would do so. Points to be included are procedures for requests of use of contingency fund, justification and conditions, and procedure for approval. Garry McCauley suggested only including a procedure for requests and a procedure for approval. When complete, the proposal will come back before the executive committee for approval.

Cass Mutters proposed developing a permanent, national RTWG website. Chuck Wilson agreed that would be an efficient way to maintain a web presence and volunteered to pick up the fee and outsource the work. Tim Walker agreed for the need for a contiguous website to carry from meeting to meeting. It was noted that one site would be preferable, and the site should include online registration capabilities. Tim Walker and Chuck Wilson agreed to work together to develop a proposal that would include bid specification, for the combining of two websites. Specifications for a permanent RTWG website will include purchasing name and establishing secure domain for online registration. Tim Walker, Chuck Wilson and Cass Mutters will report back to the executive committee by July 1, 2010, on the status of a national RTWG website.

It was noted that the reason for Louisiana Representative Eric Webster's absence was the death of his mother. Condolences were passed along.

Cass Mutters proposed adding recognition for the editor of meeting proceedings. Cass Mutters proposed including the current RTWG secretary and the additional personnel, if any, who are putting together those proceedings. Garry McCauley says the panel chair should edit and correct all abstracts according to RTWG operating procedures. Tim Walker suggested a line item change with the secretary being listed as a senior editor with the publications coordinator and others listed as co-editors. Anna McClung suggested adding a standard format for recommended citation. Cass Mutters will draft a standardized format and will return with a proposal to the executive committee before the conclusion of RTWG 2010.

Tim Walker requested further consideration on per diem rules for meeting facilities, meals, etc., because each state has different rules regarding acceptable rates. He proposed adding a fee structure increasing the meeting registration rate for those registrants that do not stay at the conference hotel. Cass Mutters asked whether wording is needed in operating procedures to that end. It was decided that the issue be left up to the host state, although Cass Mutters will make an announcement of the issue at the general session.

Garry McCauley stated that the national RTWG letterhead is the permanent letterhead and is to be used on all RTWG correspondence, including websites and meeting proceedings. While state recognition can be anywhere on the page, the official letterhead should be placed first at the top of the page. Karen Moldenhauer made a motion to add information about the national logo to the organization's operating procedures. Garry McCauley seconded the motion. The motion, with an amendment that placement in the operating procedures is left to the discretion of the chairman, was approved with no opposition.

Cass Mutters introduced a last minute addition to the 2010 Distinguished Service Awards. Karen Moldenhauer made a motion to approve the award to Dr. John Kendall. Kendall is retiring from Riviana in 2010. The motion was seconded by Gene Stevens and with all in favor, the motion carried.

Award recipients for the 2010 meeting include: Eric Webster, research award; and Jim Thompson, John Kendall and Ted Miller, distinguished service awards.

It was agreed that Cass Mutters will clarify for future executive committees that RTWG awards require a nomination plus three letters of support.

Carl Wick of California, who died in 2009, will be acknowledged in the necrology report.

Cass Mutters made the motion to close the meeting. Meeting was adjourned.

Minutes of the 33rd RTWG Meeting

Opening Business Meeting

Chair Cass Mutters called the meeting to order at 8:05 a.m. on February 23, 2010, at the Beau Rivage Resort in Biloxi, Mississippi. Minutes of the previous meeting were accepted unanimously without reading after moved by Neil Rutgers and Jim Hill seconded.

Chair Cass Mutters dispensed with the reading of the last meeting's minutes, and attendees present voted to accept the minutes as they are published in the proceedings.

The Chair discussed the proposed national RTWG website and the appointment of a committee to establish the website for all future RTWG meetings. Mutters stated he hoped to have the website online and fully operational by the 2012 meeting in Arkansas.

A proposal was discussed to recognize contributors to the meeting's proceedings. The motion was approved.

Chair Cass Mutters discussed institutional per diem rules and encouraged meeting attendees to stay in the conference hotel. The executive committee is considering a two-tier registration system with the registration fees being at the discretion of the RTWG secretary.

Chair Cass Mutters asked attendees to recognize those colleagues who have passed away since the previous RTWG meeting, including Carl Wick.

Chuck Wilson announced a Feb. 26-29, 2012 date for the 34th RTWG meeting. The meeting will be held at the Hot Springs Convention Center and the Embassy Suites hotel in Hot Springs, AR.

The Chair asked for a motion to adjourn the business meeting. The motion passed and Cass Mutters closed the meeting at 8:20 a.m., February 23, 2010.

Minutes of the 33rd RTWG Meeting

Closing Executive Committee Meeting

In attendance: Cass Mutters (Chair), Garry McCauley (Past Chair), Tim Walker (Secretary), Xueyan Sha, Nathan Buehring, Anna McClung, Jason Bond, Chris Greer, Karen Moldenhauer, Joe Street, Rodante Tabien, Gene Stevens, Eric Webster, and Chuck Wilson.

Chair Cass Mutters called the meeting to order at 7:27 a.m. on February 25, 2010, at the Beau Rivage Resort in Biloxi, Mississippi.

A continuation of discussion from the opening executive committee meeting regarding the need to give appropriate credit for the production of the proceedings occurred. Karen Moldenhauer motioned and Garry McCauley seconded that the current secretary and chair be added to the publication coordinator as editors of the proceedings. Motion carried.

After further discussion about a national RTWG website, Garry McCauley motioned and Karen Moldenhauer seconded that a 100-year license be purchased for a domain name that was available. Motion carried. If funds were needed, the contingency fund could be authorized for use and replenished by Mississippi if funds were left after the conclusion of the meeting. Furthermore, Chuck Wilson and Tim Walker would work together to write specifications and solicit bids for a third-party webmaster who could construct and maintain the national website. Tim Walker provided a list of available domain names that were available the week of RTWG. Karen Moldenhauer motioned and Garry McCauley seconded that the preferred website be www.rtwg.net.

Garry McCauley presented an amended protocol for the use of the contingency fund. Tim Walker motioned the amendment be accepted and integrated into the MOP. Jason Bond seconded. Motion carried.

Discussion occurred about the possibility of maintaining a digital archive of the historical proceedings. Garry McCauley would check the Beaumont library to see what was available. If hard copies are available, then they can be scanned to pdf's and housed with other digital copies on the new national website.

After no further business, the meeting was adjourned at 8:25 am.

Minutes of the 33rd RTWG Meeting

Closing Business Meeting

Chair Cass Mutters called the meeting to order at 8:37 a.m. on February 25, 2010, at the Beau Rivage Resort in Biloxi, Mississippi. He extended his gratitude to Mississippi for hosting the 33rd RTWG, to Michael Salassi for his efforts at publishing the proceedings, and to the participants of RTWG for their support of his leadership efforts in recent years.

Johnny Saichuk, chair of the Variety by Acreage committee, reported that all states would increase in rice acreage in 2010. Randy Ouzts reported that there would be approximately 900,000 acres of Clearfield varieties planted in the southern U.S. in 2010.

Tim Walker reported on behalf of Industry Representative, Dr. Frank Carey, that the industry luncheon was successful. Approximately 250 people attended the luncheon and the idea to absorb the cost of the luncheon in the registration helped the success of the luncheon.

No report was given from the Publication Coordinator or the Crop Germplasm Committee.

Tim Walker stated the attendance for the 33rd RTWG was 343.

Johnny Saichuk commended Nathan Buehring and the Mississippi delegation for hosting the Certified Crop Advisor Training and further stated that he saw lots of potential growth in the RTWG by incorporating more people from this segment of our industry.

Chuck Wilson, chair of the Nominations Committee, recommended the following individuals for leadership for the 34th RTWG:

Timothy Walker – Chair
Charles Wilson – Secretary
Randall Mutters – Immediate Past Chair

<u>Geographical Representatives</u>
Karen Moldenhauer – Arkansas
Chris Greer – California
Ronald Rice – Florida
Xueyan Sha – Louisiana
Nathan Buehring – Mississippi
Won Jung – Missouri
Lee Tarpley – Texas
Frank Carey – Industry

Nominations Committee Chair – Steve Linscombe

Tim Walker motioned to accept Wilson's nominations, Karen Moldenhauer seconded, and motion carried.

Cass Mutters passed the gavel to Tim Walker.

Tim Walker recognized Cass Mutters for his service to RTWG by giving him a plaque on behalf of RTWG. Tim Walker thanked his colleagues in Mississippi for their work in hosting the 33rd RTWG. Additionally, he thanked the panel chairs, sponsors, and attendants for participating.

Cass Mutters motioned the meeting be adjourned, Garry McCauley seconded. After no further business, the meeting was adjourned.

SPECIAL COMMITTEE REPORTS

Nominations Committee

The Nominations Committee proposed the following individuals for membership on the 2012 RTWG Executive Committee and Nominations Committee:

Executive Committee:

Timothy Walker	Chair
Charles Wilson	Secretary
Randall Mutters	Immediate Past Chair

Geographical Representatives:

Arkansas	Karen Moldenhauer
California	Chris Greer
Florida	Ronald Rice
Louisiana	Xueyan Sha
Mississippi	Nathan Buehring
Missouri	Won Jung
Texas	Lee Tarpley
Industry	Frank Carey

Nominations Committee:

Louisiana	Steve Linscombe, Chair
Arkansas	Rick Norman
California	Luis Espino
Florida	Ronald Rice
Mississippi	Jason Bond
Missouri	Won Kyo Jung
Texas	Fugen Dou
Industry	Frank Carey

Submitted by
Chuck Wilson

Rice Crop Germplasm Committee

The 30th meeting of the Rice Crop Germplasm Committee was held Monday, February 22, 2010, in Biloxi, Mississippi. Members in attendance were Georgia Eizenga (Chair), Harold Bockelman, James Correll, James Gibbons, Farman Jodari, Dwight Kanter, Clarissa Maroon-Lango, Anna McClung, Karen Moldenhauer, Jim Oard, Xueyan Sha, M.O. Way, Billie Woodruff, Wengui Yan, and Jack Okamuro representing USDA National Program Staff. Member participating via conference call was Mark Bohning. Guests in attendance were Debra Ahrent, Donn Beighley, Vanina Castroagudin, Nanyen Chou, Ken Foster, Yiming Jiang, Kent McKenzie, Qiming Shao, Alisha Stivers, and Zongbu Yan.

The minutes of the 29th Rice Crop Germplasm Committee held February 4, 2009. in Stuttgart, Arkansas were read and approved by a motion from Karen Moldenhauer and seconded by Dwight Kanter. Highlights of the 2009 meeting not discussed in the current report include 2,217 rice accessions were part of the second shipment to the Svalbard Seed Vault, a long-term storage facility in the Arctic operated by the Norwegian government and the Global Crop Diversity Trust (GCDT). APHIS is using a RT-PCR assay to detect rice *hoja blanca* virus in clonal rice plants going through quarantine. The NSGC rice core collection (1,794 accessions) is available from GSOR, genotyped with a total of 81 SSR/SNP markers both genome-wide and targeted and evaluated for days to heading, plant height, plant type, panicle type, awn type, lodging, and sheath blight. A subset of 726 accessions was evaluated for bran color; kernel length, width, L/W ratio, and weight; amylose and ASV. The mini-core collection (217 accessions) is genotyped with a total of 155 SSR markers placed approx. every 10 cM and evaluated for kernel smut, biomass, yield components and yield potential. Wengui Yan was added as an ex-officio member of the committee due to his responsibility for the grow-out of the rice germplasm collection.

Jack Okamuro, (USDA/ARS NPS) sent regrets from Peter Bretting, and presented the highlights from the "2010 Office of the National Programs Report for the U.S. National Plant Germplasm System," as follows. NPGS is partnering with Bioversity International and GCDT to transform GRIN into GRIN-Global on a three-year, $1.4 million project and this project is over 2/3 complete. This software will be available to genebanks of all sizes and allow information about accessions to be shared amongst researchers. There will still be the issue of seed exchange to work through depending on the country. On budget issues, across the

NPGS for FY10 modest increases in funding partially covered increases in personnel costs. The new Administration's priority areas for USDA include climate change, food safety, children's nutrition/health, international food security, and bioenergy and the President's FY11 budget proposes an increase ($6.9 million) for ARS plant, insect and microbial collections. Hearings on the FY12 budget are underway and include a National Summit of Rural America in Missouri. The National Plant Germplasm Coordination Committee with members from ARS, NIFA and SAES promotes, advises and facilitates coordination between the groups for the NPGS. The NPGS staff developed a SOP for handling the germplasm accompanied by the SMTA currently being used by the CGIAR Centers (see discussion below).

Mark Bohning (USDA/ARS GRIN DBMU) reported the development of GRIN-Global is progressing with input from curators, a survey of 6,000 users, and demonstrations to several Crop Germplasm Committees and at professional/commodity meetings. Currently, the software is being tested by several groups and when complete, one will be able to download data on the accessions into an "Excel" type sheet. GRIN is now enhanced to handle limited molecular data, and GRIN-Global will be more robust with links to other databases. It is projected that in 2011, GRIN-Global which is Microsoft based, will replace the current Oracle-based GRIN system. Work on GRIN-Taxonomy designed to cover the wild relatives of all major and minor crops is completed on 13 major crops including rice (http://www.ars-grin.gov/~sbmljw/cgi-bin/taxcrop.pl). The PI books from 1979-1997 are being formatted for downloading as pdf files. Gary Kinard is the new research leader for the unit. The Plant Exchange Office supports a "Plant Exploration and Exchange" grant program which includes both field collection and arranging germplasm exchange, respectively. Proposals for this year are due July 23, 2010. Contact Georgia Eizenga for more information.

A discussion of intellectual property issues ensued because sharing seed is a different issue than sharing information. Harold Bockelman stated that accessions covered by PVP are not distributed through the GRIN system but referred to the developer. Also, when seed covered by a MTA or SMTA, currently used by the CGIAR centers, is distributed, the person receiving the seed agrees to the MTA/SMTA. Following this discussion, James Gibbons provided the following web site for additional information on the International Treaty on Plant Genetic Resources referred to in the SMTA (http://www.planttreaty.org/). Member countries are on a link within the "Members" subheading. It indicates that the USA has signed but not ratified the treaty. Also, there is the issue that the donor has "rights" to the given accession, no matter how many times it is crossed.

Clarissa Maroon-Lango (APHIS, PPQ) reported their group is now part of the registration, permits and inspection group after reorganization. Dr. Maroon-Lango's group processed 345 rice introductions with 133 from Indonesia, 5 from South Korea and 207 from Bangladesh. Only 11 Indonesian and 184 Bangladeshi introductions germinated and produced seed. The remaining Bangladeshi introductions are being grown in 2010. There is space for additional introductions but the committee did not have other suggestions. This completes the quarantine process for the introductions from Indonesia and Bangladesh by Bob Dilday.

Harold Bockelman reported that 36 *O. sativa* accessions received new PI numbers. This gives 18,431 *O. sativa* accessions and 247 *Oryza* species accessions for a total of 18,678 *Oryza* accessions in the USDA/ARS rice germplasm collection at this time. Harold stated that after the discussion of the issues regarding seed import under the current SMTA, he will attempt to regenerate the accessions with critically low inventory due to the difficulties of importing seed from IRRI.

Harold has had several seed requests from China, India and Japan. Recently, he handled a request from Brazil for the complete rice collection. Currently, Mexico is repatriating accessions of several crops for their new genebank. The group discussed how to request Brazil and Mexico reciprocate with their germplasm. Working with Peter Bretting and Mark Bohning to coordinate requests for germplasm would be best, so it is a group effort and formal request. Each country is a different situation to work with and contacts within the country are helpful.

The 6-year term of committee members Dwight Kanter, Karen Moldenhauer, Jim Oard, and M.O. Way terminate in 2010, and these members are willing to serve another term. The motion was made by James Gibbons to re-elect the four members for another 6-year term, seconded by Xueyan Sha, and supported by all members.

The motion to adjourn the meeting was made by Karen Moldenhauer, seconded by James Gibbons and supported by all members. Meeting was adjourned.

Wengui Yan made a presentation on the "Genetic Structure of the Rice Core Collection" based on 72 SSR markers after the meeting was adjourned.

Rice Crop Germplasm Committee members as of February 22, 2010, with year term ends in parentheses:

Dr. Georgia Eizenga, Chair (2012)
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Dr. James Gibbons (2012)
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Dr. Billie Woodruff (2012)
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Dr. James Correll (2012)
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Dr. Farman Jodari (2014)
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Dr. Dwight Kanter (2016)
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Submitted by
Georgia Eizenga

Publication Coordinator/Panel Chair Committee

Publication Coordinator Michael Salassi communicated by email with the panel chairs before the 2010 RTWG meeting concerning publication of panel attendance, recommendations and abstracts in the RTWG proceedings. Timely submissions, editorial review by chairs, and quality of abstracts were stressed for the proceedings. It was stated that if an oral or poster presentation was not given the abstract would not be published in the proceedings. All changes in operating procedures will be incorporated into the RTWG guidelines for preparation of abstracts in the 2012 proceedings. Proceedings should be available in both hard copy and CD format within 12 months of the meetings.

Submitted by
Michael Salassi

Rice Variety Acreage Committee

In attendance were: Chuck Wilson (Arkansas); Rick Norman (Arkansas); Nathan Slaton (Arkansas); Karen Moldenhauer (Arkansas); Chris Greer (California); Kent McKenzie (California); David Boethel (Louisiana); Steve Linscombe (Louisiana); Johnny Saichuk (Louisiana); Xueyan Sha (Louisiana); Nathan Buehring (Mississippi); Tim Walker (Mississippi); Donn Beighley (Missouri); Cathy Dickens (Missouri); Garry McCauley (Texas); Ted Wilson (Texas); David Jones (Farmers Rice, California); Qiming Shao (Bayer CropScience); Randy Ouzts (Horizon Ag); and Wengui Yan (USDA). Absent: Brian Ottis (RiceTec); Ron Rice (Florida); and Ken Foster (California, Kennan Corp.).

The meeting was called to order by Johnny Saichuk at 10:15 a.m. Minutes of the 2008 meeting were distributed by Saichuk. Chuck Wilson moved and was seconded by Kent McKenzie to approve the minutes as presented. The motion carried.

Johnny Saichuk distributed copies of the acreage reports by state that had been submitted to him.

Chuck Wilson gave the Arkansas acreage report. He said the 2008 season was a poor one for Arkansas. Yields that year ranged from 100 to 140 bushels per acre. In 2009, yields rebounded to average around 160 bushels per acre or about 10 bushels per acre lower than the record of 170 bushels per acre. Acreage ended up around 1.47 million, which was limited by weather or it would have been more in 2009. Medium-grain acreage jumped from 100,000 acres in 2008 to 225,000 in 2009, most of which was planted to Jupiter. He said he expected an increase in overall acreage in 2010 to 1.65 million acres, but not as much interest in medium-grain production.

Chris Greer mentioned he had and was continuing to get phone calls from Arkansas by growers trying to obtain California medium-grain seed to grow in Arkansas. Disease susceptibility of these varieties makes growing them in the south an invitation to disaster he said.

Wilson indicated the varieties Francis, CL151 and Jupiter had serious blast problems. Kent McKenzie asked why the interest in long grains over medium. Wilson said salt, high pH soils, and bacterial panicle blight had affected the medium-grain varieties suppressing yield in comparison to long-grain varieties. Jupiter's disease package accounted for some of the increase in medium-grain acreage.

Steve Linscombe stated Kellogg's had just announced they would not approve Neptune. He explained part of the problem was harvesting Neptune at very low grain moisture (<10% in some cases) resulted in higher than desired levels of chalkiness in the grain. Further discussion implied there might be other reasons not revealed by Kellogg as part of the decision.

Linscombe asked Chuck Wilson if Neptune was going to be on Riceland's approved variety list. Wilson said he did think it would in light of the Kellogg's decision. It would be accepted in the seasonal pool but not under contract. Unless Kellogg's reverses their decision, Riceland was not likely to include Neptune on the 2011 list. Wilson said he expected medium-grain acreage to drop in Arkansas in 2010.

The California report was presented by Kent McKenzie. He pointed out he has had a lot of difficulty in obtaining survey information thus the acreage by variety information is lacking detail. He said he had approached both the FSA and California Rice Commission without result. He then used Foundation Seed data to estimate acreage by variety data found in the tables. Some discussion followed with the recommendation that some of the methods used by other states be employed.

Louisiana data was presented by Johnny Saichuk. He said hybrid acreage was around 16% and Clearfield acreage, including hybrids and pure lines, was about 60% of Louisiana's acreage in 2009. Reported acreage varied between 460,000 and 470,000 depending on reporting agency. Acreage was expected to increase to approximately 500,000 in 2010. He said the variety CL151 had been the leader in acreage and often yield in the state. The new variety CL111 had been only in seed production, but looked good. Chuck Wilson indicated CL111 was not that much earlier in Arkansas. Nathan Buehring said it was not much earlier than other long-grain varieties in Mississippi either. In spite of that, approximately 90 to 100 thousand acres of seed had already been sold according to Randy Ouzts of Horizon. Kent McKenzie asked about the Clearfield medium-grain variety CL261. According to Ouzts, only 10,000 acres of seed was available. Linscombe indicated it would depend on whether it is or is not approved by Kellogg's. The aromatic Jasmine type Jazzman, being marketed as Jazzmen, had been grown on 5 to 10 thousand acres and that would likely increase if the contracts were offered according to Linscombe.

Nathan Buehring reviewed the Mississippi acreage by variety report. He said Clearfield varieties had been planted on 53% of the acres in 2009. He expected the CL151 acreage to decline because of lodging problems and chalkiness. He said the CL131 acreage would still be planted but on limited acreage. He expected the hybrid variety acreage to increase in 2010. The variety Bowman was probably going to be phased out completely. Cocodrie and Cheniere were expected to make up the bulk of Mississippi's acreage in 2010. He said total acreage would likely be around 250,000 in 2010.

Randy Ouzts said some seed processors were no longer handling any conventional varieties. Linscombe reported this year was the worst year ever for Foundation Seed sales in Louisiana. Chuck Wilson said many growers were not concerned about development of resistant red rice because they expected some new technology to come along even though they have been repeatedly told nothing is on the horizon. Texas reported red rice resistance was a real problem there and would only get worse. Linscombe said some fields in Louisiana had such severe problems that they were no longer suitable for rice production. Compounding resistant red rice problems were fields infested with volunteer hybrid rice resistant to Newpath.

In Texas, about 20 lines with glufosinate resistance developed without genetic modification were in testing. Some phytotoxicity problems still need to be resolved before they will be commercially acceptable. Yields appeared to be about 90% of conventional varieties. Ted Wilson presented the grower survey data on acreage by variety. Overall acreage increased slightly from 2008 to 2009. Cocodrie was the leading variety followed by CL151. There are over 20 varieties grown in Texas he stated. Yield was estimated at 7754 pounds per acre. This includes ratoon crop production which represents about 54% of the acreage. He also said about 77% of rice acres are now west of Houston. Wilson indicated he is unable to get good data on hybrid seed acreage, thus it is not included in yield or acreage estimates. Randy Ouzts said there is about 20,000 acres of female parent acreage with typical yield of 1500 pounds per acre. If this was included, the state yield estimate would decline.

Donn Beighley said Wells was the leading variety grown in Missouri with Cocodrie and Francis following. Catahoula had not worked out well for them and probably would not be grown again. Clearfield acreage continues to increase and occupies more than 50% of their acreage. He was uncertain about hybrid acreage. He said acreage is likely to increase from 190 thousand in 2009 to 210 to 220 thousand in 2010. More continuous rice production in Missouri is inviting problems.

Randy Ouzts was asked to provide an update on Clearfield rice. He said acreage is growing with some cycling out of older varieties. The Liberty Link issue had affected sales of CL131, but he anticipates 1 million acres of pure line Clearfield varieties to be planted in 2010. Because of the problems with volunteer hybrids they no longer allow seed production of pure line Clearfield lines on land with any history of hybrid rice production. In the interest of good stewardship to protect the longevity of the technology, Horizon was trying to limit acreage devoted to Clearfield varieties. At the time of this meeting, they had commitments for 200,000 acres of CL131, 700,000 acres of CL151, 100,000 of CL111, 10,000 of CL261 and <1,000 of the Arkansas line. No orders had been placed for CL171 for 2010.

A quick survey of the group reported the following yields in 2009:
Arkansas - 6,820 pounds/acre; California - 8,500 pounds/acre; Louisiana - 6,480 pounds/acre; Mississippi - 6,700 pounds/acre; Missouri - 6,500 pounds/acre; Texas - 7,754 pounds/acre.

Following a motion, the meeting was adjourned at 11:45 a.m.

Submitted by
Johnny Saichuk

Industry Committee

The Rice Technical Working Group Industry Committee again held a successful luncheon at the 33rd RTWG meetings in Biloxi, Mississippi, on Tuesday, February 23, 2010, at The Beau Rivage. The purpose of the Industry Committee luncheon is to enhance the meeting experience in several ways. First, it serves as a means of strengthening the cohesiveness of the committee itself, allowing the committee members to become better acquainted with each other. Since the luncheon is open to all attendees of the Rice Technical Working Group meeting, it naturally encourages an interaction between industry and public sector researchers. Finally, it serves as another meeting opportunity where an invited speaker may share with the RTWG membership their thoughts and information on timely topics.

The 2010 Industry luncheon met all of these goals. The luncheon was attended by several hundred guests who heard Dr. David Mackill, Principal Scientist and program leader with the International Rice Research Institute (IRRI), Los Banos, Philippines. Dr. Mackill talked about the history of IRRI as they celebrate their 50th anniversary, the role of rice breeding at IRRI and the specific areas of his research project. There was a high level of interest as indicated by the attendance and number of questions.

The Industry Committee would like to thank Dr. Nathan Buehring, Chairman, Local Arrangements Committee, for his invaluable assistance in coordinating the luncheon. The Industry Committee looks forward to again hosting a luncheon at the 34th RTWG meetings in Arkansas in 2012.

Submitted by
Frank Carey

2008 Arkansas Harvested Rice Acreage Summary

COUNTY/ PARISH	2007 ACREAGE	2008 ACREAGE	MEDIUM GRAIN			LONG GRAIN							
			Bengal	Jupiter	Others	CL161	CL 171 AR	CL XL 729	CL XL 730	Cocodrie	Francis	Wells	Others
Arkansas	105,961	102,747	413	2,745	0	1,541	15,720	6,986	5,753	4,108	30,206	21,011	14,264
Ashley	11,200	12,713	0	0	0	4,055	521	2,288	839	1,780	0	3,229	0
Chicot	25,091	31,961	0	0	17	1,023	7,319	5,465	4,187	7,000	160	4,560	2,231
Clay	73,440	75,255	288	5,822	0	452	11,442	12,486	12,411	828	5,117	18,665	7,745
Craighead	78,155	78,477	1,470	9,281	0	3,059	14,109	7,648	11,217	4,759	3,993	14,956	7,985
Crittenden	36,761	36,935	2,053	0	0	0	1,145	5,429	480	222	0	24,373	3,233
Cross	85,053	79,819	80	2,421	41	7,503	28,907	8,461	4,230	319	11,095	16,442	319
Desha	27,572	26,660	0	1,245	0	1,394	3,841	3,815	790	3,263	2,920	8,498	894
Drew	10,233	12,441	0	0	0	3,160	4,442	1,319	2,475	0	0	759	287
Faulkner	2,316	2,839	0	0	0	0	738	741	295	0	0	1,065	0
Greene	67,557	77,459	620	1,239	0	5,150	6,197	23,990	23,425	1,596	3,325	9,407	2,510
Independence	10,381	10,177	0	0	0	0	0	6,921	0	0	0	0	3,257
Jackson	91,806	95,396	602	14,675	35	10,449	13,060	12,950	14,900	271	7,399	13,353	7,702
Jefferson	58,132	67,424	0	514	0	14,429	7,417	7,079	2,225	0	7,200	28,560	0
Lafayette	1,974	1,869	0	0	0	0	0	0	0	1,869	0	0	0
Lawrence	98,390	102,405	0	7,805	0	2,255	28,359	22,643	8,500	6,616	1,503	18,975	5,749
Lee	17,877	22,840	0	291	0	0	3,926	0	868	2,535	5,870	9,350	0
Lincoln	26,547	29,337	0	0	0	0	2,876	9,545	7,550	0	8,390	440	536
Lonoke	73,650	75,138	2,545	2,166	75	301	10,091	6,387	6,161	301	11,045	23,593	12,473
Miller	541	1,665	0	0	0	0	508	0	0	711	0	446	0
Mississippi	37,405	36,715	0	0	0	0	776	3,988	2,519	330	0	28,858	244
Monroe	46,619	52,358	585	642	0	3,613	3,707	4,608	1,990	8,273	7,644	15,204	6,094
Phillips	19,889	35,395	0	0	0	5,522	248	248	248	17,273	8,636	2,973	248
Poinsett	117,414	116,371	3,087	20,783	0	5,004	8,714	12,568	4,538	0	20,132	32,933	8,611
Prairie	59,838	60,594	1,990	8,035	40	3,211	4,423	7,340	3,757	4,242	8,544	12,019	6,994
Pulaski	3,384	3,246	0	5	0	13	766	276	266	13	477	1,079	351
Randolph	32,561	33,033	153	737	0	330	2,859	13,841	4,493	1,817	363	2,534	5,907
St. Francis	34,212	38,492	425	4,678	0	0	500	476	0	1,694	7,506	22,335	879
White	12,406	13,943	0	1,217	0	140	3,312	3,661	990	1,374	1,458	1,440	351
Woodruff	56,489	54,990	0	2,345	0	10	5,216	12,878	5,239	955	11,187	12,879	4,281
Others	4,255	5,159	0	0	0	1,678	801	481	514	170	537	499	479
Unaccounted	10,497	0											0
2008 Total		1,393,854	14,311	86,646	208	74,292	191,940	204,517	130,860	72,317	164,708	350,434	103,622
2008 Percent		100.00%	1.03%	6.22%	0.01%	5.33%	13.77%	14.67%	9.39%	5.19%	11.82%	25.14%	7.43%
2007 Total	1,327,106		99,298	44,527	2,267	135,536	13,181	68,502	53,762	85,688	145,361	470,339	208,645
2007 Percent	100.00%		7.48%	3.36%	0.17%	10.21%	0.99%	5.16%	4.05%	6.46%	10.95%	35.44%	15.72%

[1] - Harvested acreage. Source: Arkansas Agricultural Statistics and FSA
[2] - Other varieties: AB647, Banks, Cheniere, CL 131, Cybonnet , Cypress, Della, Dellrose, Gulfmont, Jackson, Jasmine 85, Koshihikari, Nortai, Pirogue, Rice Tec CL XL8, Rice Tec CL XP 745, Rice Tec XL 723, Rice Tec XP 744, Skybonnet, Spring, and Trenasse .
[3] - Other counties: Clark, Conway, Franklin, Hot Spring, Little River, Perry, and Pope.
[4] - Unaccounted for acres is the total difference between USDA-NASS harvested acreage estimate and preliminary estimates obtained from each county FSA.

2009 Arkansas Harvested Rice Acreage Summary

COUNTY/ PARISH	2008 ACREAGE	2009 ACREAGE	MEDIUM GRAIN			LONG GRAIN							
			Bengal	Jupiter	Others	Cheniere	CL151	CL 171 AR	Francis	CL XL 729	CL XL 745	Wells	Others
Arkansas	102,747	113,149	2,024	6,476	1,315	6,845	12,004	2,022	33,696	9,688	7,055	14,216	17,808
Ashley	12,713	14,968	256	0	0	0	1,750	540	0	5,742	1,167	2,457	3,055
Chicot	31,961	36,910	0	211	0	2,666	1,949	1,493	167	9,529	2,666	4,098	14,132
Clay	75,255	77,262	69	9,015	208	3,709	16,895	4,835	1,923	14,835	8,241	8,379	9,153
Craighead	78,477	79,299	0	15,146	505	3,127	14,470	12,454	732	6,986	5,788	12,042	8,050
Crittenden	36,935	37,391	1,193	7,266	0	75	1,189	604	0	2,416	6,115	17,854	679
Cross	79,819	90,169	1,818	13,532	808	0	17,121	12,064	10,861	7,471	6,503	13,559	6,433
Desha	26,660	34,613	1,613	3,134	0	3,995	9,010	0	2,431	6,901	2,123	2,878	2,528
Drew	12,441	12,761	815	1,133	0	0	2,184	0	0	815	1,941	874	4,999
Faulkner	2,839	1,742	0	0	0	0	0	0	0	0	726	910	106
Greene	77,459	72,790	3,326	0	0	1,550	7,361	8,575	4,455	29,508	8,975	4,003	5,036
Independence	10,177	8,750	34	173	0	111	1,259	1,106	198	2,457	1,012	1,012	1,389
Jackson	95,396	89,485	3,419	26,326	2,413	745	8,449	7,422	1,325	16,484	6,792	6,792	9,319
Jefferson	67,424	69,668	524	899	225	7,178	7,516	0	4,808	11,647	880	16,861	19,130
Lafayette	1,869	3,089	0	0	0	34	0	0	0	0	0	0	3,055
Lawrence	102,405	105,967	0	15,500	567	5,723	10,509	5,684	1,381	28,812	11,939	14,505	11,347
Lee	22,840	25,951	1,515	2,545	0	877	413	3,087	8,243	2,205	727	3,934	2,405
Lincoln	29,337	30,785	0	611	0	2,803	0	0	10,761	4,009	5,908	6,692	0
Lonoke	75,138	79,914	1,971	3,704	3,106	12,537	13,335	2,675	7,294	11,549	6,762	9,953	7,028
Miller	1,665	1,530	0	0	0	1,530	0	0	0	0	0	0	0
Mississippi	36,715	44,462	120	1,438	0	0	9,063	2,874	0	980	735	25,394	3,858
Monroe	52,358	57,066	1,308	3,489	1,122	10,519	3,718	176	12,282	9,968	991	10,409	3,084
Phillips	35,395	32,783	199	800	0	0	0	7,444	11,651	0	0	961	11,728
Poinsett	116,371	122,004	5,592	39,142	1,004	1,173	15,058	6,258	7,301	8,083	10,169	25,031	3,194
Prairie	60,594	62,656	307	11,047	1,473	6,013	4,116	4,671	5,838	8,466	2,919	7,064	10,742
Pulaski	3,246	3,624	0	0	0	0	0	0	0	0	0	3,624	0
Randolph	33,033	36,170	208	4,542	0	3,057	5,649	4,295	0	2,722	10,887	0	4,810
St. Francis	38,492	42,921	579	8,691	0	2,141	1,356	2,512	6,233	1,475	0	18,317	1,618
White	13,943	12,721	329	2,713	79	953	839	244	0	4,411	1,513	0	1,640
Woodruff	54,990	51,908	258	4,983	0	1,092	7,002	2,225	8,491	11,371	5,562	8,541	2,384
Others	5,159	5,497	0	253	0	0	274	493	275	2205	364	420	1,213
Unaccounted	0	11,995	0	0	0	0	0	0	0	0	0	0	0
2009 Total		1,470,000	27,476	182,768	12,826	78,455	172,488	93,751	140,345	220,733	118,461	240,778	169,923
2009 Percent		100.00%	1.88%	12.54%	0.88%	5.38%	11.83%	6.43%	9.63%	15.14%	8.12%	16.51%	11.65%
2008 Total	1,393,854		14,311	86,646	208	28860	--	191940	164708	204517	27053	350434	325178
2008 Percent	100.00%		1.03%	6.22%	0.01%	2.07%	0.00%	13.77%	11.82%	14.67%	1.94%	25.14%	23.33%

[1] - Harvested acreage. Source: Arkansas Agricultural Statistics and FSA

[2] - Other varieties: AB647, Arize QM1003, Catahoula, CL 131, CL 161, Cybonnet , Cypress, Della, Dellrose, Jasmine 85, Koshihikari, Neptune, Nortai, Pirogue, Rice Tec CL XL 730, Rice Tec CL XL 746, Rice Tec CL XL 751, Rice Tec XL 723, Taggart, Templeton, Trenasse.

[3] - Other counties: Clark, Conway, Hot Spring, Little River, Perry, Pope, and Yell.

[4] - Unaccounted for acres is the total difference between USDA-NASS harvested acreage estimate and preliminary estimates obtained from each county FSA.

CALIFORNIA RICE ACREAGE
RICE PRODUCTION OF CCRRF VARIETIES

	2008			2009		
Variety	**Seed Acres[1]**	**Estimated Acres[2]**	**Percentage**	**Seed Acres[1]**	**Estimated Acres[2]**	**Percentage**
M-104	812	19570	4.0%	802	17100	3.2%
M-202	4463	123500	25.0%	4599	128250	24.1%
M-205	4855	116850	23.7%	5096	128250	24.1%
M-206	7168	167200	33.9%	9354	190000	35.7%
M-208	434	1900	0.4%	497	2850	0.5%
M-401	189	6080	1.2%	1461	9500	1.8%
M-402	202	1900	0.4%	213	3800	0.7%
Medium Grain	18123	437000	88.6%	22023	479750	90.0%
S-102	535	13300	2.7%	544	13350	2.5%
Calmochi-101	598	15200	3.1%	1,062	16000	3.0%
Calamylow-201	109	140	0.0%	105	200	0.0%
Calhikari-201	50	1900	0.4%	151	2800	0.5%
Koshihikari	NA	11400	2.3%	NA	11400	2.1%
Akitakomachi	NA	5560	1.1%	NA	4700	0.9%
Short Grain	1291	47500	9.6%	1861	48450	9.1%
L-206	196	3990	0.8%	123	2090	0.4%
A-201	122	2470	0.5%	67	1160	0.2%
A-301	62	1235	0.3%	47	900	0.2%
Calmati-201	18	409	0.1%	36	400	0.1%
Calmati-202	22	447	0.1%	4	200	0.0%
Long grain	419	8550	1.7%	278	4750	0.9%
Total	19833	493050		24162	532950	

[1] California Crop Improvement acreage of all classes of certified seed for CCRRF varieties.

[2] Acreage estimated based on seed production of these varieties assuming they account for 95% of California planted acres reported by NASS. The remaining 5% are proprietary or older CCRRF varieties not in seed production.

2008 LOUISIANA RICE ACREAGE SUMMARY

	2008	MEDIUM GRAIN		LONG GRAIN									
Parish	Acreage	Bengal	Jupiter	Cheniere	CL 161	CL 171	CLXL729	CLXL730	Cocodrie	Cypress	Trenasse	Silver	Other[1]
Acadia	79,600	1,310	2,855	15,306	29,030	4,443	0	5,062	11,888	5,790	3,236	0	680
Allen	12,690	0	0	2,500	1,000	0	700	1,000	1,900	0	1,000	0	4,590
Avoyelles	14,560	0	0	5,267	1,427	3,395	304	0	3,836	0	0	0	331
Beauregard	1,018	0	0	85	0	0	380	227	0	0	0	100	226
Bossier	0	0	0	0	0	0	0	0	0	0	0	0	0
Caddo	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcasieu	12,556	0	0	375	2,000	100	3,650	4,323	475	0	375	0	1,258
Caldwell	2,000	0	0	175	1,125	0	0	0	700	0	0	0	0
Cameron	10,788	261	983	540	0	0	4,200	1,800	604	0	0	0	2,400
Catahoula	3,689	0	0	0	1,162	1,132	0	0	1,321	0	0	0	74
Concordia	13,444	0	0	0	2,689	0	0	0	10,755	0	0	0	0
East Carroll	7,390	0	0	443	0	2,217	0	0	2,956	0	0	0	1,774
Evangeline	44,326	150	1,069	4,500	3,772	2,375	1,500	200	15,200	1,855	4,455	6,710	2,540
Franklin	200	0	0	0	0	0	0	0	200	0	0	0	0
Iberia	660	0	0	252	28	244	0	0	0	136	0	0	0
Jeff Davis	79,385	300	1,700	12,000	6,000	7,000	3,000	4,500	24,000	2,000	10,000	0	8,885
Lafayette	3,720	61	133	715	1,356	207	0	236	555	270	1510	0	36
Madison	7,162	0	0	2,435	0	573	0	0	4,154	0	0	0	0
Morehouse	32,335	0	217	0	11,241	16,059	2,248	1,285	1,285	0	0	0	0
Natchitoches	3,823	0	0	0	0	0	0	0	0	0	0	0	3,823
Ouachita	8,971	0	950	2,005	3,208	1,604	0	0	1,204	0	0	0	0
Pointe Coupee	2,390	0	0	1,310	320	0	340	0	0	180	240	0	0
Rapides	11,176	0	0	0	5,000	0	0	0	6,176	0	0	0	0
Richland	5,003	0	0	0	1,672	853	120	0	0	0	0	0	2,358
St. Landry	26,116	131	1,175	4,714	9,925	496	1,015	1,218	2,977	1,240	992	0	2,233
St. Martin	6,152	0	0	2,398	543	631	358	0	547	1,458	0	0	217
Tensas	1,379	0	0	0	38	0	0	0	1,341	0	0	0	0
Vermilion	61,296	332	702	1,703	34,702	1,458	3,185	723	7,037	3,300	3,173	2,427	2,554
West Carroll	3,236	0	0	0	0	2,258	467	275	236	0	0	0	0
2008 Total	**455,065**	**2,545**	**9,784**	**56,723**	**116,238**	**45,045**	**21,467**	**20,849**	**99,347**	**16,229**	**23,622**	**9,237**	**33,979**
2008 Percent	**100.00%**	**0.56%**	**2.15%**	**12.46%**	**25.54%**	**9.90%**	**4.72%**	**4.58%**	**21.83%**	**3.57%**	**5.19%**	**2.03%**	**7.47%**

[1] Other varieties: CL 131, Cl 151, CLXL745, XL723, XP744, Cybonnet, Catahoula, Della, Francis, Hidalgo, Jasmine, Sabine, Wells, Bronze, Diamond, and Blends undefined lines produced by RiceTec.

2009 LOUISIANA RICE ACREAGE SUMMARY

	2009	MEDIUM GRAIN			LONG GRAIN							
Parish	**Acreage**	**Bengal**	**Jupiter**	**Neptune**	**Catahoula**	**Cheniere**	**CL131**	**CL151**	**CL161**	**CL171**	**CLXL729**	**CLXL730**
Acadia	79,434	1,271	9,532	1,907	2,402	5,004	4,870	24,441	9,341	253	2,935	2,869
Allen	13,036	130	977	196	420	870	855	4,575	1,640	0	515	0
Avoyelles	12,764	0	500	210	945	1,047	2,690	3,688	0	1,898	0	0
Beauregard	1,827	0	0	0	0	130	0	304	0	0	628	130
Bossier	12	0	0	0	0	0	0	0	0	0	0	0
Caddo	0	0	0	0	0	0	0	0	0	0	0	0
Calcasieu	12,407	0	700	0	0	300	200	2,221	100	0	5,332	3,554
Caldwell	1,400	0	0	0	327	210	0	257	466	0	0	0
Cameron	9,137	0	0	0	0	100	238	1,644	0	0	4,110	0
Catahoula	8,858	0	0	0	2,688	886	800	1,329	2,480	272	0	0
Concordia	16,144	0	2,300	0	500	400	2,737	2,639	5,162	950	0	0
East Carroll	8,826	0	441	0	0	0	523	438	0	2,217	0	0
Evangeline	42,424	294	3,400	0	0	1,700	0	14,500	1,300	0	3,800	0
Franklin	3,134	175	0	0	175	0	0	0	0	0	928	0
Iberia	540	0	0	0	0	237	74	0	0	69	0	0
Jeff Davis	78,566	1,173	8,787	1,757	2,390	4,980	4,847	26,560	9,296	250	2,920	0
Lafayette	4,094	36	276	56	268	0	298	1,490	558	0	164	0
Madison	7,282	0	1,186	0	0	978	163	104	0	0	0	0
Morehouse	46,277	0	2,530	2,070	0	4,168	12,503	0	0	8,335	4,168	0
Natchitoches	3,350	0	1,500	0	0	0	0	400	100	0	450	0
Ouachita	7,564	0	4,142	0	0	0	0	1,441	0	0	0	0
Pt. Coupee	2,743	0	0	0	0	0	0	1,180	0	0	0	0
Rapides	11,184	0	0	0	0	6,459	0	2,230	1,675	0	0	0
Richland	7,291	250	667	0	735	32	853	527	0	1,200	40	0
St. Landry	26,457	0	1,194	133	3,518	4,262	2,745	7,470	2,919	0	1,542	0
St. Martin	4,123	0	0	0	360	1,342	0	1,705	0	0	323	0
Tensas	2,918	0	0	0	603	950	0	0	205	220	0	0
Vermilion	41,055	191	2,681	447	390	2,181	4,516	16,821	8,267	0	1,408	469
West Carroll	3,450	0	0	220	0	0	1,000	900	100	0	900	0
2009 Total	**456,277**	**3,520**	**40,813**	**6,996**	**15,721**	**36,236**	**39,992**	**116,864**	**43,609**	**15,664**	**30,163**	**7,022**
2009 Percent	**100.00%**	**0.77%**	**8.94%**	**1.53%**	**3.45%**	**7.94%**	**8.76%**	**25.61%**	**9.56%**	**3.43%**	**6.61%**	**1.54%**

[1] Other varieties: Hidalgo, Sabine, Trenasse, Wells, XL 723 and Jazzman.

2009 LOUISIANA RICE ACREAGE SUMMARY (Continued)

	2009	LONG GRAIN				
Parish	Acreage	CLXL745	Cocodrie	Cypress	XP746	Other[1]
Acadia	79,434	2,868	6,672	3,002	400	1,667
Allen	13,036	500	1,150	1,208	0	0
Avoyelles	12,764	1,0446	447	0	168	125
Beauregard	1,827	535	0	0	100	0
Bossier	12	0	12	0	0	0
Caddo	0	0	0	0	0	0
Calcasieu	12,407	0	0	0	0	0
Caldwell	1,400	0	0	140	0	0
Cameron	9,137	3,045	0	0	0	0
Catahoula	8,858	0	323	0	0	0
Concordia	16,144	800	656	0	0	0
East Carroll	8,826	0	3,442	0	0	1,765
Evangeline	42,424	5,100	8,410	0	3,520	400
Franklin	3,134	928	0	0	0	928
Iberia	540	0	50	0	0	110
Jeff Davis	78,566	2,855	6,640	2,988	573	2,550
Lafayette	4,094	160	520	268	0	0
Madison	7,282	0	4,363	0	0	488
Morehouse	46,277	6,251	3,334	0	0	2,918
Natchitoches	3,350	450	0	0	0	450
Ouachita	7,564	0	900	0	0	1,081
Pt. Coupee	2,743	450	0	0	0	1,113
Rapides	11,184	0	0	0	0	800
Richland	7,291	0	1,082	0	154	1,751
St. Landry	26,457	781	1,005	727	94	67
St. Martin	4,123	158	0	0	0	235
Tensas	2,918	0	760	0	0	180
Vermilion	41,055	1,371	534	852	856	71
West Carroll	3,450	0	330	0	0	0
2009 Total	**456,277**	**27,298**	**40,630**	**9,185**	**5,865**	**16,699**
2009 Percent	**100.00%**	**5.98%**	**8.90%**	**2.01%**	**1.29%**	**3.66%**

[1] Other varieties: Hidalgo, Sabine, Trenasse, Wells, XL 723 and Jazzman.

2008 Mississippi Rice Acreage Survey

County	Clearfield 161	Clearfield 171-AR	Clearfield XL 729	Clearfield XL 730	Cocodrie	Hidalgo	Francis	Sabine	Wells	XL 723	Other[1]	2008 Acreage	2007 Acreage
Bolivar	15,433	19,815	3,171	700	26,011	0	0	0	625	376	736	66,867	52,076
Coahoma	100	865	400	250	10,750	0	0	0	650	0	300	13,315	9,473
DeSoto	100	0	200	0	1,700	0	0	0	0	0	0	2,000	643
Grenada	200	0	0	0	200	0	0	0	0	0	0	400	0
Humphreys	165	345	1,450	70	1,140	0	0	130	0	0	0	3,300	3,240
Issaquena	574	1,146	0	0	65	0	0	0	0	0	0	1,785	902
Leflore	1,290	6,155	0	250	6,570	0	0	0	0	0	1,410	15,675	17,138
Panola	0	0	0	0	3,832	0	0	0	200	0	0	4,032	5,060
Quitman	2,318	3,881	0	1,093	10,495	0	377	0	678	0	0	18,842	11,858
Sharkey	0	0	0	0	511	0	0	338	0	0	0	849	2,535
Sunflower	6,000	4,000	500	500	22,000	0	0	0	0	0	255	33,255	27,300
Tallahatchie	1,542	1,386	771	154	9,249	0	1,542	771	0	0	0	15,415	9,694
Tunica	4,050	0	2,700	0	15,750	0	0	0	0	0	0	22,500	22,776
Washington	4,690	5,220	1,000	250	14,280	0	0	760	0	0	0	26,200	25,464
2008 Total Acres	36,462	42,813	10,192	3,267	122,553	0	1,919	1,999	2,153	376	2,701	224,435	
2008 Percent	16.2	19.1	4.5	1.5	54.6	0.0	0.9	0.9	1.0	0.2	1.2	100	
2007 Total Acres	15,204	0[2]	6,645	1,272	123,169	240	3,608	4,815	10,121	10,051	864		181,262
2007 Percent	8.4	0.0	3.7	0.7	68.0	0.1	2.0	2.7	5.6	5.5	0.5		100

[1] **Other includes : Clearfield XL 745, XL 744, Clearfield 131, Clearfield 151, Cheniere**

[2] **Does not mean this variety was not grown in 2007. It was placed in the Other category due to a limited amount of acres planted.**

Data collected by County Directors/Area Extension Agents and compiled by Dr. Nathan Buehring, Rice Specialist.

2009 Mississippi Rice Acreage Survey

County	Clearfield 131	Clearfield 151	Clearfield XL 729	Clearfield XL 745	Cocodrie	Cheniere	Bowman	Sabine	Wells	XL 723	Other[1]	2009 Acreage	2008 Acreage
Bolivar	20,900	27,800	0	0	20,200	0	1,100	0		0	2,000	72,000	66,867
Coahoma	4,950	3,410	1,580	1,250	5,500	0	0	0	620	1,320	0	18,630	13,315
DeSoto	400	0	0	0	459	0	0	0	0	0	0	859	2,000
Grenada	0	100	0	0	100	0	0	0	0	0	0	200	400
Humphreys	203	203	0	406	1,624	812	812	0	0	0	0	4,060	3,300
Issaquena	460	0	0	0	1,253	0	0	0	0	0	0	1,713	1,785
Leflore	3,000	6,325	0	0	4,975	2,350	875	0	0	0	0	17,525	15,675
Panola	750	0	0	0	3,750	0	300	0	0	0	0	4,800	4,032
Quitman	1,460	6,670	285	0	8,540	0	1,980	0	715	0	765	20,415	18,842
Sharkey	360	420	0	0	890	0	0	130	0	0	0	1,800	849
Sunflower	3,000	3,000	3,000	3,000	22,000	4,000	268	0	0	0	0	38,268	33,255
Tallahatchie	1,408	1,267	1,408	141	8,448	0	0	1,408	0	0	0	14,080	15,415
Tunica	3,538	7,184	4,169	2,459	5,328	0	617	0	0	2,372	0	25,667	22,500
Washington	8,300	9,500	0	0	11,030	0	0	0	0	0	800	29,630	26,200
2009 Total Acres	48,729	65,879	10,442	7,256	94,097	7,162	5,952	1,538	1,335	3,692	3,565	249,647	
2009 Percent	19.5	26.4	4.2	2.9	37.7	2.9	2.4	0.6	0.5	1.5	1.4	100	
2008 Total Acres	0[2]	0[2]	10,192	3,267	122,553	0[2]	0[2]	1,999	2,153	376	2,701		224,435
2008 Percent	0.0	0.0	4.5	1.5	54.6	0.0	0.0	0.9	1.0	0.2	1.2		100

[1] **Other includes : Clearfield XL 745, XL 744, Clearfield 161, Clearfield 171, Cheniere**

[2] **Does not mean this variety was not grown in 2008. It was placed in the Other category due to a limited amount of acres planted.**

Data collected by County Directors/Area Extension Agents and compiled by Dr. Nathan Buehring, Rice Specialist.

Missouri Rice Acreage

	2004	2005	2006	2007	2008
Total Acres	193,666	213,999	212,174	175,791	191,398
% Change	24.3	11	-0.85	-17.1	8.9
Total Acre Change	37,857	20,332	-1,824	-36,384	15,607

2008 Texas Rice Acreage by Variety (Acreage)

Variety Acres By County												
COUNTY	2008	LONG GRAIN										
	ACREAGE	COCODRIE	PRESIDIO	CL171	CL161	CL151	DIXIEBELLE	CHENIERE	XP744	XL723	XL729	MILAGRO
East Zone												
Brazoria	14833	0	0	0	4747	6526	0	0	0	0	0	0
Chambers	13048	1735	4175	3262	0	0	0	0	0	0	104	3419
Galveston	654	654	0	0	0	0	0	0	0	0	0	0
Hardin	950	0	0	0	0	0	0	0	0	0	0	0
Jefferson	15641	0	0	5474	5474	0	0	0	0	0	0	0
Liberty	7579	0	1038	872	0	0	0	0	1554	887	1789	0
Orange		0	0	0	0	0	0	0	0	0	0	0
E. Total	**52705**	**2433**	**5310**	**9784**	**10408**	**6646**	**0**	**0**	**1582**	**903**	**1928**	**3482**
Northwest Zone												
Austin	959	959	0	0	0	0	0	0	0	0	0	0
Colorado	30776	20374	831	2554	1262	0	0	1262	708	554	154	0
Fort Bend	4358	2946	449	0	0	0	0	0	113	322	527	0
Harris	395	0	0	0	0	0	0	0	0	0	0	0
Lavaca	1255	592	0	0	0	0	0	284	0	0	0	0
Robertson	200	0	0	0	0	0	0	0	0	0	0	0
Waller	6508	1881	0	280	0	0	0	0	1562	1015	664	0
Wharton	38699	18382	3792	1122	1122	0	5379	2515		77	348	77
Lamar	203	0	0	0	0	0	0	0	0	0	0	0
NW. Total	**83353**	**45354**	**5097**	**3975**	**2396**	**0**	**5405**	**4081**	**2395**	**1979**	**1701**	**77**
Southwest Zone												
Calhoun	2803	841	1682	0	0	0	0	0	0	0	0	0
Jackson	9519	5721	209	400	133	0	0	2132	0	0	0	0
Matagorda	17979	7389	6113	36	0	0	1133	90	0	917	0	0
Victoria	1081	540	0	0	0	0	0	0	0	0	0	0
Cameron	30	0	0	0	0	0	0	0	0	0	0	0
SW. Total	**31412**	**14506**	**8012**	**436**	**133**	**0**	**1134**	**2224**	**0**	**918**	**0**	**0**
Northeast Zone												
Bowie	569	0	0	0	0	0	0	0	0	0	0	0
Hopkins	0	0	0	0	0	0	0	0	0	0	0	0
Red River	200	0	0	0	0	0	0	0	150	50	0	0
NE. Total	**569**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**111**	**37**	**0**	**0**
State Total	**168039**	**62455**	**18420**	**14195**	**12828**	**6572**	**6558**	**6328**	**4116**	**3850**	**3611**	**3521**

2008 Texas Rice Acreage by Variety (Acreage)

Variety Acres By County												
COUNTY	2008	LONG GRAIN									MEDIUM	
	ACREAGE	CLXL7 30	CLXL 745	CL131	SIERRA	TRENASSE	WELLS	CYBONNET	XP729	CLXP730	BENGAL	OTHER
East Zone												
Brazoria	14833			1780								1780
Chambers	13048	352										
Galveston	654											
Hardin	950											
Jefferson	15641				1564						3128	
Liberty	7579	227	1213									
Orange												
E. Total	**52705**	**591**	**1235**	**1813**	**1593**						**3185**	**1813**
Northwest Zone												
Austin	959											
Colorado	30776	1539	154			277			62			1046
Fort Bend	4358											
Harris	395							395				
Lavaca	1255											379
Robertson	200											
Waller	6508		664									442
Wharton	38699	542	39			194	194		155	155		4605
Lamar	203											
NW. Total	**83353**	**2091**	**860**			**472**	**195**	**397**	**217**	**156**		**6505**
Southwest Zone												
Calhoun	2803											280
Jackson	9519	266				324	162		48			124
Matagorda	17979					539			36			1726
Victoria	1081											540
Cameron	30											
SW. Total	**31412**	**266**				**864**	**162**		**84**			**2673**
Northeast Zone												
Bowie	569						569					
Hopkins	0											
Red River	200											
NE. Total	**569**						**569**					
State Total	**168039**	**2948**	**2084**	**1793**	**1575**	**1343**	**931**	**398**	**302**	**156**	**3150**	**11001**

2009 Texas Rice Acreage by Variety (Acreage)

Variety Acres By County											
COUNTY	2009	LONG GRAIN									
	ACREAGE	COCODRIE	CL151	PRESIDIO	XL723	CHENIER	MILAGRO	CLXL745	XP729	XL729	CATAHOULA
East Zone											
Brazoria	14,833	0	0	0	0	0	0	0	0	0	
Chambers	1,262	0	0	0	0	0	0	1,262	0	0	0
Galveston	1,527	0	0	0	0	0	0	0	0	0	0
Hardin	460	0	0	0	0	0	0	0	0	0	0
Jefferson	13,749	0	10,559	1,842	0	0	0	0	0	0	0
Liberty	7,227	0	1,077	0	0	0	0	5,868	0	0	0
Orange	0	0	0	0	0	0	0	0	0	0	0
E. Total	**40,677**	**0**	**21,278**	**3,368**	**0**	**0**	**0**	**13,038**	**0**	**0**	**0**
Northwest Zone											
Austin	1,036	1,036	0	0	0	0	0	0	0	0	0
Colorado	31,587	5,496	5,717	5,022	8,149	2,969	979	1,958	0	190	315
Fort Bend	5,589	2,403	1,537	458	1,140	0	0	0	0	0	45
Harris	395	0	0	0	0	0	0	0	0	0	0
Lavaca	1,057	654	0	0	0	403	0	0	0	0	0
Robertson	0	0	0	0	0	0	0	0	0	0	0
Waller	6,379	740	555	51	2,035	0	0	383	1,824	364	0
Wharton	43,064	5,728	7,192	7,795	2,747	6,201	8,699	1,120	0	0	0
Lamar	215	0	0	0	0	0	0	0	0	0	0
NW. Total	**88,927**	**16,117**	**15,057**	**13,376**	**15,128**	**9,609**	**9,714**	**3,474**	**1,831**	**555**	**362**
Southwest Zone											
Calhoun	2,154	1,331	0	0	823	0	0	0	0	0	0
Jackson	11,350	3,314	647	1,589	556	1,339	692	465	0	636	647
Matagorda	24,594	16,134	0	4,107	0	2,730	1,377	0	0	0	0
Victoria	1,622	0	0	0	0	0	0	0	0	0	0
Cameron	0	0	0	0	0	0	0	0	0	0	0
SW. Total	**39,869**	**21,731**	**677**	**5,957**	**1,442**	**4,255**	**2,165**	**486**	**0**	**665**	**677**
Northeast Zone											
Bowie	517	0	0	0	0	0	0	0	0	0	0
Hopkins	0	0	0	0	0	0	0	0	0	0	0
Red River	210	0	0	0	210	0	0	0	0	0	0
NE. Total	**727**	**0**	**0**	**0**	**149**	**0**	**0**	**0**	**0**	**0**	**0**
State Total	**169,990**	**41,832**	**30,984**	**23,695**	**18,919**	**15,492**	**13,341**	**12,555**	**2,071**	**1,350**	**1,145**

RECOMMENDATIONS OF THE PANELS

BREEDING, GENETICS, AND CYTOGENETICS

D.G. KANTER, Chair; W.G. YAN, Chair - Elect (2012); H. AGRAMA; S.N. AHN; M.L. ALI; V. ANDAYA; D.H. BEIGHLEY; H. BOCKELMAN; N. CHOU; Q.R. CHU; G.C. EIZENGA; E. FLOREZ; R.S. S. GAKHAL; J.W. GIBBONS; J.H. HAM; E. HEFFNER; S. HUNG; Y. JIA; Y. JIANG; F. JODARI; S. LEE; W. LI; G. LIU; A. LORENCE; D. MACKILL; J. MANN; A.M. MCCLUNG; K. MCKENZIE; K. MOLDENHAUR; F. MOLINO; J. MWATHI; B.R.R. NALLAMILLI; A. NOBLE; J.H. OARD; S.R.M. PINSON; S.O.PB. SAMONTE; B. SCHEFFLER; X.Y. SHA; Q. SHAO; A. STIVERS; R.E. TABIEN; T.H. TAI; H.S. UTOMO; E. WAFULA; Y. WANG; I. WENEFRIDA; L.T. WILSON; B. WOODRUFF; F. XIE; W.G. YAN; Z. YAN; G. YELTATZIE; G.M. ZAUNBRECHER; and J. ZHANG; Participants.

Cooperation of rice breeders and geneticists with pathologists, physiologists, cereal chemists, soil scientists, agronomists, entomologists, and weed scientists is essential in developing superior cultivars that will afford maximum and stable production of rice desired by consumers. Much of this progress is dependent on coordinated research to develop improved methodologies. The close working relationship maintained with all segments of the rice industry should be strengthened wherever possible, including consideration of the newest recommendations of the other RTWG panels.

Present research and development should be continued or new research development initiated in the following areas:

Genetics

Additional information is needed on the mode of inheritance of economically important characters. Phenotypic and genetic associations among such characters should be determined. Basic research is needed to determine the factors influencing pollination and fertilization over a wide range of plant environments. Efforts should be made to incorporate the cytoplasmic and nuclear genetic elements necessary for hybrid rice production into germplasm that is well adapted to the respective rice growing areas. Also, information on the economics of hybrid rice seed production is needed. Genetic control of efficiency of solar energy conversion, including photosynthetic efficiency, respiration losses, translocation rates, source-sink relationships, plant morphology, chlorophyll characteristics, etc., must be explored to determine if such factors can benefit the development of superior yielding cultivars. Particularly in rice production areas along the Gulf Coast, improving ratoon crop yield potential is very important to the profitability of producers. Understanding the genetic, epigenetic, physiological, morphological, and environmental factors that influence ratoon crop yield is important for cultivar improvement. Genetic stocks and new rice accessions that have current or as-yet-unanticipated value should be preserved by entering them into the newly established Genetic Stocks - Oryza (GSOR) collection or the USDA Germplasm Resources Information Network (GRIN). Materials in the GSOR will be accessible through GRIN and will be freely available to all interested researchers.

Molecular Genetics and Genetic Engineering

Molecular genetic studies have accelerated rapidly in rice due to the favorable qualities of this species, including its small genome size, ease of transformation, and availability of genome sequence information. Molecular markers, such as RFLPs, RAPDs, AFLPs, microsatellites, and SNPs, have been used to map loci controlling economically important traits. This knowledge should be extended to public and private breeders for application in marker-assisted selection schemes. Public user-friendly databases should be created, maintained, and updated for the ongoing advance of this science. The technology should be applied to mapping the traits listed above that have not been studied. Particular attention needs to be focused on developing markers relevant to U.S. breeding efforts. Genetic engineering is considered an emerging tool that will complement traditional methods for germplasm and cultivar development. Genes for herbicide, insect, and disease resistance and nutritional quality are being isolated and transferred to elite lines for field evaluation. Rice breeders should cooperate with molecular biologists for proper evaluation and selection of transgenic lines that would benefit the rice producers. When available, genes for increased yield, grain quality, disease resistance, and stress tolerance should be transferred into elite lines or directly into commercial cultivars.

Response to Environment and Changing Climate

Superior-yielding, widely adapted cultivars need to be developed that have increased tolerance to low soil, water, and air temperatures; greater tolerance to extremes in temperatures during flowering and grain filling stages that reduce grain and milling yields; greater tolerance to saline or alkaline conditions; plant types with the capability of maximizing light energy use, express higher metabolic efficiencies; and possess increased water use efficiency. However, because of the geographical and climatic diversity among rice-producing areas in the United States, a need still exists to develop cultivars for specific areas. New cultivars and advanced experimental lines should be tested for reaction or response to registered/experimental pesticides which may be widely used in weed, disease, or insect control in order to determine whether they are tolerant or susceptible.

Resistance to Diseases and Insects

Intensive studies are required to develop cultivars resistant to economically important diseases and insects. Breeding for increased resistance to all known fungus races responsible for rice diseases blast (*Magnaporthe oryzae*), sheath blight (*Rhizoctonia solani*), aggregate sheath spot (*Rhizoctonia oryzae sativae*), and stem rot (*Sclerotium oryzae*) should be emphasized with the objective of obtaining highly resistant cultivars within all maturity groups and grain types. Efforts should be made to develop cultivars with greater field resistance to brown spot (*Bipolaris oryzae*), kerned smut (*Neovossia horrid*), false smut (*Ustilaginoidea virens*), the water mold complex (*Achlya and Pythium* spp.), sheath rot (*Sarocladium oryzae*), narrow brown leaf spot (*Cercospora janseana*), bacterial panicle blight (*Buckholderia glumae*), bakanae (*Gibberella fujikuroi*), leaf scald, leaf smut, "pecky rice", and the physiological disease straighthead should be continued. A continuing emphasis on germplasm resources for resistance to these diseases in various cultural systems is needed. Breeding for insect resistance to rice water weevil (*Lissorhoptrus oryzophilus* (Kuschel)), rice stink bug (*Oebalus pugnax* (Fabricius)), grape colaspis, sugarcane borer (*Didatrea saccharalis* (F.), Mexican rice borer (*Eoreima loftini* (Dyar), and stored grain insects is also encouraged.

***Oryza* Species**

Other species of *Oryza* may contain the needed resistance to important diseases, insects, and environmental stresses as well as grain cereal/chemical qualities that have been lost during domestication of *O. sativa*. Evaluation of these species and the transfer of desirable factors into commercial cultivars should be pursued. As germplasm lines are recovered from interspecific crosses, their cooperative evaluation for diseases resistance, insect resistance, and other traits important in commercial production would be essential for their application to U.S. rice industry. Data from these evaluations should be entered in GRIN/GRAMENE.

Fertilizer Response

Factors that determine fertilizer response and lodging resistance and affect yield components are closely associated in determining total production and quality of grain. These factors must be studied collectively in order to understand the effects of quality, quantity, and timing of fertilizer applications on plant growth and yield components. Efforts should be made to develop cultivars with enhanced fertilizer use efficiency.

Milling, Processing, Cooking, and Nutritional Characteristics

Basic studies are needed to learn more about the role of each constituent of the rice kernel in processing, cooking behavior, nutritional value, health benefits. As these properties and more clearly delineated, new techniques, including bioassays, should be developed to evaluate breeding lines for these factors. These studies should be coordinated with attempts to genetically improve grain quality factors, including translucency, head rice yields, protein content, mineral composition, cooking properties, and resistant starch. There is increased interest in developing rice cultivars to target specialty markets, such as soft cooking rice, aromatics, waxy types, Basmati types, and Japanese premium quality rice. Research efforts need to be directed toward determining quality traits associated with various specialty rice varieties, analytical methods for evaluation, genetic variability, influence of environmental variables on character expression, and factors associated with consumer acceptance.

Cultivar Performance and Seed Source of Cultivars and Superior Breeding Materials

Rice breeders are responsible for obtaining and making available information on performance of rice cultivars and elite germplasm stocks. They also are responsible for maintaining breeder seed of recommended cultivars developed by public agencies. In addition, they must ascertain that stocks of superior breeding material are developed and maintained. Wide germplasm bases are needed and must be maintained for sustainable food production by increasing genetic diversity and decreasing production vulnerability. All breeders and geneticists must make continuing efforts to preserve and broaden the world collection of rice. In order to enhance the rapid use of rice plant introductions and the exchange of pertinent information, we must work with those responsible for plant introduction, description, and dissemination of rice accessions and pertinent data. Increased efforts are also needed to evaluate and maintain all entries in the active, working collection and to enter all descriptive data into GRIN, the USDA Rice World Collection public data base.

Germplasm Evaluation and Enhancement

Efforts should be made to develop relatively adapted, broad-based gene pools having a diversity of phenotypic and genotypic traits based on genetic understanding of the World Collection. Characteristics include components required for increasing yields of cultivars and/or hybrids, such as straw strength, seed size, panicle size, seed set, and panicle number per plant. Other useful characteristics such as bioenergy production from rice by-products may be incorporated into existing or new gene pools as appropriate when such germplasm is identified during evaluation efforts. Genetic male sterility and/or gametocides that are essential for hybrid rice may facilitate these efforts. Development of indica germplasm with high yield and grain quality standards similar to U.S. cultivars should be pursued. The core strategy is an effective way to evaluate large germplasm collections phenotypically and genetically. A core subset of about 10% of the USDA Rice World Collection has been established which provides a workable size for genetic structure analysis and a rich gene pool for valuable gene exploration. Comprehensive evaluations of the core subset for phenotypic descriptors and with DNA markers should be pursued by cooperative federal, state, and industry efforts.

Training of New Rice Breeders

There is concern about the decreasing numbers of students interested in pursuing degrees in plant breeding. Who will replace the current and retiring U.S. rice researchers in the future? New efforts to develop and train our next generation of scientists at all levels need to be undertaken. In addition to developing rice germplasm and knowledge, all rice researchers, but especially breeders and geneticists, are encouraged to interact with the public at many levels, educating students from kindergarten through Ph.D. levels about these fields of research and encouraging students to enter them. Interest in molecular genetics is currently high. That, combined with the fact that rice has served as a genetic model for other crops, the geneticist pool is presently larger than the pool for breeders. Interaction with K-12 students, teachers, science curriculum coordinators, and advisors is strongly urged as a means to encourage students to select plant breeding related fields of study for their college degrees. Interaction with undergraduate students will be required to encourage them to continue their studies with higher degrees to become knowledgeable breeders and geneticists. In addition, breeders must know both the theoretical issues of field design and the practical issues of field set-up and must have an understanding of environmental interactions and genotype response. Students from the B.S. through the Ph.D. levels should be encouraged to gain both laboratory and field training. Changes in college degree requirements may be required to adequately prepare the next generation of plant breeders and genetics.

ECONOMICS AND MARKETING

S. MARTIN, Chair; B. WATKINS, Chair-Elect (2012); M. AMBOARASOA; K. BALDWIN; E. CHAVEZ; N. CHILDS; M. DELIBERTO; A. DURAND-MORAT; H. DJUNAIDI; L. FALCONER; J. HIGNIGHT; G. KNAPEK; P. LAKKAKULA; Q. LU; R. MANE; J. RAULSTON; J. OUTLAW; M. SALASSI; M. SHARP; J. THOMPSON; E. WAILES; and B. WATKINS; Participants.

Supply/Production Research

Investigate water use practices in various rice-producing regions and estimate the costs to producers of compliance with proposed EPA water use and quality regulations.

Identify factors accounting for differences in cost of production by state and region.

Evaluate and measure economic impacts of environmental and recreational costs and benefits associated with rice production.

Make economic comparisons of alternative land tenure arrangements and respective returns to landowners, tenants, and water-lords.

Make economic evaluations of alternative enterprises at a component of rice farming systems.

Policy, Demand, and Marketing Research

Evaluate potential impacts of the current round of WTO on global rice trade and the competitiveness of the U.S. rice industry.

Develop a full export-import trade matrix for international rice by grain type and quality.

Evaluate the performance of the rough rice futures market.

Evaluate how changing markets impact the structure of the rice industry from farm level to retail.

PLANT PROTECTION

T. ALLEN, Chair; C. ROTHROCK, Chair-Elect (2012); J. BERNHARDT; B. BLACKMAN; L. ESPINO; K. FOTHERGILL; L. GODFREY; E. GOLDMAN; D. GROTH; J. HAMM; S. HINO; N. HUMMEL; S.K. LANKA; R. LASSITER; A. MESZAROS; A. MILLER; J. SIDHU; M. STOUT; K. TINDELL; S. UOE; and M.O. WAY; Participants.

Diseases

The principal objectives of basic and applied rice disease research in the United States include more complete understanding of molecular mechanisms of pathogenesis of the pathogen, host resistance to rice pathogens, and the ultimate control of the diseases. Ultimately, an effective and integrated disease management program relying on resistance, cultural practices, and chemical control based on cooperative research with scientists in agronomy, entomology, and weed science should be striven for. If future advances are made in the understanding and application in biological or molecular-genetic control aspects, these factors should be developed and included in the program.

Major yield and quality diseases in the United States causing damage to the rice crop each year currently include sheath blight, caused by *Thanatephorus cucumeris* (A.B. Frank) Donk (anamorph: *Rhizoctonia solani* Kühn); stem rot, caused by *Magnaporthe salvinii* (Cattaneo) R. Krause & Webster (synanamorphs: *Sclerotium oryzae* Cattaneo, *Nakataea sigmoidae* (Cavara) K. Hara); blast, caused by *Pyricularia grisea* Sacc. = *P. oryzae* Cavara (teleomorph: *Magnaporthe grisea* (Hebert) Barr); kernel smut, caused by *Tilletia barclayana* (Bref.) Sacc. & Syd. in Sacc. = *Neovossia horrida* (Takah.) Padwick & A. Khan; and bacterial panicle blight, caused by *Burkholderia glumae* Kurita & Tabei. Seed rot and seedling diseases continue to be major stand establishment problems in both water- and dry-seeded systems, especially with the trend to earlier planting dates. In water-seeded systems, *Achlya* and *Pythium* spp. are important while *Pythium*, *Rhizoctonia,* and possibly *Bipolaris*, *Fusarium*, and other fungi have been considered important in dry-seeded rice in the South. The role of seedborne *Pyricularia* and *Burkholderia* in stand establishment and later epidemics should continue to be investigated. Straighthead, a physiological disease, remains a major problem in certain areas.

Diseases that are more locally important include narrow brown leaf spot, caused by *Cercospora janseana* (Racib.) O. Const. = *C. oryzae* Miyake (teleomorph: *Sphaerulina oryzina* K. Hara); aggregate sheath spot, caused by *Ceratobasidium oryzae-sativae* Gunnell & Webster (anamorph: *Rhizoctonia oryzae-sativae* (Sawada) Mordue); brown spot, caused by *Cochliobolus miyabeanus* (Ito & Kuribayashi) Drechs. ex Dastur (anamorph: *Bipolaris oryzae* (Breda de Haan) Shoemaker); false smut, caused by *Ustilaginoidea virens* (Cooke) Takah.; crown sheath rot, caused by *Gaeumannomyces graminis* (Sacc.) Arx & D. Olivier; and bakanae, caused by *Gibberella fujikuroi* Sawada Wollenworth *(anamorph: Fusarium fujikuroi* Nirenberg = *F. moniliforme* J. Sheld.). White tip, a nematode disease of rice caused by *Aphelenchoides besseyi* Christie, remains an economic constraint to rice exports in the southern United States although direct yield and quality losses in the field remain minor. Peck of rice, caused by a poorly defined complex of fungi and possibly other microbes in concert with rice stinkbug feeding, remains a problem in certain areas and years.

Currently, minor diseases include leaf scald, caused by *Microdochium oryzae* (Hashioka & Yokogi) Samuels & I.C. Hallett = *Rhynchosporium oryzae* Hashioka & Yokogi; sheath rot caused by *Sarocladium oryzae* (Sawada) W. Gams & D. Hawksworth = *Acrocylindrium oryzae* Sawada; stackburn disease, caused by *Alternaria padwickii* (Ganguly) M.B. Ellis; sheath spot caused by *Rhizoctonia oryzae* Ryker & Gooch; and leaf smut, caused by *Entyloma oryzae* Syd. & P. Syd. A minor and confusing strain of *Xanthomonas* caused symptoms on rice in the early 1990s in part of Texas and Louisiana. Originally identified as a weakly virulent strain of *Xanthomonas oryzae* Ishiyama pv. *oryzae* Swings, the cause of bacterial leaf blight in other parts of the world, recent information suggests this strain differs from XOO. More definitive molecular research is needed to separate these strains.

Miscellaneous diseases and problems of currently unknown causes are scattered in the rice growing regions of the United States and include an unidentified crown rotting disease, forms of hydrogen sulfide toxicity (autumn decline), eyespot disease, sheath blotch, white leaf streak, undefined leaf bronzing, and various grain-spotting problems.

Areas in which research should be continued or initiated concerning the following:

1. Systematic and coordinated field monitoring and diagnostics should be established and continued long-term in the various rice states to detect new pathogens or changes in existing ones. Yearly surveys should be conducted to support existing and future research and extension programs, including breeding efforts.

2. The cooperative testing and breeding program with rice breeders should be continued for the development of improved disease-resistant rice varieties. Newly released varieties should be fully evaluated for reaction to the recent field isolates. In addition, screening programs should endeavor to locate new germplasm with high degrees of resistance to major and developing diseases while susceptibility to other problems should be monitored. Straighthead testing should continue and cooperative regional or area testing should be encouraged.

3. A comprehensive testing program focused on new and existing chemical therapeutic control options should be continued with regional coordination encouraged. A better understanding of efficacy and economic return under realistic field conditions should be emphasized in the future, in addition to inoculated efficacy trials. The discovery and development of improved scouting and detection methods and decision thresholds should be continued. Measurement of crop loss to various diseases under different conditions should be encouraged.

4. Genetic and chemical control options should be researched for early planted rice to improve the reliability of stand establishment and survival each year.

5. Research on the molecular genetics of host/parasite interactions, including molecular characterization of the pathogen isolates, and their interaction mechanisms with rice in U.S. rice and the use of molecular genetics and biotechnology, including genetic engineering, molecular-assisted breeding, and biotechnology-based tools to improve disease control should be a high priority.

6. Research on the effects of cultural practices on disease incidence and severity and the interaction of rice soil fertility (mineral nutrition) and other soil factors in disease severity should be continued and increased.

7. Given the failure of the current system of importation and quarantine of rice germplasm to allow rapid and orderly dissemination and usage of exotic rice germplasm for U.S. breeding programs, additional funding should be sought to research and implement a more workable but safe system. While existing federal quarantine procedures are effective and warranted, the United States needs to fund enough personnel and facilities to make them practical – a situation that does not currently exist.

8. Molecular characterization of virulent blast isolates IE1k in commercial fields and on the weakly virulent bacterial strains, originally reported as XOO in Texas and Louisiana, should be conducted to characterize and identify them.

9. Additional disease research should be conducted on hybrid rice, niche varieties, and organic systems to provide workable management recommendations for current and future producers.

10. Cooperative research on the interaction of disease with water stress (limited irrigation water), salt, and other environmental stress should be encouraged as these problems increase in certain areas.

Insects and Other Animal Pests

We have attempted to point out research areas that are concerned with immediate and long-term problems. No attempts have been made to place recommendations in order of importance.

Investigations should include the use of biological agents, cultural practices, resistant varieties, and other methods that might be integrated with chemical control to provide the most effective economical and safe way to manage insect and related pests attacking rice.

The major insect pests that damage the seed or rice plants between planting and harvesting are the rice water weevil, *Lissorhoptrus oryzophilus* Kuschel; rice stink bug, *Oebalus pugnax* (Fabricius); grape colaspis, *Colaspis brunnea* (Fabricius); stem borers, *Diatraea saccharalis* (Fabricius), *Eoreuma loftini* (Dyar), and *Chilo plejadellus* Zincken; rice leaf miner, *Hydrellia griseola* (Fallen); South American rice miner, *Hydrellia wirthi* Korytkowski; armyworm, *Pseudaletia unipuncta* (Haworth); fall armyworm, *Spodoptera frugiperda* (JE Smith); chinch bug, *Blissus leucopterus leucopterus* (Say); various species of leaf and plant hoppers; numerous grasshopper species (Locustidae and Tettigoniidae); midge larvae (Chironomidae); greenbug, *Schizaphis graminum* (Rondani); bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus.); rice root aphid, *Rhopalosiphum rufiabdominalis* Sasaki; western yellowstriped armyworm, *Spodoptera praefica* (Grote); yellow sugarcane aphid, *Sipha flava* (Forbes); and an exotic stink bug, *Oebalus ypsilongriseus* (DeGeer), found in Florida. Pests other than insects can damage rice directly or indirectly. *Triops longicaudatus* (LeConte), the tadpole shrimp, causes seedling drift by dislodging loosely rooted seedlings while feeding on the leaves and roots. Crayfish, *Procambarus clarkii* (Girard), damage irrigation systems by burrowing and also reduce stand establishment by feeding on germinating seeds and small seedlings. Birds trample and feed on seeds and sprouting and ripening rice. Rodents, through their burrowing activity, damage levees and directly feed on rice plants.

Specific recommendations include the following:

1. Continue studies on the biology and ecology of rice insects, especially in relation to the influence of cropping and management practices, such as water management, fertilization, and varietal changes on rice pests and their natural enemies.

2. Conduct studies on interactions between insects and other stresses (both biotic and abiotic) on plant growth and development.

3. Continue research on chemical control compounds and determine their a) efficacy, b) effect on nontarget organisms, c) compatibility with other agricultural chemicals, d) relationship between dosages and mortality, and e) proper timing, application, and formulation.

4. Monitor the potential of pests to become resistant to chemicals used in pest control programs.

5. Determine the role of natural enemies and pathogens, individually and collectively, in reducing rice pest populations.

6. Continue interdisciplinary cooperation with rice breeders and plant pathologists to evaluate and identify rice lines for resistance to insects and/or disease problems.

7. Encourage and assist in the development of genetically engineered rice plants for pest control.

8. Determine economic levels and improve and standardize methods of sampling for possible use in systems-approach, pest management programs.

9. Monitor rice for possible introduction of exotic pests.

10. Identify and assess bird and rodent damage and develop management programs that are cost effective and environmentally safe.

POSTHARVEST QUALITY, UTILIZATION, AND NUTRITION

E. CHAMPAGNE, Chair; R. BRYANT, Chair-Elect (2012); K. BETT-GARBER; M. CHEN; K. DAIGLE; C. GRIMM; J. LEA; Z. PAN; J. PATINDOL; S. PINSON; F. SHIH; T. SIEBENMORGEN; and J. STEWART; Participants.

Our group is concerned with the processing, storage, and quality of rice. We believe research is needed in the following areas:

Website: Varietal Database
Breeding stations in the mid-south and gulf coast (CA has already completed this effort) would post data for released varieties, including parentage, amylose content, milling yield, grain weight, alkali number, sensory, and functional data, etc.

Rice Harvesting, Drying, Storage, and Handling
Correlate environmental factors (temperature, humidity) at harvest to physical, chemical, and functional properties of the rice kernel.

Develop new and/or improved rice drying, storage, and handling systems to impart desirable functional properties, improve efficiency, and reduce energy use.

Incorporate economic factors into post-harvest models and guidelines for harvesting, drying, and storage recommendations.

Develop sensors to rapidly and objectively monitor rice properties.

Evaluate alternatives to chemical fumigants for grain and facility treatment.

Develop biological and other non-chemical pest-control measures using parasites, predators, and micro-organisms.

Determine mechanisms for head rice loss when rice is transferred.

Milling Characteristics
Determine the physicochemical properties of rice varieties and milling conditions that contribute to optimizing milling performance based on degree of milling.

Determine the nature of defective or fissured grains that survive processing and their effect on the end use processing.

Develop sensors to rapidly determine and objectively predict milling quality (constrained by degree of milling) for U.S. and international varieties.

Incorporate laboratory research into industry practice. Validate methods and identify performance levels.

Processing, Quality, and Cooking Characteristics
Develop instrumental methods for screening lots and evaluations of perspective new varieties for processing quality.

Study the correlations of 'functional amylose' to processing and cooking properties.

Determine the basic relationship between composition, molecular structure, physical state, and end-use performance (flavor, texture, processing properties, storage stability, etc.).

Determine impact of genetic, environmental, and processing factors on sensory properties, functionality, kernel size and property uniformity, and storage stability.

Improve inspection methods for measuring chemical constituents and quality factors.

Develop identity preservation and detection techniques for genetically modified and transgenic rice.

Utilization of Rice Components
Develop effective, cost-efficient methods for fractionating rice components (e.g., starch, protein, oil, and fiber).

Identify applications for rice components (i.e. starch, protein) in native and modified forms.

Study the genetic mechanisms controlling amounts and compositions of components that might have significant economical and nutritional value (e.g., oil, brain, phytochemicals, etc.).

Characterize bioactive components in varieties in regards to physicochemical and functional properties. Measure the amount of these bioactive components in various varieties.

Develop non-food uses for rice, rice hulls and ash, straw, bran, and protein.

Nutrition and Food Safety
Promote the health benefits of rice and develop rice products and constituents that promote human and animal health.

Evaluate the bioavailability of rice components, specifically nutraceuticals, and investigate the levels required to generate responses in humans and animals. Investigate the effects of processing, and storage conditions on microbial loads in rice for improved food safety.

RICE CULTURE

D. HARRELL, Chair; N. SLATON, Chair-Elect (2012); R. DeLONG; P. FITTS; D. FRIZZELL; B. GOLDEN; J. HILL; D. JONES; W. JUNG; R. LOEPPERT; R. MAZZANTI; G. McCAULEY; R. NORMAN; T. ROBERTS; J. SAMFORD; G. STEVENS; E. VORIES; T. WALKER; C. WILSON; Participants.

The panel on rice culture reaffirms the value of the meeting in (1) reviewing the research already completed, (2) facilitating the exchange of information, (3) developing cooperative research on problems of mutual interest, and (4) in directing the attention of proper authorities to further work that should be undertaken. Under various research categories represented by this panel, the following continuing research needs are specified:

Cultural Practices
Evaluate rotation systems that involve rice.

Determine the effects of water management, fertilization, and water-use efficiency on grain yield and quality.

Identify factors that cause poor stand establishment and develop practices that will ameliorate these conditions.

Develop conservation tillage practices for efficient production of rice under water-seeded and dry-seeded systems, including "stale" seedbed management.

Expand research on crop residue management, including soil incorporation, collection, and economic uses.

Study management systems that enhance ratoon production.

Evaluate aquaculture rotation systems that involve rice, such as but not limited to crawfish/rice rotations.

Explore crop establishment, including planting methods and geometry, plant density, seeding date, and other factors necessary to characterize BMPs for various cultivars of interest.

Evaluate the use of harvest aid chemicals in rice production.

Develop cultural practices to minimize potential detrimental environmental impacts on rice quality.

Fertilizers and Soils
Develop a greater understanding of the chemical, physical, and physicochemical changes that occur in flooded soils and their influence on the growth of rice, nutrient transformations, and continued productivity of the soil.

Study nutrient transformations, biological nitrogen fixation, and fertilizer management systems in wetland soils, especially as related to soil pH.

Develop soil and plant analysis techniques for evaluation of the nutrient supply capacity of soils and the nutritional status of rice to enhance the formulation of fertilizer recommendations.

Cooperate with plant breeders, physiologists, and soil researchers to develop techniques for efficient utilization of nutrients.

In cooperation with other disciplines, study the interactions among cultivars, soil fertility, diseases, weeds, insects, climate, and water management.

Develop integrated systems to more efficiently utilize fertilizer while reducing pesticide use.

Gain a better understanding of silica deficient soils, silica sources, and their effect on rice yield.

Determine the potential use of non-traditional fertilizer sources and additives in rice production.

Physiology
Determine the effects of varying climatic environments on growth, development, and yield of both main and ratoon crops of rice.

Determine the physiological factors related to grain yield and quality and plant growth and development of the main and ratoon crops of rice.

Determine the physiological processes, including root functions, involved in nutrient uptake and utilization in an anoxic environment.

Water
Accurately determine the complete water balance on rice as a function of soil textural groups, regions, time within the irrigation season, rice growth stage, and meteorological parameters.

Determine the impact of sub-optimal water availability at various physiological stages on dry matter accumulation, maturation, grain yield, and grain quality.

Determine optimum water management guidelines for flush-flood, pin-point flood, continuous-flood, and alternative irrigation.

Evaluate the effect of water conservation practices, such as underground pipe and/or flexible polyethylene pipe, land forming, multiple inlets, reduced levee intervals, and lateral maintenance on water use.

Continue to evaluate water quality in terms of salinity and alkalinity and its effect on rice productivity.

Evaluate water use as related to water loss and evapotranspiration.

Environmental Quality
Determine the effect of various management systems on changes in the quality of water used in rice production. Monitoring should include all water quality parameters, such as nutrient inputs, suspended and/or dissolved solids, organic matter, etc.

Determine the fate of agricultural inputs in the soil, water, and plant continuum as related to varying rice cropping systems. This information should be applied to minimize losses from the field and reduce any attendant environmental degradation associated with such losses and in the development of Nutrient Management Plans.

Assess the relationship between greenhouse gasses, global climatic change, and rice production and evaluate the magnitude of potential environmental effects of gaseous losses from rice fields.

Assess the relationships of global climactic change and rice production.

Engineering Systems
Study energy inputs in rice production and harvesting.

Expand investigations to improve equipment for proper and efficacious applications of seed and fertilizers.

Analyze and improve harvesting practices to assure maximum recovery of top quality grain through timeliness of harvest and harvester adjustments by cultivar and climatic zone.

Determine ways to use the Global Positioning System and Geographic Information System to aid rice research and reduce rice production cost.

Rice System Modeling
Encourage development of rice models and expert systems that enhance our knowledge of rice development, aid in diagnosing problem situations, and provide decision support for growers.

Determine the effects of cultural and chemical practices used in rice-based cropping systems on species demography and dynamics.

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RICE WEED CONTROL AND GROWTH REGULATION

J.A. BOND, Chair; R.C. SCOTT, Chair-Elect (2012); C. ALLEN; B. AUGUSTINE; F. BALDWIN; R. BOND; L. BOYD; E. CAMARGO; B. COURVILLE; G. CRANE; G. DANIELS; B. DAVIS; S. DEVILLIER; A.B. DOWDY; A. ELLIS; T. FLOWERS; B.D. FONTENOT; J. FORD; B. GUICE; J. HARDEN; J. HENSLEY; B. KILLEN; M. KURTZ; R. LASSITER; J.R. LEEPER; C. LEON; D. LOGGAINS; J. MAGANA; R. MANN; S. MATTHEWS; E. MCCALLISTER; H. MILLER; N. MILLER; W. MINSON; R. MITCHELL; J. NORSWORTHY; M. POUEDA; A. RHODES; C. SANDOSKI; T. SATTERFIELD; S. SENSEMEN; J. SIEBERT; R. SMITH; B. VEAZEY; M. WALLACE; G. WILLIAMS; J. WILSON; and R. WOOD; Participants.

The overall objective of the Rice Weed Control and Growth Regulation Panel's recommendations is to develop integrated nonchemical and chemical methods with basic biological processes to improve weed control and growth regulation in rice. The categories listed below are separated for the purpose of describing the research areas more specifically.

Chemical Weed Control
Evaluate weed control systems for prevention and management of herbicide-resistant weeds.

Mechanisms of resistance.

Evaluate new chemicals for the control of weeds in rice.

Facilitate label clearance and continued registration for rice herbicides.

Evaluate varietal tolerance to herbicides in cooperation with plant breeders.

Study new and existing herbicides for their fit in conservation tillage in rice-based cropping systems.

Cooperate with environmental toxicologists and others to study the fate of herbicides in the rice environment and their potential to affect non-target organisms.

Cooperate with agricultural engineers and others to study improved application systems.

Study basic processes on the effect of herbicides on growth and physiology of rice and weeds.

Cooperate in the development of herbicide-resistant rice weed control systems.

Establish rotational methods with new chemistries for red rice control to prevent possible outcrossing.

Weed Biology and Ecology

Determine and verify competitive indices for rice weeds to predict yield and quality losses and cost/benefit ratios for weed control practices. Verify yield and quality loss models.

Intensify studies on weed biology and physiology, gene flow, molecular biology, and population genetics.

Survey rice-producing areas to estimate weed infestations and losses due to weeds.

Determine the effects of cultural and chemical practices used in rice-based cropping systems on species demography and dynamics.

Non-Chemical Weed Control

Evaluate the influence of cultural practices, including crop density, fertility and irrigation management, tillage practices, and others, on weed control and production efficiency.

Evaluate the influence of cultural practices on red rice control.

Study methods for the biological control of important rice weeds.

Evaluate rice cultivars for weed suppressive traits.

Growth Regulation

Evaluate the use of growth regulators for areas such as yield enhancement, shortening plant height, increasing seedling vigor, and red rice seedhead suppression in rice.

Study basic biological and physiological processes regulated by applied chemicals.

Facilitate label clearance for growth regulators.

Cooperate with environmental toxicologists and others to study the fate of growth regulators in the rice environment and their potential to affect non-target organisms.

Abstracts of Papers from General Session

Seed Response of Rice to Sub-Lethal Herbicide Rates Applied To Simulate Drift

Hensley, J.B., Webster, E.P., Harrell, D.L., Bond, J.A., Bottoms, S.L., Carlson, T.P., and Fish, J.C.

Four studies were conducted at the Louisiana State University Agricultural Center Rice Research Station near Crowley, Louisiana, to evaluate the effects of simulated herbicide drift on 'Cocodrie' rice. The experimental design was an augmented two-factor factorial arrangement of treatments in a randomized complete block with four replications. Factor A consisted of herbicides being applied at 6.3 and 12.5% of the labeled use rate of 863 g ae/ha of glyphosate, 70 g ai/ha of imazethapyr, 493 g ai/ha of glufosinate, and 44 g ai/ha of imazamox. Factor B consisted of application timings at different growth stages: one-tiller, panicle differentiation (PD), boot, and physiological maturity. Spray volume varied proportionally to herbicide dosage and was 15 L/ha for the 6.3% herbicide rate and 29 L/ha for the 12.5% herbicide rate using 234 L/ha as the target spray volume and were applied with a tractor-mounted CO_2-pressurized sprayer. One-hundred count rice seed weight, seed germination, and seedling vigor were evaluated. Data were evaluated using SAS PROC MIXED.

The germination potential of seed collected from grain harvested in the simulated drift field studies at primary crop harvest, 2005 through 2007, and at ratoon crop harvest, 2005 and 2007, was evaluated at 13, 16, 19, 22, and 25 C. One hundred seeds from each field plot were placed in a Petri dish between two germination blotters with 10 ml of a distilled water plus fungicide solution. Petri dishes were sealed to prevent moisture loss and placed in a constant-temperature growth chamber in total darkness. Germination counts were taken 5, 9, and 14 d after initiation (DAI) of the study. A seed was considered germinated if the radical had reached a length of 1 mm.

Vigor of seedlings from grain collected at primary crop harvest in the simulated glyphosate drift field study in 2006 and 2007 was examined. Seeds were pre-germinated by soaking in distilled water for 24 h. Ten pre-germinated seeds from each field plot were placed along the center of single sheet of moistened germination paper cut to fit a 12 by 23 by 0.3 cm acrylic sheet. Seeds were oriented with the radical end of the seed toward the lower half of the sheet. A one-ply paper towel strip was placed over the seed, and 5 ml of a distilled water plus fungicide solution was applied on top of the strip to reduce seedling diseases. The plated seeds were then placed vertically in a rack and then placed in a glass dish with 1,420 ml of distilled water to allow for evaporation. The dish and racks of plates were wrapped in plastic wrap to prevent desiccation. The glass dish was placed in a growth chamber at 21 C for 12 d in total darkness. At the end of 12 d, shoot lengths were measured and an average of the 10 shoot lengths was obtained for data analysis.

Glyphosate had no effect on primary crop rice seed weight; however, ratoon crop rice seed weight was reduced when glyphosate was applied at boot. Primary crop rice seed germination was reduced at 22 C by glyphosate applied at PD and boot and at 25 C when applied at one-tiller, PD, and boot. Ratoon crop rice seed germination was not reduced. Glyphosate had no effect on primary crop seedling vigor. Imazethapyr applied at boot reduced primary crop rice seed weight. Primary crop rice seed germination was reduced at 19, 22, and 25 C by imazethapyr applied at one-tiller, PD, and boot. Ratoon crop rice seed germination was reduced at 19 and 22 C by imazethapyr applied at the 6.3% rate to rice at PD. Imazethapyr had no effect on primary crop seedling vigor. Glufosinate had no effect on rice seed weight. Regardless of rate, glufosinate reduced primary crop rice seed germination at 19 C and reduced primary crop seedling vigor; however, ratoon crop rice seed germination was not affected. Imazamox had no effect on rice seed weight. Primary crop rice seed germination was reduced by imazamox at 19, 22, and 25 C with the greatest reduction at each temperature resulting from a boot application. Ratoon crop rice seed germination was not affected by imazamox. Primary crop seedling vigor was reduced with imazamox applied at boot.

The germination of seed harvested from susceptible rice plants treated with glyphosate, imazethapyr, glufosinate, and imazamox can be reduced. Therefore, the potential exists for drift of these herbicides to susceptible seed rice fields to reduce the profitability of subsequent crops planted using seed from affected plants due to increased seed cost to compensate for reduced seed germination or replanting due to inadequate rice plant density. Applicators should use caution when applying these herbicides near susceptible seed rice fields.

Water-Savings Using Intermittent Rice Irrigation

Massey, J.H.

For the past 6 years, multiple-inlet plus intermittent rice irrigation has been investigated in Mississippi production fields. These studies have involved predominately the cultivar Cocodrie planted in clay soils following standard pest control and fertility programs. Intermittent irrigation lowers water inputs (a) by reducing over-pumping and (b) by increasing rainfall capture by keeping the rice paddies less than full. Multiple-inlet irrigation uses plastic tubing to (a) improve overall control of the flood and (b) to allow rapid reestablishment of the flood. When coupled together, multiple inlet plus intermittent irrigation reduces water use by up to 50% relative to conventional (continuous) flooding practices. Depending on the producer and growing season, upper paddies can remain less than full from 60 to 100% of the time after flood initiation. As it takes approximately 2.6 liters of diesel fuel (about 29 kilowatt-hrs for an electric system) to pump an acre-inch/acre water from a typical Mississippi Delta well, a 30- to 40-cm reduction in water use per acre can result in measurable energy savings as well. Moreover, water used by multiple-inlet plus intermittent irrigation averaged only about 6% more than zero-grade rice irrigation systems used during this time in Mississippi. Thus, intermittent irrigation is a way to extend the water savings of multiple inlet irrigation to nearly that of zero-grade without the potential drawbacks of zero-grade systems, namely the water-logging of rotational crops such as soybean. To date, rice yields and grain milling quality have been unaffected by the wetting and drying cycles of intermittent irrigation, and current weed control programs appear able to suppress weeds under intermittent irrigation regimes. Participating growers, who have also incorporated manual pump timers and visual flood depth gauges to assist in flood management, indicate that their effort in maintaining the rice flood is less using intermittent irrigation compared with conventional practices. An additional benefit of intermittent irrigation is that non-point source runoff of agrichemicals can be reduced by up to 60%. Thus, water and energy savings and improvements in water quality are some of the benefits to adopting intermittent irrigation.

Field Validation of N-ST*R: A Precision Nitrogen Management Tool for Direct-Seeded, Delayed-Flood Rice

Roberts, T.L., Norman, R.J., Slaton, N.A., Wilson, Jr., C.E., and Fulford, A.M.

In recent years, production agriculture has experienced a wide array of price fluctuations influenced by the instability of the world economy. This extreme market volatility was experienced firsthand by rice producers as the price of urea quadrupled in less than a year's time. Increasing nitrogen (N) fertilizer prices threaten the long-term sustainability of U.S. rice production, and the implementation of a soil-based N test will result in better management of N fertilizer and more profitable rice production, while lowering the potential environmental impacts of rice production. Soil fertility has searched for a soil-based testing method to manage N fertilization in crop production for decades. Current practices rely on soil type, residual inorganic N (NO_3^- and NH_4^+), yield goal, and previous crop to determine N fertilizer recommendations. Many crops, such as corn and rice, require large amounts of N fertilizer when utilizing either a yield-based or soil texture-based fertilizer recommendation. These methods do not take into account the soil N that may become mineralized during the growing season and have no predictive value. Conventional rice production has relied on yield goal estimates for determining N fertilizer needs, which can often lead to over-fertilization of crops and potentially higher impacts on the surrounding environment. Understanding the amount of N that can be supplied by the soil may significantly reduce the amount of N fertilizer required in many fields to obtain maximum rice yields. Implementation of a soil-based N test for rice production will allow N fertilizer recommendations on a field-specific basis and ensure more profitable rice yields while lowering environmental impacts due to excess N.

Researchers at the University of Arkansas have successfully correlated and calibrated a soil-based N test for rice (N-ST*R) using 27 site-years of data collected from N rate trials on experiment stations and producer fields. Successful correlation and calibration was accomplished when the soil was sampled to a depth of 45 cm. Research has also shown that in most situations the standard N recommendation results in over-fertilization, and some producers planting rice after continuous soybean, catfish, or fallow may be able to eliminate N fertilizer applications completely while maximizing yields. Work on the N-ST*R recommendations has lead to the development of three calibration curves, which will prescribe the N fertilizer rate required to achieve 90, 95, and 100% relative grain yield. Utilization of the three N-ST*R calibration curves will allow producers to make management decisions based on their production philosophy and current production costs. Implementation of a soil-based N test will allow site-specific N fertilizer recommendations, thereby avoiding excess N applications and lowering potential environmental impacts, while decreasing the incidence of lodging and disease. Prior to the implementation of this soil-based N test for rice fertilizer recommendations in Arkansas, there are a series of issues that must be addressed and include the validation of the test from a production standpoint, field variability, and the timeframe in which samples must be taken relative to fertilizer application.

A series of small-plot to field-scale experiments are being conducted to validate the N-ST*R calibration and soil sampling protocol. Field validation studies included five N rate treatments and four replications. Nitrogen rate treatments included a check (0 kg N ha^{-1}), standard recommendation for silt loam soils in Arkansas (168 kg N ha^{-1}), and prescription N rates for each field based on the N-ST*R value and the three calibration curves. Using N-ST*R for the 95% relative grain yield goal resulted in N rate recommendations ranging from 50 to 213 kg N ha^{-1}. Yields were compared for the 90, 95 and 100% relative grain yield treatments with the standard recommendation to evaluate the ability of N-ST*R to predict site-specific N rates that would maximize yield. Initial results show that maximal yields could be obtained using the 95 and 100% relative grain yield curves for each of the nine sites investigated. In many cases, the yield obtained using the N rate from 90% relative grain yield calibration curve was not significantly different from the maximal yield for a given location. Success of the N-ST*R program will lead to further validation studies and implementation of strip verification trials in producer fields to gain more data on the ability of N-ST*R to prescribe site-specific N rates and provide a field-scale demonstration of this exciting new management tool.

Multi-State Resistance Monitoring of Rice Stink Bug with a New and Old Insecticide

Miller, A.L.E., Way, M.O., Bernhardt, J., Stout, M.J., and Tindall, K.V.

The rice stink bug, *Oebalus pugnax*, is an important insect pest of rice, *Oryza sativa*. Rice stink bugs are estimated to reduce crop value by $29-54 per hectare. Both adults and nymphs damage rice by piercing the flower resulting in a sterile flower (non-filled seed), removing endosperm from developing seeds (reduced grain weight), and reducing the quality of the grains (pecky rice). Rice stink bugs develop through five instars, but only late instars and adults are considered economically important. They are primarily grass feeders and will go through many generations on grass hosts before moving to rice.

Insecticides are the primary method used for controlling rice stink bugs. Currently, carbaryl, methyl parathion, malathion, *lambda*-cyhalothrin and *zeta*-cypermethrin are registered for rice stink bugs in rice. Of these insecticides, pyrethroids are the most commonly used. Organophosphate insecticides have been reassessed by the EPA for use recently in row crop production and may lose registration due to their toxic properties in the future. Should rice producers lose the currently registered organophosphate and, potentially, carbamate insecticides, they would be left with a single class of insecticides, pyrethroids. This would be devastating for resistance management options for rice stink bugs in rice. Currently, there is *anecdotal* evidence that rice stink bug has developed resistance to pyrethroids. In 2001 and 2002, a LC50 was calculated for rice stink bugs exposed to lambda-cyhalothrin. A LC50 is the concentration of a chemical where 50% of the population is killed following exposure of a given time. Because baseline data were determined for lambda-cyhalothrin in the early 2000's, a comparison can be made to rice stink bugs collected nearly 10 years later.

Additionally a neonicotonoid-like insecticide, dinotefuran, will likely be registered for rice stink bugs on rice in the near future. Recent research has shown that dinotefuran can provide protection for 10 or more days. Because this product is likely to see heavy use, efforts were made to gather baseline data for this insecticide to have data available to conduct resistance monitoring studies in the future.

A multi-state project was initiated to monitor resistance of rice stink bug using lambda-cyhalothrin in rice stink bugs and compare the findings to those collected in 2001 and 2002. Rice stink bugs were collected from Missouri, Arkansas, Texas and Louisiana Additionally, rice stink bug populations were used to gather baseline data for dinotefuran from Texas and Missouri.

The adult vial test was used to subject rice stink bug adults to a range of concentrations of insecticides. This methodology is suitable for determining LC50s for contact insecticides, like pyrethroids. The interior walls of glass scintillation vials were coated with varying concentrations of technical grade insecticide dissolved in HPLC-grade acetone. One adult was placed per vial and mortality was rated after 4 hours of exposure. A stink bug was considered alive, if, when placed on its dorsal side, it was able to right itself.

Dinotefuran needs to be consumed by an insect for best efficacy. Therefore, a method developed for another Hemipteran insect for oral insecticides was modified for rice stink bug. Varying concentrations of insecticide were dissolved in a honey-water solution and provided to rice stink bugs on floral foam. Insects were rated every 24 hours for four days.

Researchers in all states but Texas monitored one population of stink bugs for resistance to lambda-cyhalothrin. Four populations were sampled in Texas. The highest LC50 encountered from all populations was from Round Mott, Texas was 3.51μg/vial; this value is 2.2 times greater than baseline data collected in 2001 and 2002 (0.63 μg/vial). The state average for Texas was 1.4 μg/vial. LC50s for Louisiana, Missouri and Arkansas were 0.86, 0.65, and 0.53 μg/vial, respectively. These data suggest that resistance is developing, but it may be localized to certain areas. Additionally, this implies that poor control in the field may not be due solely to insecticide resistance.

Baseline data for dinotefuran was gathered for rice stink bug populations in Texas and Missouri. The LC50s for Texas and Missouri were 1.03 and 0.54 μg/vial, respectively. These studies will be continued in future years.

Interaction of Rice Varieties and Fungicides under Moderate to Severe Sheath Blight Pressure

Groth, D.E., Dischler, Sr., C.W., and Leonards, L.E.

The development of sheath blight (*Rhizoctonia solani*)-resistant rice cultivars will allow producers to use less fungicide and to avoid significant reductions in grain and milling yields. Among cultivars currently in cultivation in the southern United States rice-producing region, sheath blight resistance levels range from very susceptible to moderately resistant. Rice varieties differ in their susceptibility to sheath blight and also differ in the level of loss within the same susceptibly rating. Disease nurseries and yield loss trials are needed to accurately characterize varietal response to sheath blight. Three studies were conducted in 2008 and 2009 to determine the response of cultivars, with different levels of susceptibility, to sheath blight inoculations or natural inoculum and different fungicide applications to determine the effects of host resistance, fungicide type, and location on sheath blight development, yield, and grain quality.

Sheath blight epidemics in field plots were initiated by inoculation at the panicle differentiation growth stage in 2008 and 2009 at the LSU AgCenter Rice Research Station, Crowley, LA, or from natural infection at Lake Arthur and Fenton, LA, locations. Four varieties, CL151, Cheniere, Neptune, and Catahoula, were treated with four fungicide treatments, unsprayed, Azoxystrobin at 0.16 kg a.i. ha^{-1} (Quadris 9 oz/A), Azoxystrobin at 0.15 kg a.i. ha^{-1} and propiconazole at 0.21 kg a.i. ha^{-1} (Quilt 28 oz/A), and trifloxystrobin at 0.17 kg a.i. ha^{-1} and propiconazole at 0.17 kg a.i. ha^{-1} (Stratego 19 oz/A) were applied applications at mid-boot.

Artificial inoculation and natural inoculum significantly increased sheath blight severity and incidence similarly and caused yield losses of 3% in the moderately resistant Neptune to 13% in the very susceptible cultivar Catahoula. Milling yields were affected to a lesser extent. All of the fungicide treatments effectively reduced sheath blight incidence and severity, regardless of cultivar and location, and returned yield and milling levels to light diseased levels. A single application of either of the three fungicides effectively reduced sheath blight incidence and severity restoring yield and milling to uninoculated levels, regardless of cultivar. There was no significant difference between artificially inoculated trials and naturally infested locations. However, sheath blight severity often tended to be greater in the naturally infested trials probably because of sheath blight infection starting earlier.

In previous studies, in older very susceptible to susceptible cultivars, sheath blight reduced yields by 20 to 60%. In the current very susceptible to very susceptible cultivars studied, yield losses were in the 10 to 15% range. This tolerance to sheath blight damage appears to be caused by the lack of fungal penetration into the culm and subsequent lodging. Because of these differences in yield loss, evaluations need to be continued to effectively evaluate damage to sheath blight in different cultivars in the same susceptibility group. Fortunately, fungicides as single applications were effective in controlling sheath blight and maintaining grain yield and quality on all cultivars under varying disease conditions.

SNP Haplotypes: Unveiling the Truth of Past Relationships

McClung, A.M., Zhao, K., DeClerck, G., Eizenga, G.C., Ali, M.L., Bustamante, C.D., and McCouch, S.R.

Over the last ten years, molecular markers have been widely accepted as a breeding tool for crop improvement. Currently, microsatellite markers are being used in rice to select for several simply inherited traits like components of cooking quality and a number of major genes linked to resistance to blast disease. In addition, markers are used to verify true crosses in a rice breeding program, facilitate selection of true breeding seed sources prior to release of a new cultivar, and fingerprint a cultivar for identity preservation. Markers have been used to survey historical cultivars found in the U.S. rice pedigree and these revealed the inheritance of genes in current cultivars that are identical by descent from landraces originally introduced into the U.S. over a century ago. Funding from USDA AFRI during 2004-2009 for RiceCAP extended the development of microsatellite markers from those linked with simply inherited traits to quantitative trait loci associated with sheath blight resistance and milling quality.

Continued technological advances have resulted in faster throughput and greater marker saturation accompanied by rapidly diminishing costs of genotyping each year. In 2005, as a result of an international research collaboration, the japonica rice variety, Nipponbare, became the first crop genome to be completely sequenced. Subsequently, the indica cultivar 93-11 was sequenced, allowing detailed comparison of the genetic differences between these two representatives of indica and japonica rice; the two major varietal groups which are the basis for most of the commercially grown rice in the world. In 2008, another international collaboration, the OryzaSNP Project, resulted in re-sequencing of 20 world cultivars representing all five sub-populations found in *Oryza sativa*. This data set served as the basis for identification of 1536 single nucleotide polymorphisms (SNP) that were used by our group as part of an NSF funded project on rice diversity to develop an automated SNP assay and evaluate a panel of ~400 diverse *O. sativa* cultivars representing all five sub-populations and 100 *O. rufipogon* accessions. The genome scans revealed large linkage blocks common to each of the sub-populations as well as regions of chromosomal introgression between sub-populations. For example, in the tropical japonica material from the U.S., clear indica introgressions on chromosomes 1 and 12 were observed that were associated with the semidwarf gene (originating from Dee Geo Woo Gen) and the *Pi-ta* blast resistance gene (originating from Tetep), respectively. This information provides breeders with insights into marker assisted selection strategies that will conserve genomic regions or facilitate recombination. The 1536 "SNP chip" was also used in collaboration with the RiceCAP project to evaluate approximately 400 elite cultivars from all of the U.S. rice breeding programs. This analysis demonstrated that U.S. breeding programs each have relatively unique genepools, although some cultivars represent a synthesis of multiple genepools. Such detailed genomic information will be useful to breeders to help identify the best cultivars for crossing to maximize genetic recombination within the relatively narrow U.S. germplasm base. In addition, it can be used "in hindsight" to track how recombination and selection occurred during cultivar development. For example, the 1536 SNP assay was used to compare Cypress and its two parentals, Lemont and L202. It revealed that large portions of chromosome 8 in Cypress were very similar to Lemont, whereas much of chromosome 4 was like L202. In contrast, chromosome 3 in Cypress demonstrated significant recombination between the two parental lines.

Although the 1536 SNP chip provided greater marker saturation than previously available, it also demonstrated that there are large linkage blocks within U.S. germplasm that appear to have no genetic diversity. The NSF project, in collaboration with Affymetrix, developed a custom-designed 44,000 SNP marker array and economical procedure for genotyping of rice samples. Concurrently, RiceCAP, the USA Rice Foundation, and the Mississippi Rice Promotion Board provided funding to re-sequence 14 U.S. cultivars. The re-sequencing effort identified thousands of SNPs that differentiate cultivars within the U.S. genepool and these data are being used to develop customized SNP assays that are tailored for applications in rice improvement using U.S. germplasm. The new, cost effective, high throughput SNP assays will help breeders identify linkages between SNP markers and economically important traits and improve the efficiency of cultivar development in the U.S. As a result of research collaborations that span the globe and bring researchers from the breeding, genomics, and bioinformatics communities together, along with extramural funding opportunities, the U.S. rice research community has been able to actively participate in the development of cutting-edge genomic technologies tailored to applications of interest. The next steps will require on-going development of appropriate marker assays and analysis capacity so that these technologies can be efficiently translated into practical breeding tools for the development of productive new crop varieties.

Abstracts of Papers on Breeding, Genetics, and Cytogenetics
Panel Chair: Dwight G. Kanter

A "Rice Diversity Panel" Evaluated for Genetic and Agro-Morphological Variation between Subpopulations

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Since ancient times, *Indica* and *Japonica* have been recognized as the two major subspecies of Asian rice (*Oryza sativa* L.). First with isozymes and subsequently with DNA markers, five subpopulations *indica*, *aus*, *temperate japonica*, *tropical japonica* and *aromatic/GroupV* were identified. A "Rice Diversity Panel" composed of 409 purified accessions originating from 79 countries was established to explore the genetic and phenotypic diversity within and between these subpopulations. Currently, this diversity panel is being genotyped with an Affymetrix 44K SNP chip with the ultimate aim of conducting an association mapping study for the agronomic, morphological and grain quality traits included in this study.

Phenotypic data were collected from three representative plants of each accession in two replications in the field for characterization during two different years. The accessions were fingerprinted with 36 SSR markers to determine the molecular variation, gene diversity, clustering, and population structure of the diversity panel using the *Arlequin*, *PowerMarker*, and *Structure* software. The Diversity Panel was evaluated for over 40 agro-morphological traits and the grain quality traits, amylose content, protein content, and alkali spreading value (ASV) which is a measure of gelatinization temperature. In addition to the 36 SSRs, the panel also was screened with DNA markers associated with amylose content (RM190 and Intron1) and ASV (*Alk*). Differences between the accessions and subpopulations were assessed based on 18 agro-morphological traits using canonical discriminant analysis (CDA) in the CANDISC procedure (SAS software) and between the pairs of subpopulation group means for the individual traits by t-tests and LSD values using the procedure ANOVA (SAS software).

A total of 330 alleles were detected with an average of 9.17 alleles per locus across all accessions, an average polymorphism information content (PIC) value of 0.63 and gene diversity of 0.68. The accessions clustered into five ancestral groups (subpopulations), *indica* (90 accessions), *aus* (59), *aromatic/Group V* (15), *tropical japonica* (104) and *temperate japonica* (108) based on genetic distance-based clustering and model-based structure analyses. Thirty-three accessions with <60% ancestry from any single group were identified as 'admixtures'. The genetic diversity was higher in the *indica* and *aus* subpopulations than in *aromatic, temperate japonica* or *tropical japonica*.

CDA identified agronomic traits such as, plant height, panicle number per plant, flag leaf width and panicle length, panicle branch number, and grain traits (length, width, weight, and volume) as the main discriminatory characteristics. Both SSR allele- and phenotypic trait-based analyses indicated a close relationship between *aus* and *indica*, and similarly between *temperate* and *tropical japonica*. In addition, both methods agreed that *indica* and *aus* are only distantly related to *temperate* and *tropical japonica* types, supporting the existence of two deeply divided major clades or varietal groups, *Indica* and *Japonica.* The *aromatic* or *GroupV* rice represents a distinct small group that is more closely related to *tropical japonica* based on SSR alleles but to *aus* and *indica* based on phenotype.

Aus had the highest amylose content whereas *temperate japonica* had the lowest. *Aus* had alleles for Intron1 associated with high/intermediate amylose content while 75% of *temperate japonica* had the allele associated with low amylose. Similarly, for RM190, 96% of *aus* had alleles associated with high amylose while 95% of *temperate japonica* had alleles associated with low amylose. *Temperate japonica* and *indica* were classified as having low gelatinization temperatures whereas *aus* and *tropical japonica* had intermediate gelatinization temperatures. Sixty percent of *temperate japonica* had alleles associated with low gelatinization temperature whereas all the *aus* and 88% of *tropical japonica* had alleles for intermediate/high gelatinization temperature.

Results from the association mapping will be presented which should further delineate the population sub-structure, lead to a better understanding of the domestication process and have applications in rice breeding, especially related to hybrid rice. Panicle and seed images and seed stocks will be available through the USDA-ARS Genetic Stocks-*ORyza* collection (Dale Bumpers National Rice Research Center, Stuttgart, Arkansas) and seed stocks through the International Rice Research Institute (Philippines) upon completion of this project.

OsMADS6 Subjected to Epigenetic Regulation and Plays an Essential Role in Flower Development and Endosperm Nutrient Accumulation in Rice (*Oryza sativa*)

Zhang, J. and Peng, Z.

MADS-box transcript factors play an essential role plant growth and development and are highly conserved among plants. Employing DNA oligo microarray technique, we found that OsMADS6 gene, one of the two AGL6-like MADS-box genes in rice, was highly expressed in endosperm compared with vegetative tissues (Unpublished results, Peng). RNA in-situ hybridization results also showed that strongest expression of Osmads6 was detected in young embryo. Meanwhile, strong Osmads6 signal was detected in young endosperms, particularly in the aleurone layer. The expression pattern in endosperm extended to the later stage of the endosperm development with the signals slightly reduced. The expression pattern of Osmads6 suggested a possible role of the gene in endosperm development or endosperm metabolism.

Therefore, we carried out a detailed phenotypic study of Osmads6 by using the T-DNA knock-out mutant *Osmads6-1*. In addition to the flower organ identity change, we observed several interesting phenotype in seeds development as well. In grain-filling stage, almost 90% of the *Osmads6-1*seeds were sterile with dark brown color in the hull. But noticeably, we found that about 32% of the grains were aborted after pollination, indicating the metabolism in *Osmads6-1* was retarded. The fertile grains were deformed in shape. The shape of harvested mutant seeds changed from elliptical into more roundish. The *Osmads6-1* mature seed length was 7.3mm on average while the Wt seed length was 7.76mm. Meanwhile, *Osmads6-1* seeds are about 15.8% wider than the Wt seeds. The defects in flower and seed development leaded to a very low mature seed setting rate (10%) of *Osmads6-1* while 66.4% of the Wt spikelets produced fertile seeds under our growth condition in the winter.

Due to the seed color and shape change in the mutants, we tested if the nutrient content in the well developed mature seeds was affected in *Osmads6-1*. We measured crude protein, total starch, crude fiber and ether extract content. Interestingly, the *Osmads6-1* protein content increased from 12.1% to 15.0% ($P<0.05$). In contrast, the total starch content was significantly decreased ($P<0.01$). Meanwhile, the fiber and ether extract content kept the same as Wt seeds ($P>0.05$). Although we did not measure other nutrient content such as iron and vitamins, some of them must have changed because the total content should be 100%.

Since Osmads6 displayed a time and spatial-specific expression pattern and involved in the regulation of nutrient accumulation and endosperm development, in which epigenetic regulation is well reported, we tested if OsMADS6 was also subjected to epigenetic regulation. We employed chromatin immunoprecipitation followed by PCR amplification (ChIP-PCR) of short OsMADS DNA fragments to check the histone modification status within Osmads6 genomic DNA. H3K27me3 often act as a suppressing epigenetic marker in plant cells whereas the H3K36me3 is frequently used as a gene activation marker and both are highly abundant modifications in plant histones. We tested the association of these two modifications with OSMADS6 DNA using ChIP-PCR in five different tissues, including suspension cells, roots, leaves, developing seeds and flowers. Osmads6 was highly expressed in flowers and developing seeds, but not in suspension cells, leaves and roots. When equal amount of H3K27me3 ChIP DNA was used as template for PCR, a strong PCR band was detected in suspension cells, leaves and roots; a very weak band was detected in developing seeds; but no band was detected in flowers. In contrast, when equal amount of H3K36me3 ChIP DNA was used for PCR, we detected a sharp band in flowers, a distinct band in developing seeds, and no bands in suspension cells, roots, and leaves. Our results suggested that in highly expressed tissues, Osmads6 was associated with H3K36me3 and in suppressed tissues Osmads6 was associated with H3K27me3.

In summary, Osmads6 is epigenetically regulated by H3K27me3 and H3K36me3; the high gene expression profile of OsMADS6 gene in endosperm tissues was consistent with the nutrition content change in OsMADS6 mutants. OsMADS6 mutants display substantial protein content increase, starch content decrease and seed size and shape change, suggesting that it can be a potential target for seed nutrition improvement via genetic engineering.

Enzyme Responses to Nighttime Air Temperatures during Rice Kernel Development

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High night temperatures have been shown to lower head rice yields. A study was conducted to more fully understand the underlying reasons for this. Kernel physicochemical properties largely determine rice quality and functional properties. Starch is formed in the grain-filling process that begins with sucrose and ends with the finished starch granule. There are seven enzyme steps in the pathway from sucrose to starch. These enzymes are affected by environmental conditions during grain filling. Soluble starch synthase (SSS) is partially deactivated at high temperatures in wheat and maize; the objective of this study was to determine if this was true in rice.

A controlled temperature experiment was conducted at RiceTec, Inc. facilities at Alvin, Texas. Rice plants were grown in a greenhouse until the R5 stage of development (at least one caryopsis on the main stem panicle expanding within the hull). At that point (R5) plants were matched by size and stage of development, assigned to one of four phytotrons with each phytotron set at a different nighttime temperature treatment, and further randomly assigned to a location within each of four beds in each phytotron. Plants were then moved into the phytotrons. The treatments were night temperatures of 18, 22, 26 and 30ºC. The cultivars were Cypress, LaGrue, Bengal, M204, XL8 and XP710. Panicles were sampled between the R6 and R7 growth stages for the plant in such a way as to maximize the number of individual kernels at the active filling stage of development (R6 - expanded caryopsis to the tip of the hull). Three panicles per replication were placed on ice and stored at -80 º C. Afterwards, the individual R6 kernels were removed from the panicle, dehulled and had the aleurone layer removed. These kernels were ground in liquid nitrogen, extracted with buffer, centrifuged and the supernatants were assayed for the enzymes. Five enzymes were assayed: sucrose synthase, UDP-glucose pyrophosphorylase, starch synthase, starch branching enzyme and starch debranching enzyme.

Significant responses to night temperature and cultivar were found for four of the enzymes but the most dramatic responses were for SSS. The SSS activities were significantly affected by temperature and cultivar and by a cultivar by temperature interactions. The enzyme activity response to nighttime temperature can be characterized as (1) an expected temperature optimum for enzyme activity for LaGrue, Cypress and M204 at 22ºC, (2) an optimum response to temperature for Bengal at 26º C, and (3) little change between 18 and 22ºC for XL8 and XP710 and a decrease as night temperatures increased between 22 and 30ºC. Others have found similar quadratic responses for maize and wheat to those we found for LaGrue, Cypress, M204 and Bengal. The SSS builds the amylopectin molecules glucose unit by glucose unit. This enzyme has been reported to have a lower temperature optimum than other enzymes in the grain filling process. The significant temperature by variety interaction is promising for development of varieties that are insensitive to high night temperature stress. Of particular interest in this regard, is the higher temperature optimum for Bengal relative to the other cultivars. The responses of the hybrids were also noteworthy, in that both XL8 and XP710 responded to night temperature differently from the other cultivars in the test. It would appear that selection for improved rice yield and quality could result from effectively manipulating SSS in the rice grain.

There appear to be four or five isoforms of starch synthase present in filling rice endosperm tissue. The relevant genes for starch synthase in rice endosperm during grain filling have been identified. RNA was extracted from tissue from the same grain samples described above. From this tissue, RNA was extracted and real-time, RT-PCR analyses were done. For Bengal and LaGrue, expression of all four isoforms above appeared to be unchanged in response to night temperatures. For Cypress and M-204, expression of starch synthase isoforms seems to have been reduced by the highest night temperature (30 ºC) compared to cooler temperatures. This work will be exploited to find genetic sources of resistance to high night temperature stress.

Genetic Diversity for Cold Tolerance at Germination in the U.S. Rice Collection

McClung, A.M., Gibbons, J.W., Duke, S., Yan, Z., Nelms, A.M., and Yan, W.

Rice production practices are constantly being modified as a result of the availability of new technologies and the changing economic picture. Farmers are planting rice at least one month earlier than a decade ago. With increasing interest in alternative cropping systems, minimum tillage, and water conservation, there is a need to develop rice cultivars that have improved seed germination and vigor under the cold temperatures that can exist during early spring plantings. Such cultivars will have improved stand establishment and will better compete with weeds at a time when herbicides are not as effective. In addition, cultivars that have improved vigor under cold temperatures will allow harvest earlier in the season, thus reducing irrigation demands during late summer.

The objectives of this study were to survey rice germplasm to identify accessions with improved seedling vigor under cold temperatures and, ultimately, to identify genetic markers linked to this trait that can be used by breeders for varietal improvement. We screened some 2600 rice accessions including 1685 diverse cultivars in the USDA "Core" collection, 823 accessions from "Temperate" regions, 69 UAR "Breeding" lines, and 41 "Genetic Stocks" and mapping parents. Seed for accessions in each of these categories were produced in the same environment. Some 400 accessions were common to the Core (produced in 2007 and stored at 4 C) and Temperate (produced in 1999 and stored at 4 C) groups allowing us to evaluate the impact of seed source (production year and storage) on vigor. Each accession was evaluated for germination in growth chambers using thirty seed and three replicates at 12C and two replicates at 26C. Each seedlot was cleaned, sterilized with 10% Chlorox, and seed were placed on paper towels that were uniformly moistened then sealed prior to being placed into the growth chamber. Percent germination was determined approximately 7 days after initiation for the warm treatment and following 30 days of the cold treatment. The accessions were compared to repeated checks Quilla 66304 (PI 560281) (70% germination at 12C), Lemont (48%), and Zhe 733 (40%). Initial results demonstrated that cold temperature germination for the accessions ranged from 0 to 100%.

Results identified 590 cultivars (23% of the accessions) that were equal to or better than Quilla 66304 for cold germination. Accession 89-5 (PI 614993) originating from Sichuan, China had plant and grain quality traits comparable to southern U.S. long grains along with 79% germination under cold temperatures. Significant difference was observed due to seed source (1999 vs 2007) for both warm and cold germination treatments but there were no consistent trends indicating that seed source can be a confounding factor. Within the Core and Temperate groups, 31 cultivars were identified that had >90% germination at 12C. These originated from countries in both tropical and temperate climates. On-going analysis will include an association mapping study using 70 SSR markers that have been determined on accessions in the Core group and a correlation analysis of plant phenotype with cold germination and vigor.

Progress on Re-Sequencing and Data Analysis of Rice Germplasm

Scheffler, B., Farmer, A., and May, G.

Progress on re-sequencing and data analysis of U.S. rice cultivars and RiceCAP mapping parents will be presented. Data analysis includes SNP (Single Nucleotide Polymorphisms) detection. The web based interface of the SNP data aligned to the reference genome (Nipponbare) will also be introduced as a prelude to a special planned within the RTWG framework. The workshop will provide U.S. rice researchers the necessary working knowledge to utilize the re-sequencing data for their own research programs. Visualization of data may help breeders understand the strengths and weaknesses of U.S. cultivars in relation to their breeding programs and U.S. rice production.

Purification of a Polycomb Complex and Examination of Its Role in Seed Development in Rice (*Oryza sativa*)

Nallamilli, B.R.R. and Peng, Z.

Polycomb complexes in *Arabidopsis* have been shown to suppress endosperm development before fertilization. Mutations in polycomb group genes lead to endosperm development without fertilization in *Arabidopsis*. To study the role of these complexes in rice, we purified a polycomb protein complex using a tandem affinity purification method. Histone methyltranferase activity assay showed that the purified complex was an active protein complex. The subunits of the purified protein complex were identified using mass spectrometry analysis. The biological function of the complex in rice seed development was examined by generating overexpression lines of subunit FIE2. The *FIE2* overexpression plants produced smaller seeds, suggesting a role in repressing endosperm development. The transgenic seeds also displayed some changes in nutrition contents.

Seed Dormancy Genes Map-Based Cloned from Weedy Rice and Their Applications

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Seed dormancy distributes germination over time to promote the survival of wild species in adverse environments and contributes to the persistence of weeds in agro-ecosystems. Domestication of cereal crops from wild relatives has reduced seed dormancy from cultivars to synchronize germination. We developed weedy rice as a model system to elucidate genetic, evolutionary, and physiological mechanisms directly regulating natural variation of seed dormancy in the grass (Poaceae) family. Weedy rice, which is also known as "red rice" because of red pericarp color, is greatly divergent in seed dormancy from cultivated rice in our collections. Ten quantitative trait loci (QTL) were identified from the cross between a wild-like weedy and a cultivated rice line. The weedy and cultivar parents contribute dormancy-enhancing alleles to 8 and 2 of the 10 loci, respectively, suggesting that a vast majority (~80%) of dormancy genes have been eliminated from cultivars during domestication and breeding. A dormancy QTL on the short arm of chromosome 7 (*qSD7-1*) was map-based cloned as a bHLH-containing transcription factor (TF). This gene also has pleiotropic effects on red pericarp color, seed weight, abscisic acid (ABA) accumulation in developing seeds, and salinity tolerance of seedlings. Transcriptomic analysis revealed that this TF activates five genes of the proanthocyanidin biosynthetic pathway to express red pigmentation in the lower epidermal cell layer and up-regulates expression of genes of the ABA biosynthetic pathways to induce primary seed dormancy. The major dormancy QTL on the long arm of chromosome 12 (*qSD12*) was narrowed to a genomic region of three predicted genes, which are being characterized for genomic and genic structures and tissue-specific expression profile. Our research indicates that natural selection for "red rice" is due to the *SD7-1* TF's pleiotropic effects on multiple adaptive traits and this dormancy gene cannot be used to manipulate germinability for white grain-colored varieties. We are introducing the *qSD12* dormancy allele into male sterility and maintainer lines of hybrid rice to improve their resistance to pre-harvest sprouting. Based on the genomic information of the two QTL underlying genes, we are developing strategies to identify their orthologs from wheat and to reduce the risk of transgene flow from cultivated into weedy rice.

Nutritional Value of Rice and Current Research Efforts to Enhance Grain Protein Content among Louisiana Lines

Wenefrida, I., Utomo, H.S., and Linscombe, S.D.

Future market driven by nutrigenomics may require significant improvement of nutritional values for each food product. Advanced applications of human genome will produce individual dietary recommendations for nutrition and personal health and, therefore, will create new specific demand. Current preventive life styles provide an indication of potential future consumers. Emerging rice-based products, such as rice milk, high-protein rice flour and rice whole grain cereals, are examples of potential products for markets that emphasize the nutritional quality of rice. As a rich source of natural dietary energy, rice is also a good source of thiamine, riboflavin, and niacin. Un-milled (brown) rice contains a significant amount of dietary fiber. Rice bran is a natural source of dietary fiber, vitamins, minerals, specific oils (γ-oryzanol), and some disease-fighting phytochemicals. Our research objective was to improve protein content of rice.

Over 2,000 new lines have been developed from Louisiana cultivars and germplasm lines. Crude protein contents as high as 14.51% were found among new entries derived from the cultivar Cocodrie. The highest protein content found among new entries derived from the cultivar Cypress was 14.2%. Typical protein contents in varieties Cocodrie and Cypress are between 7 to 8.5%. A total of 183 lines developed from Cypress exhibits protein contents ranging from 10.5 to 14.2%. Seventeen lines have crude protein contents of 12.5 to 14.2%, 72 lines have 11.5 to 12.4%, and 94 lines with protein contents between 10.5 and 11.4%. Seventy-nine lines developed from Cocodrie have crude protein contents between 10.5 and 14.5%. Among these, 16 lines have protein contents of 12.5 to 14.5%, 23 lines have 11.5 to 12.4%, and 40 lines show protein contents of 10.5 to 11.4%.

Base on its amino acid profiles, the highest amino acid increase in a Cocodrie-derived line HP-1570 was in arginine (48.22%). The lowest increase (17.41%) was in the methionine content. An average increase of 33.21% was observed in the lysine content. Lysine is synthesized through a branch of the Asp family pathway that also leads to the synthesis of two additional essential amino acids, methionine and threonine. HP-1570 showed an increase of 17.41 and 34.50% for methionine and threonine, respectively. The lysine biosynthetic branch is strongly regulated by a feedback inhibition loop in which lysine inhibits the activity of dihydrodipicolinate synthase (DHDPS), the first enzyme specifically committed to lysine biosynthesis.

Some high protein lines exhibit chalkiness. Seed storage proteins are packaged and stored in organelles called protein bodies (PB). Glutelins and globulins are stored in a vacuolar compartment (PB II), and prolamins are in endoplasmic reticulum (ER)-derived PB I. Rice storage proteins are composed of approximately 5% prolamins (alcohol soluble), 15% albumins (water soluble) and globulins (saline soluble), and 80% glutelins (residue). Different compartmentalization of storage protein may cause the alteration of grain quality in some high protein lines exhibiting chalkiness.

High protein research was also focused on determining the stability of the trait across growing seasons. Important production traits including yield, plant height, milling quality, grain quality, length of time from seeding to maturity, resistance to lodging, and seedling vigor are a part of selection criteria to advance high protein lines. Improved protein content provides a foundation for producing high nutritive value varieties that could potentially be used to support functional food.

Molecular Characteristics of High Rice Grain Protein Content and Potential Marker Development

Utomo, H.S., Wenefrida, I., Groth, D.E., and Linscombe, S.D.

Protein content is an important part of nutritional values of rice. Various approaches have been used to increase grain protein content and improve essential amino acid compositions in grain crops. Among them are induced mutations to improve protein content in general or enhance amino acids of a specific target, transgene technology to alternative biochemical pathways causing elevated accumulation of grain protein content, and molecular breeding and map-based cloning to maximize the use of natural genetic variation to improve protein content in the breeding process. The objectives of this study were to (1) conduct molecular characterization of high protein lines through their sequence differences of the dihydrodipicolinate synthase (DHDPS) gene and (2) develop marker profiles, QTL mapping of major gene loci, and high protein rice lines.

DHDPS gene sequence of eight high protein rice lines that have a significant increase in lysine and threonine contents show two polymorphic regions that could attribute to their elevated levels of these two essential amino acids in the grain. The differences in the nucleotide sequence cause the alteration of amino acid residues within the DHDPS gene. Such alteration may decrease its sensitivity to the feedback inhibition, causing significant accumulation of these two amino acids.

Four separate crosses were made between four high protein lines and breeding lines. Following an initial cross, two backcrosses and self pollination of BCF1 plants were conducted. The means of BC2F2 family were used in QTL identification for a high protein trait. Five major QTLs have been identified to contribute to high levels protein content. The progression of backcross families has facilitated gene fine mapping. Candidate markers for high protein content together with other important agronomic traits were identified using bulk-segregant analysis. The availability of DNA markers identified from this specific crossing scheme could provide a molecular frame work for systematic accumulation of favorable alleles of target and could be directly used to assist the direction and progression of elite line development. By employing specific parental lines in the initial crosses, this approach may be used for cultivar development that is supported by integrated marker utilization within the scope of the breeding platform.

Early Generation Selection for Rice Fissure Resistance Proves Effective and Indicates a Fissure Resistance Gene on Chromosome 1

Pinson, S.R.M., Jia, Y., and Gibbons, J.

Whole rice kernels have two to three times more market value than brokens, which means that any reduction in milling yield results in financial losses for both rice producers and millers. One of the leading causes of reduced milling yield is exposure of the rice kernels to severe moisture changes before or after harvest which causes them to fissure. 'Cypress', a southern U.S. variety released in 1993, is known for its resistance to kernel fissuring, but is not grown widely today, having been replaced with cultivars having higher yield potential and disease resistance. While breeders would like to incorporate Cypress' fissure resistance into improved cultivars, their efforts have been limited due to a lack of methods for identifying and selecting for fissure-resistance in early breeding generations. A laboratory method wherein small samples of seed are evaluated for fissure rates after controlled rewetting has proven to reliably identify fissure resistance among pure-breeding material grown in several replicated environments. The present study was conducted to determine if this laboratory evaluation method could be use to accomplish early generation breeding selections, which be limited to small amounts of heterogeneous seed obtained from unreplicated F_2 and F_3 progeny plants. To measure the efficacy of this laboratory method as a selection tool, we used it to conduct divergent selection for fissure resistance (FR) and susceptibility (FS) among F_2 and F_3 plants, then evaluated the success of the selections using F_3 and F_4 progeny testing. The amount of phenotypic change accomplished with a round of selection is known as "Realized Heritability".

Laboratory Selection Method: Seed samples of 50 dried kernels each were evaluated for rates of kernel fissuring after exposure to controlled levels of fissure-inducing humidity. The relative humidity of the air around the seed samples was controlled by using a growth chamber to provide a 45 (+/- 1) ^{O}C air temperature outside of a closed-box system containing seed samples suspended over a layer of water. Dried seed samples were first held in a controlled environment for 14 days to allow their grain moistures to equilibrate, then were pretreated with 45 (+/- 1) ^{O}C dry heat for 0 to 4 hours before placing them in the high-humidity boxes. The humidity within the sealed boxes was documented to reach 100% RH within 60 minutes after sealing. Forty seed samples were placed at a time in each sealed box, and two boxes were run in synchrony. Critical to the success of this evaluation method is the use of seed that is fully mature but not overmature so as to ensure that it is not already field-fissured. We accomplished this by hand harvesting mature seed from the upper portions of panicles when they were completely straw colored, and had dried to the point that the seed were seen to pull away from the hulls, giving them a dry, papery appearance. The widely-spaced F_2 plants tillered profusely and exhibited a wide range in heading time among panicles per plant. The ideally mature seed was hand-harvested from the tips of the earliest panicles, without waiting for later panicles to mature. Seed was dried gently using forced unheated air, to prevent causing post-harvest fissures. The response of rice kernels to the laboratory fissure-induction system was known to vary depending on the source or growing conditions of the seed to be studied. The lengths of the dry 45^{O}C heat pre-treatments ranged from 0 to 4 hours, and length of the humidity exposure periods ranged from 8 to 16 hours, as they were adjusted for each field replication. Additional amounts of seed of the Cypress and LaGrue check varieties were collected from each field study in order to determine these optimum lab-fissuring conditions for each set of seed studied.

In 2006, seed was harvested from 312 Cypress (FisR) x LaGrue (FisS) F_2 plants grown in the field and interspersed with multiple replicates of parental single-plant plots. Progeny from the 10% most FisR and FisS F_2s were planted as replicated F_3 families in TX and AR in 2007. FisS $F_{2:3}$ progeny fissured twice as much as FisR progeny, with an average response to selection of 13.5%. Response to F_3 selection was smaller, averaging 2.6%. Broad-sense heritability averaged 0.38 +/- 0.13 over all generations. Narrow-sense heritabilities (h^2) were 0.47 and 0.54 for the FisR and FisS F_2 selections, respectively, and smaller thereafter due to the reduced response to F_3 selection. The laboratory fissure-evaluation system proved to be a successful breeding selection tool in that the FisR and FisS parents identified in one generation proved produced progeny that retained these fissuring differences. This study documented, for the first time ever, successful early-generation selection for FisR, opening new opportunity for breeders to develop rice cultivars improved for this important agronomic trait.

During the course of selecting for FisR and FisS F_3 families and individuals, an association between FisR and Cypress' *sd1* allele was detected. All of the most FisR F_2 and F_3 plants proved to be homozygous *sd1*, while the progeny of the FisS visibly segregated *Sd1Sd1*, *sd1sd1*, and *Sd1sd1*. This indicates that *sd1* on chromosome 1 is linked to a FisR gene is one of multiple genes required for rice to be as highly FisR as Cypress. To map additional FisR genes, molecular characterization of the divergent FisR and FisS progeny populations is being pursued.

New Marker Development for the Rice Blast Resistance Gene *Pi-km*

Costanzo, S. and Jia, Y.

The blast resistance (*R*) gene *Pi-km* protects rice against specific races of the fungal pathogen *Magnaporthe oryzae*. The use of blast *R* genes remains the most cost-effective method of disease control. To facilitate the breeding process, we developed a *Pi-km* specific molecular marker. For this purpose, we explored the existing sequence diversity for alleles of the two genes responsible for the *Pi-km* specificity in several U.S. rice cultivars. In 15 rice cultivars we found that the majority of nucleotide polymorphism was associated almost exclusively with the *Pi-km1* gene. The amino acid variation was localized within the predicted coiled-coil domain of the *Pi-km1* translated products. In contrast, the sequence of *Pi-km2* alleles was highly conserved, even within cultivars more distantly related. Furthermore, the cultivars blast inoculation reaction patterns, as well as the two genes phylogenetic analysis, revealed a good correlation with known *Pi-k* genes (*-k*/ *-kh*/ *-km*/ *-ks*/ *-kp*) historically reported for some of these cultivars. Based on these findings, specific primer sets have been designed to discriminate among the various *Pi-km* sequence variants. These new markers should simplify the introgression of *Pi-km* blast resistance genes and possibly other *R* genes in the complex *Pi-k* locus into new improved rice cultivars.

Comparative Study on Induced Straighthead in the U.S. with Natural Straighthead in Argentina

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Straighthead is a physiological disorder of rice that results in sterile florets, thus tremendously reducing grain yield. Straighthead has been a serious problem in many countries including Argentina, Australia, Bangladesh, Colombia, Japan, Portugal, and Thailand besides the U.S. Among several options, cultivar resistance is the most effective way to control this disorder and secure rice production. Identifying straighthead resistant germplasm is essential for breeding resistant cultivars in rice.

A total of 990 accessions selected from the USDA rice core collection were evaluated for straighthead in the induced conditions with application of 6.7 kg ha^{-1} monosodium methanearsinate (MSMA) to soil right before planting on 29 April 2003 at Stuttgart, Arkansas, U.S. These accessions ranged 48 ~ 107 days from emergence to heading and 62 ~ 150 cm of plant height. Single row plots, 1.5 m long and 0.5 m spacing, were arranged using the randomized complete block design (RCBD) with three replications. Three check cultivars, resistant Zhe 733 and susceptible Cocodrie and Mars, were inserted three times in each tier for monitoring the induced conditions. Straighthead was rated using the 1-9 scale where 1 is immune and 9 is the worst. The rating data were analyzed using SAS program. Using the results, 300 accessions plus three checks were selected for testing in the natural conditions. They were 37 resistant (rating 1.0-4.0), 82 susceptible (rating 4.1-6.0), and 184 very susceptible (rating 6.1-9.0) accessions. Previous study indicated no yield reduction caused by straighthead rated 4 or below.

A field where straighthead had severely and frequently occurred was reserved in the National Institute of Agricultural Technology (INTA), Corrientes, Argentina. The selected nursery of 303 entries was planted in the reserved field in October 2008 similarly with the U.S., single plot and RCBD with three replications except for the MSMA treatment. Straighthead was rated in late March 2009 using the same scale and same rater to the U.S.

Straighthead was less severe and more variable in Argentina than in the U.S., indicated by lower mean (3.8) but higher CV (44%) for the ratings in Argentina than in the U.S. (mean=6.5, CV=33%). Thirty seven accessions that showed resistance in the U.S. demonstrated resistance in Argentina as well with two exceptions. Among 82 accessions that were susceptible in the U.S., 69 (84%) became resistant and the remaining 13 (16%) remained susceptible in Argentina. Among 184 accessions that were very susceptible in the U.S., 106 (58%) were resistant, 46 (25%) were susceptible and the remaining 32 (17%) were very susceptible in Argentina.

Among 210 accessions that were resistant in Argentina, 35 (17%) were resistant, 69 (33%) were susceptible and the remaining 106 (50%) were very susceptible in the U.S. Among 61 accessions that were susceptible in Argentina, two (3%) were resistant, 13 (21%) were susceptible and the remaining 46 (76%) were very susceptible in the U.S. All of the 32 accessions that were very susceptible in Argentina were very susceptible in the U.S. as well.

The comparative study between the induced conditions in the U.S. and natural conditions in Argentina concluded that 1) straighthead performs more severe and more uniform in the induced than natural conditions, 2) resistant accessions identified in the induced conditions are reliably resistant in the natural conditions and 3) moderately susceptible accessions in the induced conditions could be resistant or moderately resistant in the natural conditions. Therefore, the induced conditions using the MSMA play a reliable and important role in study on straighthead in rice.

RiceCAP: Sheath Blight QTLs Identified in Two Bengal/*O. nivara* Advanced Backcross Populations

Eizenga, G.C. and Prasad, B.

Rice sheath blight disease, caused by *Rhizoctonia solani,* is one of the most important fungal diseases worldwide. Wild relatives of rice may contain novel genes for biotic/abiotic stress resistance lost during domestication. We identified seven moderately resistant accessions from a collection of 67 wild *Oryza* species accessions. To identify QTLs and ultimately genes related to sheath blight resistance, we developed two mapping populations with two of these accessions as donor parents using the advanced backcross method. This method has proven to be effective for simultaneously identifying QTLs and improving germplasm, especially when the donor parent is not adapted.

Bengal (PI 561735), a popular medium grain variety in the southern USA, which is moderately susceptible to sheath blight disease, was used as the recurrent parent for both advanced backcross populations. The donor parents were wild *O. nivara* accessions (IRGC100898; IRGC104705) from Orissa and Maharashtra, India, respectively, previously identified as moderately resistant. The "Wild-1" population with IRGC100898 is composed of 252 BC_2F_2 families and was genotyped with 129 SSR markers distributed throughout the 12 rice chromosomes. The same SSRs are being used to genotype the "Wild-2" population with IRGC104705. Products of the PCR reactions were visualized on an ABI Prism 3730 and "allele calling" completed with GeneMapper 4.0. Sheath blight disease was evaluated under inoculated conditions in the greenhouse using the micro-chamber method and in replicated field trials over two years using the standard field inoculation method. Plant height, days to heading, and plant type which are known to confound sheath blight ratings, were collected from the field trials. The linkage map was created using JoinMap 4.0 and QTLs identified using multiple interval mapping as performed by QGene 4.2.0. Graphical Genotype (GGT) was used to determine the percentage of the genome heterozygous for Bengal/*O. nivara*.

The preliminary linkage map for the Wild-1 population covered a 1742 cM distance with an average interval size of 13.8 cM between two markers. Marker distributions mirrored the published Cornell SSR map. There were 17 markers (15.9 %) skewed towards the recurrent parent Bengal and 15 (13.5 %) markers skewed towards the heterozygous Bengal/*O. nivara* class. Based on the marker analysis, the *O. nivara* genome segments in the heterozygous state in the BC_2F_1 plants varied from 5.7 to 60% with an average proportion of 24.5%. This genomic proportion fits the expected genotypic ratio of 75% recurrent parent and 25% donor parent in the BC_2 generation.

Significant variation ($p < 0.01$) was observed for sheath blight reactions and morphological traits. The correlation coefficients between each pair of traits revealed plant height had a significant negative correlation with plant type (rated as 1=upright, 3, 5, 7, 9=spreading) and field sheath blight ratings. Heading date also had a significant negative correlation with greenhouse and field sheath blight ratings. The most important finding was that sheath blight ratings in the greenhouse had a significant positive correlation with sheath blight ratings taken in the field.

Preliminary QTL mapping results identified at least three sheath blight QTL (SB-QTL) located on chromosomes 2, 3 and 6; qSB2, qSB3 and qSB6, respectively. All three SB-QTL were detected using both screening methods. The SB-QTL, qSB2 and qSB6, were attributed to the *O. nivara* parent with 3.8 to 8.9% of the variance explained and 0.42 to 1.7 of the additive effects. One QTL (qSB2) previously had not been reported, suggesting a potential novel SB-QTL. Three heading date QTL, all attributed to the *O. nivara* parent, and were identified on chromosomes 3, 6 and 7 with the LOD peaks ranging from 2.9 to 7.3, explaining 7.5 to 18.0% of the variation and an additive effect of delaying heading by 1.1 to 4.6 days. Two SB-QTLs (qSB3, qSB6) were located in the same region as days to heading QTL, suggesting this morphological trait influences sheath blight response. The QTL identified on chromosome 6 (qSB6, qHD6) coincided with previously identified QTL for sheath blight and days to heading. The fact that these QTL were found in approximately the same region as a previously reported QTL from *O. sativa* cultivars indicates QTL are conserved across the *Oryza* genus. One QTL for plant height detected on chromosome 7 with a LOD peak of 2.9, was attributed to the *O. nivara* parent and explained 5.7% of the variation with an additive effect of increasing height by 21.2 cm. Two QTLs were detected for plant type on chromosomes 1 and 9. The QTL on chromosome 9, attributed to the *O. nivara* parent, increased tiller angle by nearly a class (1.5 score), and explained 37.4% of the total variation with a LOD score of 11.7. Previously, QTL for tiller angle were identified in this same region. The other QTL for tiller angle was attributed to the Bengal parent. QTL mapping results from the Wild-2 population will be analyzed once the genotyping is complete and compared with these results as a validation of the SB-QTL. Through additional backcrossing of lines containing the putative SB-QTLs from *O. nivara* with Bengal and subsequent genotypic selection, we are developing germplasm with improved sheath blight resistance.

QTL Analysis of Field Resistance Gene to Rice Blast in an Advanced Backcross Population between *Japonica* Cultivars in Rice

Ju, H.G., Kim, D.M., Kim, S.S., Hahn, N., RohH, J.H., and Ahn, S.N.

We identified the QTL for field resistance to rice blast using an advanced backcross population of 117 BC_3F_5 lines from a cross between two *japonica* cultivars. Genotypes were determined for 117 BC_3F_5 lines by 134 simple sequence repeat (SSR) markers. These 117 lines were evaluated in blast nurseries at four locations for two years. QTL analysis identified two QTLs on chromosomes 4 and 7 for resistance in blast nursery tests. One QTL, *bn4* on chromosome 4 was detected at all locations in both years explaining from 16.8% to 35.9% of the phenotypic variance. Genetic analysis of the blast phenotypic data of the F_2 and F_3 population from a cross between a BC_3F_5 line harboring the target region on chromosome 4 and the recurrent parent, indicated that a major dominant gene designated as *Pi45*(t), was conferring resistance to blast in the nursery test. Linkage analysis indicated that *Pi45*(t) was located in the interval RM5709- RM3687, a region of approximately 577kb. Twelve lines with/without *Pi45*(t), were assayed in the greenhouse using a sequential planting method in seven cycles using 29 virulent isolates in Korea. Lines with the *Pi45*(t) gene showed less than 20% diseased leaf area, which was significantly below the threshold level of 40% considered for durable blast resistance. Five promising lines nearly isogenic to the recurrent parent expect for blast resistance were evaluated at the preliminary yield trial. These lines with enhanced blast resistance did not show differences from the recurrent parent in amylose content and 1,000 grain weight. Our study based on a new method of sequential planting test of breeding lines with the resistance gene *Pi45*(t) provided would be effective for durable blast resistance breeding in rice.

Linkage Drag: Implications for Plant Breeding

Jia, Y., Costanzo, S., Lee, S., Lin, M., and Jia, M.

Linkage drag is commonly observed in plant breeding, yet the molecular mechanisms controlling this is unclear. The *Pi-ta* gene, a single copy gene near the centromere region of chromosome 12, confers resistance to races of *Magnaporthe oryzae* that contain *AVR-Pita*. The *Pi-ta* gene in Tetep has been successfully transferred to several U.S. rice cultivars, Katy, Kaybonnet, Drew, Madison, Cybonnet, Ahrent, Spring, and Banks, by classical plant breeding. The *Pi-ta* gene is also found in IR64, the most widely grown rice cultivar in the world. Recently, we demonstrated that *Pi-ta* could produce 12 proteins (variants). Each Pi-ta variant may have the ability to recognize numerous races of blast fungus. In an effort to identify the minimal genomic region required for blast resistance, we discovered a large linkage block at *Pi-ta* in backcrossed progeny and elite cultivars. The presence of multiple resistance genes near *Pi-ta* may explain the observed durability of *Pi-ta* mediated resistance in the southern U.S. Genetic analysis of genes in global germplasm has revealed several novel resistance genes at the *Pi-ta* region. Genotyping of worldwide rice germplasm demonstrated that the *Pi-ta* linkage block is common in resistant accessions. The implications of linkage drag at the *Pi-ta* locus in disease resistance and crop productivity will be presented.

Confirming QTLs and Finding Additional Loci Responsible for Resistance to Sheath Blight in Rice

Liu, G., Jia, Y., McClung, A., Oard, J.H., and Correll, J.C.

Rice sheath blight (ShB) caused by the soil borne pathogen *Rhizoctonia solani*, is one of the most destructive diseases of rice around the globe, causing severe losses in rice yield and quality annually. Major genes governing resistance to ShB have not been found in cultivated rice worldwide; however, quantitative trait loci (QTLs) for resistance have been identified using field evaluations and greenhouse assays. This study was conducted to verify previously identified ShB-QTLs under greenhouse conditions using microchamber and mist-chamber methods, and to determine additional loci conditioning ShB resistance. Field evaluations of recombinant inbred lines derived from Lemont/Jasmine 85 were conducted in replicated inoculated trials conducted in Arkansas, Texas and Louisiana during 2008-2009. The results from all locations verified the presence of the major QTL *qShB9-2* on chromosome 9 with LOD value of 2.6-6.5. The results from Arkansas and Texas verified QTL regions on chromosomes 2 and 3 with the LOD value of 3.3-4.1 and 3.3-3.7, respectively. An additional locus responsible for ShB resistance on chromosome 7 (LOD = 4.0-6.0) was identified between markers RM125 and RM214. These confirmed ShB-QTLs will be useful in marker-assisted breeding programs to improve ShB resistance.

Current Status and Perspective in Hybrid Rice Development at the LSU AgCenter Rice Research Station

Li, W., Sha, X., Linscombe, S.D., Groth, D.E., Oard, J.H., Theunissen, S.J., and Henry, B.J.

Hybrid rice is the commercial rice crop of F_1 cross seeds between two genetically different inbred parents. Due to heterosis, hybrid rice can have a 15% yield advantage over the best inbred variety under similar conditions. By incorporating hybrid rice-related traits of Chinese germplasm into U.S. long-grain genotypes, our ultimate goals are to develop and identify male-sterile lines, restorer lines, and hybrid combinations adapted to southern U.S. environmental conditions.

According to a collaborative research agreement between the Louisiana State University Agricultural Center and Guangxi Academy of Agricultural Sciences, a number of advanced hybrid rice germplasm lines were introduced. These materials have been successfully propagated in the greenhouse under quarantine. A total of 42 testcrosses between Chinese male-sterile lines and Louisiana long grains or Chinese restorer lines were made, and the resulting seed were grown for field evaluation in mid-May. Our preliminary results indicated that some of the Chinese cross combinations had a significant yield advantage over commercial checks. Their milling yields, grain quality, maturity, and plant height are comparable with that of current commercial hybrids. Some of the testcrosses between Chinese male-sterile lines and Louisiana long grains also showed good yield potential, milling quality, and seed set. In spite of the huge challenges in the development of improved and adapted lines and hybrids, our limited preliminary results show very good promise.

Pre-Heading Heterotic Relationships between Rice Hybrids and Their Parents

Samonte, S.O.PB., Wilson, L.T., and Medley, J.C.

Comparing pre-heading trait parameters of a hybrid to the average of its parents (mid-parent heterosis) or to its better parent (heterobeltiosis) provides measurements of a hybrid's performance. The objective of this study was to determine the pre-heading heterotic relationships between rice hybrids and their parents, and to estimate the contribution of traits to heterosis in stem mass.

Field experiments were conducted at the Texas AgriLife Research and Extension Center in Beaumont in 2008 and 2009. Five hybrids and their parents were evaluated in 2008 and 8 hybrids and their parents were evaluated in 2009. Around the booting stage, light interception (sampled at one-hour intervals from 830 to 1630 h) was estimated for all hybrids and parents. Plant were then destructively sampled and measured for leaf area, and masses of leaves, stems, and roots. Heterobeltiosis and mid-parent heterosis were estimated for all traits. Path analysis was used to estimate the direct effects of heterobeltiosis and mid-parent heterosis for root and leaf masses, leaf area index (LAI), and light interception on stem mass.

In 2009, light interception was higher in all hybrids than their respective parents. Heterobeltiosis for light interception percentage ranged from 2% to 24%, while mid-parent heterosis ranged from 4 to 29%. Heterobeltiosis for LAI ranged from -35 to 17%, with 3 hybrids having positive values, while mid-parent heterosis ranged from -5 to 45%, with 7 hybrids having positive values. Heterobeltiosis for leaf mass ranged from -24 to -4%, while mid-parent heterosis ranged from 1 to 40%. Heterobeltiosis for root mass ranged from -18 to 71%, with 5 hybrids having positive values, while mid-parent heterosis ranged from -12 to 120%, with 6 hybrids having positive values. Heterobeltiosis for stem mass ranged from -21 to 57%, with 7 hybrids having positive values, while mid-parent heterosis ranged from 9 to 79%. Path analyses showed that the direct effect (path coefficient) of LAI heterobeltiosis on stem mass heterobeltiosis was 0.82, and the direct effect of LAI mid-parent heterosis on stem mid-parent heterosis was 0.62. Further analysis of plant samples to include nitrogen and TNC concentrations are being conducted.

Expression of Heterosis in Rice

Wilson, L.T., Samonte, S.O.PB., Medley, J.C., Yan, Y., and Yan, D.

The expression of heterosis in rice is dependent on the traits being measured. In this presentation, we present results from a study that examine the heterotic effect on light capture, photosynthesis, tillering, and biomass accumulation comparing a population of inbreds and their hybrid offspring.

Goals and Accomplishments of the Puerto Rico Winter Nursery

Rivera, A. and Aviles, L.

The Puerto Rico winter nursery is an integral part of the varietal development activities of all southern U.S. public rice breeding programs. The nursery operates under a cooperative agreement between the University of Puerto Rico and the affiliated universities: Louisiana State University, Texas A&M, University of Arkansas, Mississippi State University as well as the U.S.D.A. and has been in operation since 1972. The nursery typically grows out over 40,000 breeding rows each winter for the various programs which include segregating populations as well as seed increases of soon to be released varieties. Most varieties currently being grown in the southern U.S. came through the nursery at some stage of their development. The operation, goals and accomplishments of the winter nursery will be discussed.

Twenty-Five Years of Rice in Arkansas - Impact and Changes

Moldenhauer, K.A.K., Nalley, L.L., Watkins, K.B., and Gibbons, J.W.

Rough rice grain yield is the economic trait that has had the most genetic gain in the last 25 years in Arkansas. The varieties released by the University of Arkansas rice breeding program experienced an increase in annual yield, and a decrease in yield variance. In Arkansas the average yields have increased by approximately 2666 kg ha^{-1} from 4794 kg ha^{-1} in 1983 to 7459 kg ha^{-1} in 2008. This represents a 56% increase in on farm yields. Another key economic trait in rice is milling yield (mg g^{-1} whole kernel:mg g^{-1} total milled rice) at 120 mg g^{-1} moisture. This trait has been relatively constant over the last 25 years in the United States. In 1983/84 the milling yield was 614:711 and in 2006/07 the milling yield was 614:710 (the range over the last 25 years for whole kernel rice has been 588 to 622 mg g^{-1}).

Yield increases for rice varieties released by the University of Arkansas Division of Agriculture (U of A) rice breeding program were quantified, holding growing conditions, grain length, climatic conditions, and other agronomic improvements in production constant. The yield differential for each rice variety included in the U of A's annual Arkansas Rice Performance Trials (ARPT) study was quantified to isolate the percentage of yield enhancement attributable to the rice breeding program at the University of Arkansas.

During the 1983-2007 period, the U of A rice breeding program showed a cumulative genetic gain of 1052 kg ha^{-1} due to the release of new rice varieties. An estimate of the total economic benefits received by Arkansas producers from the U of A rice breeding program averages $19.1 million dollars per year, in constant 2007 dollars, for the 25 year period. During the last decade, 1997-2007, this annual economic benefit has increased to an average of 34.3 million (2007) dollars annually. When you account for the spillover of U of A rice varieties to neighboring states the average annual economic benefit of the breeding program from 1997-2007 increases to 40.5 million (2007) dollars. To put this in perspective the U of A rice breeding budget for 2007 was $1.47 million and the estimated total benefits, from Arkansas and surrounding states, was $98.27 million in 2007, resulting in a cost-benefit ratio of 1:67. That is, in 2007 every $1 invested in the University of Arkansas breeding program resulted in a $67 return. Over the past 25 years the Arkansas Rice Breeding Program has contributed because of improved varieties $429,377,888 to the Arkansas Economy. Given these estimates, the benefits of the rice breeding program outweigh the costs by a large multiple. This result of large benefits is typical for public agricultural research, since more productive agricultural methods have often led to widespread adoption of yield-enhancing technologies that result in large economic gains.

Expanding Genetic Diversity in Southern Long-Grain Rice by Incorporating the Anther Culture-Derived Germplasm

Sha, X.Y., Linscombe, S.D., and Chu, Q.R.

Long-grain rice (*Oryza sativa* L.), which accounts for about 75% of the U.S. rice acreage, has extremely narrow genetic diversity. Crossing the locally adapted genotypes with exotic germplasm is the most effective way to expand the gene pool in U.S. long-grain rice. Unfortunately, these crosses produce excessive segregation, which requires time-consuming repeated selection and re-selection. By applying anther culture on F_1 or F_2 segregating progenies, the homozygous doubled-haploid (DH) plants can be generated in as short as a few months. With the aid of bridge parents and genotype-specific media, which significantly improved the anther regenerability of U.S. long-grain rice, a large number of long-grain DH lines were successfully produced. To evaluate their field performance, 10 elite DH lines were chosen to be included in the advanced yield trial conducted at seven Louisiana locations during 2004-2005. Most of these lines were found to have the similar yield and milling quality to commercial checks. To explore their potential in expanding the genetic diversity in U.S. long-grain rice, the newly developed lines derived from the crosses between the elite DH lines and locally adapted cultivars/lines were evaluated in replicated yield trials in 2009. Preliminary results indicated that the new lines displayed even higher yields compared with both DH lines and predominant commercial cultivars. Our findings suggested that the doubled-haploid technology cannot only hasten the breeding process but also be effective in the improvement of yield by broadening genetic diversity in U.S. long-grain rice.

Abstracts of Posters on Breeding, Genetics, and Cytogenetics
Panel Chair: Dwight G. Kanter

Marker-Assisted Selection to Improve Grain Quality and Disease Resistance at the Rice Experiment Station

Andaya V.C., Yeltatzie, G., Oster, J.J., Lage, J., Jodari, F., and McKenzie, K.S.

A new DNA marker laboratory was built recently at the Rice Experiment Station in Biggs, California to support the various rice breeding projects. With the new lab, the capacity for marker-assisted selection has increased at least ten folds. The use of the marker technology is expected to expedite breeding for improved short-, medium-, and long-grains varieties and to speed up the blast resistance gene introgression efforts in the medium grains project.

Since early 2009, approximately 20,000 progeny lines were screened for one or a combination of markers associated with amylose content, Pi-z blast resistance gene, fragrance gene, markers associated with elongation of cooked kernels in basmati-types, and markers for taste characteristics of premium quality Japanese short grains. Additional markers from important traits will be incorporated or validated as they are identified by the rice research community.

Efforts to map the stem rot resistance genes from *O. rufipogon* and *O. nivara* are also underway. This mirrors the work being done with blast resistance gene introgression into M-206, a medium-grain variety. The poster highlights the activities conducted in the new DNA marker lab at Rice Experiment Station.

Development of Clearfield® Indica Rice Cultivars in Uruguay

Blanco, P.H. and Molina, F.

Uruguay grows 165,000 ha of irrigated rice and average yield of the last 3 years was 7.9 t/ha. Most of the crop area is grown with long-grain varieties, and those from Indica type account for 84% of the area. High use of certified seed (85%), rotation with pastures for grazing of beef cattle and other cultural practices, as manual elimination of red rice (*Oryza sativa* L.) plants, have contributed to maintain populations of this weed under control. However, there is an increased concern about spread of red rice, which has been reported as being present in 31% of the cultivated area, mostly in patches or isolated plants. This drives the attention to chemical methods for controlling red rice, especially to Clearfield® production system, which involves the use of imidazolinone (IMI) herbicides and tolerant varieties. Such varieties were developed using conventional breeding methods (mutation techniques), therefore are not genetically modified organisms. IMI herbicides inhibit acetohydroxy acid synthase (AHAS), a central enzyme in the synthesis of some amino acids, and control a broad spectrum of weeds in IMI-tolerant crops. Several IMI-tolerant varieties, as CL121, CL141 and IRGA 422, and highly resistant varieties and hybrids, as CL161 and XL-8, were developed from the mutant lines 93AS3510 and PWC-16, respectively, obtained in the U.S. Recently, INTA (Argentina) developed a new source of resistance, releasing the indica variety Puitá INTA CL.

In Uruguay, varieties derived from 93AS3510, as IRGA 422 (indica), widely grown in Brazil, do not provide consistent tolerance to herbicides under low temperatures that are common in the country, and the highly resistant variety CL161 (tropical japonica), grown in the U.S., has limited yield potential and long growth duration. INIA introduced IMI-tolerant germplasm, under research agreements with BASF Corporation, in 1998 and 2001, with the purpose of developing Clearfield cultivars adapted to local conditions. In 2003, after discarding germplasm derived from 93AS3510, cultivar development was focused on germplasm from PWC-16. Introduced material was used in selection and in crosses with local germplasm, either of indica and tropical japonica background. The purpose of this abstract is to present results from field testing (3-4 seasons) of two groups of advanced breeding lines developed from crosses with local indica varieties.

Tolerant germplasm introduced from LSU, including the cultivar CFX-18 and populations obtained from its crosses with Brazilian indica varieties IRGA 416 and IRGA 417, were crossed in Uruguay with the local indica varieties

INIA Olimar, El Paso 144 and INIA Cuaró. Segregating populations were treated with imazapyr + imazapic (74 + 25 or 110 + 37 g/ha). A first group of 57 F5 indica breeding lines were included in preliminary yield trials in 2005/06 and 2006/07 in Paso de la Laguna (PL). Selected lines from this group were included in advanced yield trials in 2 locations in 2007/08 and 2008/09 (PL and Artigas). A second group of 120 F6 breeding lines from the same crosses was included in preliminary trials in 2006/07 and 50% were selected for 2007/08 trials. In 2008/09, 30 of those breeding lines were included in an advanced trial in PL. Preliminary and advanced trials had 2 and 3 replications, respectively, and plots had 6 rows of 3.5 m length, with 0.2 m between rows. Plots were sprayed with imazapyr + imazapic in post emergence (similar dose as indicated above). Check varieties were the introduced IMI-resistant CL161 and Puitá INTA CL. Determinations included grain yield, agronomic traits, disease incidence and milling quality.

All cultivars had good tolerance to the herbicide and the 14 breeding lines from the first group showed high yields in the advanced trial in 2008/09, averaging 9.5 t/ha (CV 5.4%, LSD 0.849 t/ha) in PL and 8.8 t/ha (CV 4%, LSD 0.588 t/ha) in Artigas. Grain yield of the check cultivar Puitá INTA CL was significantly higher than that of CL 161 in PL (9.9 and 8.9, respectively). One breeding line, CL 118-1, showed higher yield (11 t/ha) than Puitá INTA CL, but its % of whole kernels was lower (56.5 vs 61.7%). Considering the average for 4 years of testing, some breeding lines as CL155-1, CL146 and CL 118-1 had yields 5-7% higher than that of Puitá INTA CL, but milling quality was lower than that of the check. Most of the lines had shorter growth duration than the check varieties.

In the second group, grain yields of the 30 lines included in the advanced trial in 2008/09 ranged from 8.9 to 11.9 t/ha. Puitá INTA CL showed very high yield in the season (11.6 t/ha). Among the top yielding breeding lines, CL257 and CL244 had shorter growth duration and similar milling yield than Puitá INTA CL, but the first one had higher chalkiness. Considering 3 years of testing, average grain yield of CL244 and CL257 was 9.7 and 9.3 t/ha, respectively, 15-18% higher than that of Puitá INTA CL, with similar grain quality than the check variety. Considering these data, CL146 and CL244 were included in seed production program in 2009/10 season.

High-Throughput DNA Extraction Method Modified for Rice Seed and Suitable for Marker-Assisted Selection

Boyett, V.A., Booth, V.L., Humphries, A.L., Lockwood, M.B., and Gibbons, J.W.

Molecular tools such as genotyping and marker-assisted selection (MAS) are being used in the development of improved rice varieties. Fundamental to all molecular analyses of breeding material is a reliable source of genomic DNA. The DNA should be of sufficient amount and quality for PCR amplification. Obtaining this DNA should be a simple, fast, and inexpensive procedure. The objective of this project was to develop a quick and economical method for obtaining quality genomic DNA from rice samples. A high-throughput sodium hydroxide DNA extraction method designed for leaf tissue in a 96-well format was modified for rice seed embryos to eliminate the need for greenhouse production of rice seedling tissue, greatly reducing the time and costs required to produce the DNA samples.

Rice seeds were manually de-hulled using a handheld rice husker. Before loading rice seeds, 1 mm glass beads were added to each 2 ml microtube or plate well. Molecular grade water was then pipetted into the wells in the ratio of 0.7 µl H_2O per seed to eliminate static electricity. Embryos and most of the bran were separated from the endosperm using a Mini-BeadBeater-8 (2 ml tubes) or Mini-BeadBeater-96 (96-well plates).

Samples were processed for 8-35 seconds to detach the embryos, and then centrifuged one minute at 4000 rpm. The endosperm was discarded, and then a second two minute processing pulverized the remaining embryos and bran.

Buffer A (2% Tween 20, 100 µM sodium hydroxide) in a volume of 20 µl per seed was added to each sample and tubes were vortexed briefly. Deep-well plates were mixed by returning to the Mini-BeadBeater-96 and processing 30 seconds, and then centrifuging for one minute at 500 rpm. Tubes and plates were incubated ten minutes in 95°C and 85°C water baths, respectively. After a one minute centrifugation at 1000 rpm, a volume of Buffer B (100 mM Tris-HCl, 2 mM EDTA) equal to the volume of Buffer A in each sample was added and mixed. This neutralized DNA solution was used directly as a template for PCR with BSA and PVP 40 in the reaction mixture, or precipitated and ethanol washed for PCR without the reaction mixture additives.

PCR quality DNA suitable for MAS can be obtained in as little as five hours from 96 samples of rough seed, at a cost of approximately 6¢ per sample. Amplicons can be resolved by either gel or capillary electrophoresis.

Development of Three Allele-Specific Co-Dominant PCR Markers Suitable for Marker-Assisted Selection of Amylose Class and Paste Viscosity of Rice

Chen, M.-H., Fjellstrom, R.G., Christensen, E.F, and Bergman, C.J.

Most rice is consumed as whole kernel cooked rice, and the consumer preferences for cooked rice texture and other sensory properties differ among regions of the world. Rice is also used as an ingredient in a multitude of foods by food-processing companies across the globe. These sensory and functional properties of rice are predominantly associated with its apparent amylose content (AAC). Thus, rice breeders around the world developing breeding lines with specific end-use properties often select for specific AAC. However, AAC and other processing related properties, such as starch paste viscosity, are traits known to be variably affected by environmental factors.

Both AAC and pasting properties have been genetically mapped to the *Waxy* gene, encoding the granule bound starch synthase enzyme that is active in the developing rice endosperm. Recent studies identified three functional single nucleotide polymorphisms (SNPs) in the *Waxy* gene. These SNPs had a strong association with AAC and pasting properties. These findings provide opportunities for the selection of desired end-use quality traits using molecular genetic technologies. The methods reported in the original identification of these SNPs and their associations are either low-throughput genotyping methods or require special instrumentation along with skills not typically found in molecular-breeding programs. The development of a high-throughput method with a simple protocol for analyzing these SNPs would greatly enhance their usefulness as part of a marker assisted selection scheme.

We have successfully developed three codominant allele-specific PCR (AS-PCR) markers to genotype these three functional SNPs in the rice *Waxy* gene. Each marker contained two allele-specific primers and one common primer. For each marker, the two allele-specific primers differed by one base at the 3'-end to provide discrimination of the SNP alleles, and were labeled with unique fluorescence probes. An additional mismatched base, the third base from the 3'-end, was inserted in some allele-specific primers to increase selectivity. Thus, for each AS-PCR marker, the alleles were differentiated or detected by color and by length of the amplified products.

These co-dominant markers selectively identify and amplify target SNP alleles from genomic DNA in a single step by including both allele-specific primers and one common primer. The PCR-amplified product can be detected by capillary electrophoresis and fluorescence using the same instrumentation as those for microsatellite markers. The assay is as simple as those for microsatellite markers. With these AS-PCR markers, rice breeders are now able to select the desired quality traits in their breeding lines based on genetics, thus eliminating the need to routinely phenotype the same breeding lines in multiple locations. These markers would be useful in selecting homozygous breeding lines and diverse germplasm and in verifying varieties and cultivars with respect to their amylose classes and paste viscosities.

The Gramene Genetic Diversity Module: A Resource for Genotype-Phenotype Association Analysis in Grass Species

DeClerck, G., Casstevens, T., Chen, C., Youens-Clark, K., Spooner, W., Sun, Q., Thomason, J., Yap, I., Tung, C-W., Zhang, J., Avraham, S., Ren, L., Wei, S., Bradbury, P., Ware, D., Jaiswal, P., McCouch, S., and Buckler, E.

Characterization of genetic diversity is a central activity in biology today and plays a key role in plant breeding. With the introduction of an increasing number of high-throughput sequencing and array-based genotyping technologies, identifying variation at the molecular level is becoming routine, while the ability to associate this type of data to variation at the phenotypic level continues to present significant challenges. The bottleneck encountered by studies aiming to elucidate genotypic-phenotypic associations is most acute in the areas of data post-processing, data storage, and in the computationally-intensive analyses of results. The Genetic Diversity module of the Gramene database (www.gramene.org/diversity) is specifically designed to handle these data and to facilitate data integration and analysis. It uses the Genomic Diversity and Phenotype Data Model (GDPDM; maizegenetics.net/gdpdm) to store RFLP, SSR and SNP allele data, information about QTL experiments that study variation, passport data for rice, maize, wheat, sorghum, and *Arabidopsis* germplasm, and quantitative phenotypic data for a subset of these accessions. The module is developing direct connectivity with analysis packages such as TASSEL (maizegenetics.net/tassel) which can be used for finding trait associations, evolutionary patterns, and linkage disequilibrium. Of increasing importance for the Diversity module is the effort to develop associations between rice, maize, and *Arabidopsis*, which will allow users to integrate information from each of these model genomes, building on the advantages and compensating for the disadvantages of each system and dataset for discovery of genes underlying traits in the cereals and in the broader plant kingdom. The Gramene database (gramene.org) and the Diversity module are updated two times a year. The latest release was in October 2009 with Build #30.

Development of a Genetic Mapping and Breeding Program to Develop Resistance to the Bacterial Panicle Blight and Sheath Blight Diseases

Ham, J.H., Shrestha, B.K., Karki, H.S., Sha, X., Groth, D.E., Utomo, H., and Rush, M.C.

Sheath blight (SB), caused by the fungal pathogen *Rhizoctonia solani*, and bacterial panicle blight (BPB), caused by the bacterial pathogen *Burkholderia glumae*, are serious constraints to rice production in Louisiana. Growing disease resistant varieties is a cost-effective and environment-friendly way to manage rice diseases and it would be desirable to introduce disease resistance traits against multiple diseases into one rice variety. Two rice cultivars/lines developed by the Rice Research Station, Jupiter and LM-1, show high levels of partial resistance to both SB and BPB. In this study, these disease resistant lines are being utilized as source materials for both genetic mapping of disease resistance and breeding rice lines possessing a broad-spectrum disease resistance.

For mapping the genes responsible for broad disease resistance in Jupiter and LM-1, Jupiter and LM-1 were crossed with Trenasse and Bengal, which are both highly susceptible to BPB and highly susceptible and moderately susceptible, respectively, to SB. F_2 segregating populations from each cross were grown in 2009. In total, 484, 455, 501 and 454 F_2 plants from LM-1/Trenasse, Jupiter/Trenasse, LM-1/Bengal and Jupiter/Bengal hybridizations, respectively, were grown in the field at the Rice Research Station for initial investigation of the segregation patterns of the partial resistance to BPB. F_3 seeds for generating homozygous mapping populations were also collected from individual F_2 plants. All the F_2 plants from the four crossing combinations as well as parental lines were inoculated with the BPB pathogen, *Burkholderia glumae*, and the 1,894 F_2 plants were rated individually for disease severity. An additional 300 F_2 plants from each cross were also grown in the green house at the LSU campus as a backup for generating mapping populations. F_3 seeds from each F_2 plant will be planted in a row and re-examined for their disease resistance phenotype to both SB and BPB. Meanwhile, 298 simple sequence repeat (SSR) markers have been screened so far to get polymorphic molecular markers for Jupiter, LM-1 and Trenasse, Among the 298 SSR markers screened, 178 markers showed polymorphism between Trenasse and Jupiter or Trenasse and LM-1. While the mapping populations are being established, more SSR markers will be screened until enough polymorphic markers for QTL mapping are obtained.

For breeding of rice lines with a broad-spectrum disease resistance trait, Jupiter and LM-1 were crossed with disease susceptible commercial cultivars, Trenasse, Bengal and Cocodrie, and with each other. The F_2 plants from Jupiter/Trenasse, Jupiter/Bengal, LM-1/Trenasse and LM-1/Bengal crosses, were grown for both mapping and breeding, while those from Cocodrie/LM-1 and Jupiter/LM-1 crosses were grown for breeding purposes only. Among the cross combinations, the Cocodrie/Jupiter cross resulted in sterile F_1 plants, so F_2 seeds could not be obtained. All the F_2 plants grown in the field were sprayed with *B. glumae* and primarily screened for disease resistance to BPB. F_3 plants from the F_2 plants showing high levels of partial resistance to BPB will be grown for generating homozygous rice lines resistant to both SB and BPB along with other desirable traits, such as yield and milling quality, after several generations of panicle row selection.

Phenotypic Data Collection and Management using Barcodes, MS Excel and MS Access

Hancock, T.A., McClung, A.M., McCouch, S.R., and Eizenga, G.C.

A "Rice Diversity Panel" composed of 409 purified *Oryza sativa* accessions originating from 79 countries was developed in order to conduct an association mapping study. The methods used to collect and manage the phenotypic data on plant morphology, seed morphology, grain quality, and selected agronomic traits for the association mapping are described in this study. To better understand how plant and seed traits were selected during domestication, 133 accessions of the rice (*O. sativa*) ancestral species, *O. rufipogon* were included in this phenotypic evaluation with the objective of including them in the association mapping. The other long-range goal is to explore the genetic basis of transgressive variation that is observed after hybridization both within *O. sativa* and between *O. sativa* and *O. rufipogon*.

Trait data for over 30 plant, seed, and grain quality characteristics were collected on the 409 rice accessions. The accessions were evaluated in a randomized complete block design conducted in the field at Stuttgart, Arkansas with two replications during two different years. Three representative plants were chosen from each replication for evaluation, thus phenotypic data were collected from twelve plants of each accession. In a similar study, 133 *O. rufipogon* accessions were grown in the greenhouse during two different years. Data were collected for 24 plant and seed traits from three plants of each *O. rufipogon* accession each year totaling six plants for each accession. These two studies produced over 165,000 data points that needed to be organized by accession, year, replication, and trait for accurate analysis. Although Microsoft Excel and barcodes were initially used to assist in the collection and organization of the data, during the second year we also began using Microsoft Access. Access allowed us to quickly look at averages by accessions, by one or more years, as well as by multiple traits which was useful for quality control and preliminary analysis.

Unique identifiers were created for each plant in the study. Tags which contained barcodes with these unique identifiers were placed with each plant in the field or greenhouse. This was particularly important for some traits where there was wide variability among the plants for a given accession (e.g., days to heading 50 to >120 days).

Envelopes (business #10) for panicle harvest were labeled with the unique barcode identifier along with categorical ratings for eight phenotypic traits being recorded during harvest. These traits were shattering, leaf pubescence, plant type, awn presence, awn size category, panicle type, lodging incidence, plant height, and plant number in the row. All possible ratings for the traits were listed on the envelope, thus one only needed to circle the appropriate score. These "envelope notes" were transformed into electronic format using a Symbol barcode scanner with TracerPlus software while data on the single panicle in the envelope (panicle length, number of primary branches, number of whole seeds per panicle, number of unfilled florets per panicle) also were recorded electronically.

To harvest seed from the individual field grown *O. sativa* plants, tags were removed from the stake and threaded through a plastic zip-tie (31 cm) which was wrapped around the plant tillers. The tillers were cut with a sickle, seed threshed using an Almaco bundle thresher, and seed collected in a Spear safety envelope labeled with the unique identifier barcode and other pertinent information. Tags were placed in the envelope to aid in quality control. The thresher was cleaned with compressed air between samples to ensure purity.

Traits were recorded on hulled and dehulled seed using a WinSEEDLE Pro image analysis system. For recording the data, a subsample of seed from the plant harvest was placed in a coin envelope (#3) labeled with the unique barcode. Later, this sample was placed on a color optical scanner and the WinSEEDLE software counted the seed and measured the length, width, volume and surface area of the seed. Afterwards, the sample was dehulled and these traits were measured again on the dehulled seed. Subsequently, the dehulled sample was prepared for quality analyses (alkali spreading value, amylose and protein content) using the appropriate methods, keeping the unique identifier with the sample throughout these analyses.

In conclusion, using Microsoft Excel and Access allowed us to easily and quickly manage a large amount of phenotypic data that facilitated quality control and analysis. The methods of phenotypic data collection and management used in this study are applicable to collecting/managing data for large breeding programs and germplasm collections.

Dwarf Few Tillering Rice Mutant with Different Panicle Type

Harper, C.L., Tabien, R.E., and Frank, P.M.

Mutants are important tools in genetic studies and trait improvement. These are essential in determining gene function and dissecting biochemical and metabolic pathways. These mutants are important plant genetic resources in understanding genetic factors that influence plant mechanisms and morphological development. Information on inheritance of these traits can be used to explain gene expression and influence future functional genomic studies that will enhance utilization of these traits in breeding programs.

Mutation breeding at the Texas AgriLife Research and Extension Center in Beaumont, Texas, aimed to generate herbicide tolerant germplasm, was initiated in 2003. Seeds of several genotypes including Presidio, a high yielding long grain cultivar, were treated with three levels (0.4, 0.8, and 1.2%) of ethyl methanesuphonate (EMS). Treated seeds were planted singly in trays and harvested individually at maturity. Remnant seeds after herbicide testing were bulked and stored. In 2007, a dwarf mutant plant with spike panicles was identified from the plantings of Presidio-EMS treated remnant seeds. Only two plants of the same phenotype were obtained in 2008 but 2009 planting generated several plants for phenotypic observations. The EMS derived dwarf mutant has 3-4 big tillers before heading and 5-6 tillers at harvest. It has wide short dark green leaves (30 cm), short erect panicles (13.4 cm), with more than 100 spherical tiny grains. This mutant has big tillers but shorter in height (30 cm at panicle tip and 44 cm at flag leaf tip), compared to normal plants. For two seasons, the mutant plants had erect panicles but few plants produced split panicle type in 2009. In some spiked panicle mutants, one to three grains were prominently display like ponytail at the tip of the compact panicle. This mutant has traits in contrast to the dwarf very high tillering mutant isolated from a cross developed in Beaumont and reported at the 2008 RTWG meeting in San Diego, CA.

Functional Characterization of the Rice Low Phytic Acid 1 Gene *OsLpa1*

Kim, S-I. and Tai, T.H.

Phytic acid (*myo*-inositol-1,2,3,4,5,6-hexa*kis*phosphate or $InsP_6$) is the primary storage form of phosphorus in seeds, typically accounting for 65 to 85% of the total P. $InsP_6$ has a major impact on livestock production and human nutrition as it cannot be digested by non-ruminants and its ability to bind minerals reduces the bioavailability of these important micronutrients. We recently cloned the rice low phytic acid 1 (*OsLpa*1) gene which is required for normal levels of seed $InsP_6$. *OsLpa*1 is a novel gene with at least three splice variants. Analysis of two independent rice lpa1 mutants indicates that the largest transcript is needed for wild-type seed $InsP_6$ levels. Our progress in determining the function of LPA1 protein will be presented. Functional analysis of the *OsLpa1* will provide insight into seed and seedling development and will contribute to our understanding and exploitation of low phytic acid grain crops for human and livestock consumption.

Enhancement of Cold Tolerance Screening at the Rice Experiment Station

McKenzie, K.S., Jodari, F., Andaya, V.C., Lage, J., and Oster, J.J.

The California Rice Experiment Station Breeding Program has used air-conditioned units to cool a section of the quonset-style greenhouses to induce low temperature induced sterility (blanking) as a routine part of the screening and selection process in developing new rice varieties for more than 30 years. The standard treatment involves cooling the greenhouse from midnight to morning to 13.8ºC (55ºF) when the pollen is susceptible, about 10-15 days before heading. Breeders visually score the panicles at maturity for seed set (% blanking) as an indicator of a line's resistance to cool temperature induced blanking. This information is combined over years with field results collected at cold tolerance nurseries. This screening step has been an integral part in the selection process in developing cultivars with low temperature blanking resistance in all grain types. Examples with a high level of low temperature blanking resistance include Calmochi-101, M-103, M-104, S-102, and L-206.

Enhancement of greenhouse cold screening facilities was identified as an important capital need in the 2007 Rice Breeding Program Review. Air-conditioning units are not designed to achieve the large temperature decrease required, especially during the summer when daytime temperatures exceed 37ºC. The operation of the air conditioners and the variability in the greenhouse did not always ensure reliable results and there was a need for more capacity. The engineering recommendations were to go to a refrigeration based system, replace the single pane glass with double wall Lexan® polycarbonate, and use the entire greenhouse to double the screening capacity. Variable frequency drives were added to regulate air flow and for energy-use efficiency. A web-accessed control system and connection through a local area network was also installed.

The Rice Research Trust approved and funded the renovation and expansion of the cold tolerance screening greenhouses as part of the $900,000 capital improvement project that was completed in June of 2009. Two cycles of greenhouse screening were completed in the summer and fall of 2009. The system had no problems achieving treatment temperatures of 11ºC when daytime temperatures reached 42ºC. High levels of induced blanking were achieved in these tests. Further tuning of the treatment protocol will be made to address variability and identify optimum screening temperatures and treatments.

Characterization of the Recombinant Inbred Line Population Derived from the Cross of Nipponbare/9311

Liu, G., Jia, Y., Jia, M.H., Venu R.C., Wang, G.-L, Meyers, B., and McClung, A.

As a part of the project entitled "Understanding the rice epigenome: From genes to genomes" funded by the National Science Foundation, a mapping population of 480 F_{6-8} recombinant inbred lines (RILs) derived from a cross of Nipponbare with 9311 (Nip/9311) was developed. Phenotyping important agronomic traits and genotyping of the population was conducted at USDA-ARS Dale Bumpers National Rice Research Center, Stuttgart, AR and Rice Research Unit, Beaumont, TX in 2009. To date, phenotypic transgressive variation among the Nip/9311 RILs was observed and two hundred and seventy Nip/9311 RILs were genotyped using 200 simple sequence repeat (SSR) markers to establish a linkage map. The goal of this project will lead to the identification of four best-performing lines that outperform both parental lines for yield, yet retain a significant combination of both parental genomes based on genotypic data. Comparisons of epigenomic profiles between parental lines, F_1 hybrids and selected RILs should provide information on the inheritance of DNA methylation, histone modification and imprinting over multiple generations, and may help elucidate their roles in hybrid vigor and heterosis. Ultimately, a broader set of these lines will be analyzed to gain a better understanding of molecular mechanisms of heterosis.

Association Mapping of Grain Quality and Flowering Time in Elite *japonica* Rice Germplasm

Ordonez, S.A., Silva, J., and Oard, J.H.

Grain quality traits play an important role in the economic prosperity of commercial rice markets. The objective of our research was to identify candidate molecular markers associated with three grain quality and flowering traits in a collection of elite rice *japonica* inbred lines evaluated in five U.S. states. Candidate marker effects associated with the traits mapped within regions reported from previous QTL analyses while several new allelic interactions were also detected. Common markers for each trait were observed across two or more locations, and two-way interactions unique to a single location were also found. Significant genotype x location interactions were detected while broad-sense heritability estimates were low for all characters. All but one selected marker effect was associated with a reduction in apparent amylose content. A reduction in heading date at three locations was observed with one marker as a main effect or as a component of two-way interactions that mapped ~ 5 cM from the *Hd3a* flowering locus. The majority of selected effects for head rice were associated with modest to substantial increases in value. Marker loci and their interactions identified in this study highlighted targeted regions for future association studies and marker-assisted breeding efforts of grain quality traits.

Performance of Support Vector Regression and the General Linear Model for Prediction Accuracy and Variance Estimates of Complex Traits in Rice

Silva, J. and Oard, J.H.

DNA marker technology has proven beneficial to the U.S. rice industry for improvement of certain traits with simple genetic control and minimal environmental interaction. A few examples include blast resistance, semi-dwarf stature, amylose content, and gelatinization temperature. However, substantial challenges remain for DNA technology to explain complex agronomic traits governed by many genes that interact at different levels with the environment. The general linear model (GLM) as a "parametric" approach has been the foundation to identify candidate markers associated with quantitative traits. The objective of our research was to compare variance explained and the correlation of observed vs. predicted values for amylose content, heading date, and head rice values using a linear model with the SAS GLMSelect package and a non-parametric machine-learning approach known as Support Vector Regression (SVR). The ability to explain observed phenotypic variation for the three traits in the 2000 URN trial was similar for GLMSelect and SVR when the number of selected predictor variables (DNA markers) was low (≤ 8). When the number of selected variables was > 8, the SVR method explained greater variance vs. GLMSelect that reached a plateau of 0.80 to 0.90 for adjusted R^2 values with 18 to 20 selected markers. Consistent with these results, greater correlations between observed and predicted values were found using SVR vs. GLMSelect. All results indicate that alternative approaches such as SVR should be further explored and developed as a tool for marker-assisted improvement of complex agronomic traits in rice.

Flowering Traits and Grain Filling of Six Cultivars with Varying Milling Quality

Tabien, R.E., Harper, C.L., Samonte, S.O.PB., and Tiongco, E.R.

Head rice recovery is very important to farmers since it can determine farm income. Recent studies indicate that flowering traits, such as rate and duration of flowering, affect grain uniformity at harvest and hence, head rice recovery. Head rice recovery is also affected by maturity, rate and duration of flowering within a panicle, panicle size, and panicle length. These imply that rice breeders need to select plant types that have a high uniformity in grain characteristics, and in those traits that have a positive impact on yield and milling quality, such as greater grain size, weight and density. This study was conducted to determine the variation in flowering traits and grain filling of six cultivars with diverse milling quality.

Six rice cultivars, namely: Cypress, Cybonnet, Cocodrie, Francis, Priscilla and Jefferson, with diverse head rice recovery percentages were evaluated in replicated plots for two years. For each plot, dates on the onset of flowering, 25%, 50%, 75% and 100% flowering were taken. Before heading, five equally spaced plants were tagged in each plot to evaluate the flowering of the main stem and primary tiller for each entry. At weekly intervals starting from 50% flowering, five panicles were harvested per plot. These were used to gather panicle traits such as number of filled and unfilled grain, weight of filled and unfilled grain, and total grain per panicle. Percentages of filled and unfilled grain for each sampling date were estimated.

Variations were observed in almost all parameters measured. On a plot basis, Jefferson and Priscilla, which are known for lower head rice recovery, had longer flowering duration and slower rate of flowering than the two best cultivars with high milling yield, Cypress and Cybonnet. The main stems and primary tillers of these cultivars followed the same pattern of flowering. The extended flowering duration favored non-uniformity of the grain at harvest, thereby affecting head rice recovery. The data gathered on panicles sampled every week from 50% flowering showed a faster grain filling for cultivars with low milling yield. The percentage of filled and unfilled grain were the same for all cultivars at one week after 50% flowering, but significant differences were noted after 14 days from heading until harvest. The number of filled grain increased with sampling time, but faster rates was noted for Priscilla and Jefferson relative to Cypress and Cybonnet.

Rice TILLING: A Reverse Genetics Resource and Service for the Rice Research Community

Tai, T.H., Colowit, P., Takachi, C., Tsai, H., Holowell, T., Watson, B., Ngo, K., Missirian, V., and Comai, L.

TILLING (Targeting of Induced Local Lesions IN Genomes) is a general reverse genetics method that combines traditional chemical mutagenesis with high throughput discovery of mutations. We report here the development of a rice TILLING population in the reference cultivar Nipponbare and the establishment of a TILLING by sequencing service for the rice research community.

Identification and Genotyping of Single Nucleotide Polymorphisms in Rice Using Next-Generation Sequencing of Reduced Representation DNA Libraries

Tai, T.H., Fass, J., Ngo, K., and Comai, L.

Single nucleotide polymorphisms (SNPs) have become the markers of choice for genetic mapping and association analyses. Several studies have demonstrated that short read sequencing of reduced representation DNA libraries, constructed by ligation of adapters to restriction fragments, is an efficient approach for identifying and genotyping SNPs. Typically, when such libraries are sequenced, SNPs are called by comparing multiple reads of the same genomic region (type II discovery). SNPs may also be identified through the discovery of restriction sites not present in the reference sequence (type I discovery). We have developed molecular and bioinformatics methods for the construction, multiplex sequencing, and scoring of reduced representation DNA libraries. We have demonstrated high reliability and efficiency of SNP discovery by scoring of single type I reads as well as reliable construction of libraries that optimize type II discovery. Here we report the application of this SNP discovery method, Restriction Enzyme SequenCe ANalysis (RESCAN), to identify and genotype SNPs in rice.

Breeding Value of the qSB9b and qSB12a QTLs in Rice

Wang, Y., Pinson, S.R.M., Fjellstrom, R.G., and Tabien, R.E.

Sheath blight (SB) caused by *Rhizoctonia solani* Kuhn is a serious rice disease worldwide. The results of the inoculation test of 123 TeQing-into-Lemont (TILs) showed that lines with introgressions containing *qSB9b* and/or *qSB12a* were among the most SB resistant TILs. Three TILs, namely: TIL:615, TIL:642 and TIL:567 were consistently resistant in field plots, and they were identified to contain *qSB9b* and/or *qSB12a.* To accurately evaluate the resistance effect of *qSB9b* and/or *qSB12a,* TIL:615, TIL:642 and TIL:567 were crossed to a susceptible cultivar, Lemont. The F_2 plants, which contain Lemont genetic background, *qSB9b* and *qSB12a,* were selected based on the primers for *qSB9b* and *qSB12a* and were used to construct $F_{2:3}$ families. The resistance of $F_{2:3}$ families to the sheath blight pathogen *Rhizoctonia solani* was evaluated using a micro-chamber screening method in the greenhouse at Beaumont AgriLife Research & Extension Center, TX. Preliminary results showed that *qSB9b* and *qSB12a* segregated in typical Mendelian trait and function as dominant resistance QTLs. These results provide initial useful information for rice breeder to fully utilize these important QTLs for SB. These further suggest that strong SB resistant varieties/lines can be obtained by marker-assisted selection (MAS) method.

Development of U.S. Hybrid Rice Germplasm

Li, W., Oard, J., Ordonez, S., Sha, X., and Linscombe, S.

The potential for hybrid rice has generated considerable interest recently in the U.S. rice industry. Yield advantage of ~10 to 15% for commercial hybrids vs. inbreds has been realized in plot research by private and university researchers and farmers. However, there are certain disadvantages to current hybrids that include, but not limited to, lodging, shattering, milling quality, and yield stability. We propose to initiate development of hybrid rice germplasm that will address major limitations of commercial hybrids while maintaining high grain and head rice yields. This project will create a broad base of genetic material from different Asian and U.S. sources that can be rapidly incorporated into existing U.S. public breeding programs. Organization, activity, and progress of this project will also establish a knowledge base and working model of cooperation among U.S. public breeders for hybrid germplasm development.

Progress in Development of Male Sterile Germplasm for Hybrid Rice Breeding

Yan, Z., Yan, W.G., McClung, A., and Deren. C.

Currently, there are two types of male sterility mainly commercialized in hybrid rice production, three-line type or cytoplasmic male sterility (CMS) and two-line type or environmental male sterility (EMS) via both photo-period and temperature. The great majority belongs to the CMS and there are four strategies that have been proven successful in breeding hybrid rice in China started in 1960s. The first is to cross the less evolved or wild rice, which is naturally male sterile, with *indica* cultivars adapted to early season cropping, represented by Zhenshan 97A and Xieqingzao A. The second is to cross African rice adapted to lower latitude environments with Chinese cultivars adapted to higher latitude environments, represented by Gang 46A and D ShanA. Similarly, the third is to cross Indonesian rice in the low latitude with Chinese cultivars in high latitude, represented by II-32A and Zhong9A. The last is to cross *Japonica* with *Indica* rice cultivars, represented by K17A. Most male sterile lines in the EMS are bred from natural sterile plants in either *Japonica* cultivar such as Nongken 58, or *Indica* breeding line and cross of *Indica* with *Japonica* cultivars such as Pei-ai 64s, Annong S, Anxiang S and Guang Zhan 63S. Most of commercial restoring lines either are cultivars bred by the International Rice Research Institute (IRRI) as IR24 and IR26 for the 1st generation of hybrid cultivars or derived from IRRI cultivars like Minghui 63, Shuhui 527 and Fuhui 838.

The USDA rice world collection holds about 20,000 accessions of 19 species originated from 116 countries. There are 2,082 accessions from China including those obtained in 1996 exchange program, 355 from Indonesia, 3,201 from IRRI and Philippines, and 1,052 from 26 countries in Africa in the collection. In the collection, 34% of the accessions belong to *indica*, 25% to *tropical japonica*, 24% to *temperate japonica*, 10% to *aus* and the remaining 7% to *aromatic*. Therefore, our objective is to use the highly diversified germplasm collection and use these successful strategies to breed male sterile germplasm for being utilized in the U.S. rice breeding programs.

A total of 156 accessions including 19 accessions of wild rice species were sampled from the USDA rice world collection and planted in single-plant-hill-plot, 14 hills each. These accessions originated from numerous countries including Indonesia, Chad, Madagascar, Egypt, Senegal, Philippines, Mali, China, South Korea, Liberia, South Africa, Guyana, EI Salvador, Suriname, Gninea-Bissau, West Africa, Rwanda, Uruguay, India, Thailand, Vietnam, Italy and Dominican Republic. About 500~40 hills of F2 from each of 237 crosses among these accessions were planted for selection of both male sterile plants toward to breeding male sterile lines and fertile plants toward to breeding male restoring lines.

Numerous male sterile materials have been identified from crosses anomy PI 406035 from Chad, 400345 from South Africa, 373139 and 373140 from Senegal, 403391 from Indonesia, 369806 from Suriname, NSGC 6205 from China and U.S. cultivars, M-202, Francis and Rondo, etc. These selected materials were test-crossed with both maintaining and restoring germplasm accessions available in the collection according to our knowledge. Consistent effort will be paid to search for more male sterile materials and to follow up with the testing. Meanwhile, about 4,000 panicles were selected from the crosses involving the maintaining and restoring accessions according to our knowledge. A traditional breeding strategy will be taken for these panicles till advanced generation before testing their maintaining or restoring capabilities using the selected male sterile materials. This project is a collaborative effort with Drs. Bihu Huang and James Garner, University of Arkansas at Pine Bluff.

Identification of Informative Marker Panels for Population Assignment of Rice Germplasm

Agrama, H., Yan, W.G., and McClung, A.M.

Understanding the population sub-structure of rice germplasm accessions is useful for designing an effective strategy for gene transfer in a breeding program. Our objective was to develop a small marker panel that can effectively assign rice germplasm into one of five genetic sub-populations, *indica, tropical japonica, temperate japonica, aus* and *aromatic*. Highly polymorphic molecular markers, such as single sequence repeat (SSR), has markedly improved the resolving power for discrimination among closely related populations. WHICHLOCI is a computer program that selects the best combination of loci for population assignment through empiric analysis of molecular marker data. Successive assignment trials using data from one locus at a time rank the loci based on their efficiency for correct population assignment, or discriminatory power. Subsequent trials with increasing numbers of loci are then performed to determine which combination contains the minimum number of loci required to reach a specific level of assignment success. The minimum number of loci with maximum assignment success for each genetic population is important for saving time and resources in a breeding program.

The USDA rice germplasm Core collection possessing 1,794 accessions was genotyped using 72 SSR markers. The SSR markers were distributed over the entire rice genome about every 30 cM in genetic distance. Total genomic DNA was extracted using a rapid alkali extraction procedure from a bulk of five plants derived from a single plant selection of each accession. Each accession was inferred to one of the five sub-populations using the admixture analysis model-based clustering algorithms implemented in TESS v. 2.1. Using WHICHLOCI, each marker locus was ranked based on its discriminatory power for each sub-population, and a highly informative marker panel having a minimum number of loci required to reach 98% of assignment success was developed for each sub-population. Correspondence of population classification of each accession using the entire set of 72 SSRs and the informative marker panel was tested using correlation and regression analyses.

Marker panel with 98% of assignment success included RM125, RM536 and RM555 for *indica*; RM11, RM489 and RM555 for *tropical japonica*; RM489, RM171 and RM145 for *temperate japonica*; RM178, RM551 and RM1339 for *aus*; and RM551, RM169 and RM408 for *aromatic*, respectively. Determination coefficient (r^2) was 0.932 for *indica*, 0.910 for *tropical japonica*, 0.890 for *temperate japonica*, and 0.908 for *aus*. Thus, these initial results demonstrate that a set of 12 SSR markers was effective in assigning diverse germplasm to the five major sub-populations of rice. Further verification of each panel is needed using multiple sets of reference accessions. Once the assignment accuracy of each panel is well estimated, these markers can be used to identify germplasm within and among rice sub-populations pools to achieve breeding goals.

Abstracts of Papers on Economics and Marketing
Panel Chair: Steven W. Martin

The Farm Level Impacts of Cap and Trade Legislation on Texas Rice Producers

Raulston, J.M., Outlaw, J.L., Knapek, G.M., Anderson, D.P., and Richardson, J.W.

The passage of Cap and Trade legislation is expected to raise costs for agricultural producers across the nation. Prior AFPC research involving Cap and Trade and carbon sequestration assumed rice producers would be unable to benefit from offsets involving sequestering CO2 and selling CO2e credits, especially considering rice cultivation results in greenhouse gas (methane) emission. This study evaluates potential income that could be generated if rice producers are able to sequester carbon on cropland and sell CO2e credits. Alternative carbon sequestration and Cap and Trade legislation scenarios are examined to determine if Texas rice producers could generate sufficient income through selling CO2e credits to offset expected cost increases resulting from the passage of Cap and Trade legislation.

The potential impacts of H.R. 2454 on four representative Texas rice farms were evaluated accounting for the following principles: 1.) The anticipated energy related cost increases directly experienced by agricultural producers for inputs such as fuel and electricity and indirectly experienced, such as, higher chemical prices resulting from higher energy prices, 2.) The expected commodity price changes resulting from producers switching among agricultural commodities and afforestation of land previously employed in agricultural commodity production, and 3.) The estimated benefits to agricultural producers from selling carbon credits. AFPC currently does not maintain sector level economic models with the amount of detail required to develop estimates of all of the impacts listed above along with their feedback effects; therefore, recently published United States Environmental Protection Agency (EPA) estimates were utilized in evaluating the farm level effects. This study was the basis for estimating energy price changes along with estimates of carbon and agricultural commodity prices to evaluate the farm level impacts of H.R. 2454. The results of this analysis are dependent on the estimated outcomes contained in the EPA analysis of H.R. 2454.

The AFPC maintains a network of 98 representative farms, ranches and dairies located in major production areas throughout the United States. The network includes 14 representative rice farms with four located in Texas. Each representative farm was created through a focus group interview process in meetings typically involving four to six producers. Follow-up visits occur every three years to maintain and update the parameters necessary to represent production agriculture in these key regions. This study will team this representative farm data with a farm level simulation model developed by Richardson and Nixon at Texas A&M to evaluate the farms under a base and three alternatives. A base and three alternative price and carbon sequestration scenarios based on the EPA study and information from the Chicago Climate Exchange (CCX) will be examined. The base scenario assumes projected prices, policy variables, and input inflation rates from the Food and Agricultural Policy Research Institute (FAPRI) January 2009 Baseline. The C&T without Ag Carbon Credits scenario assumes H.R. 2454 becomes effective in 2010. This scenario imposes EPA commodity price forecasts along with estimated energy cost inflation on representative farm inputs. The C&T with Ag Carbon Credits run also assumes H.R. 2454 becomes effective in 2010 and imposes the same commodity price forecasts as the C&T without Ag Carbon Credits scenario; however, the farms are able to sell CO2e credits at EPA estimated market prices according to potential for carbon sequestration from CCX. The final alternative is C&T with ½ Ag Carbon Credits. This alternative is identical to the C&T with Ag Carbon Credits with the exception that the rice farms are assumed to only receive carbon credits on half of the cropland on the farm. A 2010 to 2016 study period will be evaluated, and average annual total receipts, average annual total cash costs, average annual net cash farm income, average ending cash reserves in 2016, and average ending real net worth in 2016 will be the key financial output variables used in ranking the scenarios.

All four of the rice farms will likely experience higher average annual cash receipts under the cap and trade scenarios, as rice prices are expected to be higher throughout the projection period with the passage of H.R. 2454. Although higher total receipts are expected, higher total cash costs are expected under the cap and trade due to increased input costs. Higher expected commodity prices alone will not be enough to offset increased costs due to passage of H.R. 2454. Selling CO2e credits on half of the cropland will help to defray some of the increased costs associated with the passage of H.R. 2454; however, it is expected that selling CO2e credits on all of the cropland will be necessary to fully offset the estimated increased input costs. Although this idea is promising, at the current time, it is unknown if Texas rice producers will be able to generate income from sequestering carbon on all of the land on their farms

Evaluating Gross and Net Share Rents in Louisiana Rice Production

Deliberto, M.A. and Salassi, M.E.

Many rice producers in Louisiana are renegotiating their crop share rental arrangements away from traditional cost-shares and towards a predetermined percentage of the market returns. Under this alternative to the traditional method, landlords contribute zero production dollars to the development of the rice crop. The magnitude of which this “net percentage” of the crop’s market return is paid to the landlord in exchange for land and/or water rights, can increase risk to the producer. By comparing the equity of a traditional cost share rental arrangements in terms of the degree to which returns are shared relative to production cost contribution(s) against those of paying a determined percentage of the crop, a producer can better evaluate their risk level. Proportionality is a key concept in land tenure negotiations due to the underlying principle that returns should be shared in the same proportion as the costs are contributed. Other production expenses such as seed, fertilizer, chemical, and drying may or may not be shared by the grower and landlord in the same percentage that the crop proceeds are shared. The inherent nature of the variability in cost sharing in agriculture is due to the fact that no two arrangements are exactly the same for two producers in one region or state.

Energy-related inputs, which require a large appropriation from the total rice farm operating budget, have seen the largest increase in per unit costs to date. The 2007/08 crop year brought extreme volatility into the agricultural production sector, and given the high production costs of rice, Louisiana producers were dealt with nearly a 20% increase in direct operating expenses per acre. During that time interval, per acre costs of fertilizer and farm diesel increased by 43% and 38%, respectively. The 2008/09 crop year witnessed increase in fertilizer expenditures by an additional 36%. However, farm diesel unit price (gallon) decreased substantially by 24%. This contributed to an overall 2% increase in direct operating costs per acre. However, the cost for conventional rice seed increased by 23% and Clearfield rice seed increased by 26%. Similar to an earlier statement that the landlord incurred the full increase in irrigation costs, the grower, in turn, will incur the seed cost. From 2007 to 2009, fertilizer has increased by 95%; conventional rice 52%; Clearfield rice seed 40%; and hauling 20%. Overall, direct for rice in Louisiana has increased by 21% per acre.

A financial simulation model was constructed in SAS to evaluate grower and landlord income levels, net returns, production costs, and risk measure among varying input cost parameters, market prices, and farm yield levels. A “gross” rent model evaluated a (GRW/LLD) 50/50, 60/40, 70/30, and 80/20 rental arrangements. The landlord was assumed to finance all irrigation pumping costs in the 50/50, 60/40 and 70/30 arrangements. Chemicals, drying, hauling, and fertilizer expenses were then said to be share relative to the portion of crop receipts shared. Random numbers were obtained using the SIMETAR software package for each selected farm input. There were six (6) variables incorporated into the model: rough rice price per hundredweight, farm diesel price per gallon, nitrogen fertilizer price per pound, phosphorus fertilizer price per pound, potash fertilizer price per pound, and average first crop yield per acre. Mean values were entered based on historical prices from 1999-2008. The model conducted 1,000 iterations per input. Next, a “net” rent model was constructed. Similar to the “gross” rent model selected farm inputs were set to vary. However, a major difference with this model was that the landlord received a flat percentage of the crop (a reduction from a traditional LLD share in the “gross” rent model) and contributed $0 in production costs.

Calculation of Economic Optimum Nitrogen Application Rates for Arkansas Rice

Watkins, K.B., Hignight, J.A., Norman, R.J., Roberts, T.L., Slaton, N.A., Wilson, Jr., C.E., and Frizzell, D.L.

Large price volatility and historically high nitrogen (N) prices in recent years have increased farmer interest in determination of economically optimal N rates for rice production. This study uses five to eight years of rice variety by N data from four research locations in Arkansas (the Southeast Research and Extension Center (SEREC) near Rohwer; the Northeast Research and Extension Center (NEREC) at Keiser; the Rice Research and Extension Center (RREC) near Stuttgart; and the Lake Hogue Research Farm (LH) near Wiener) to estimate quadratic rice yield response to N functions for each location/year. The soil series varies for each location (Perry clay (Vertic Haplaquepts) for the SEREC; Sharkey clay (Vertic Haplaquepts) for the NEREC; DeWitt silt loam (Typic Albaqualfs) for the RREC, and Hillemann silt loam (Thermic, Albic, Glossic Natraqualfs) for LH). Ex ante economic optimum N rates for rice are calculated by research location using the Maximum Return to N (MRTN) method. The MRTN method calls for estimation of yield response curves by location/year. Yields are then estimated by location/year in 1 kg N ha^{-1} rate increments from 0 to the maximum experimental N rate used for each location/year, and returns to N are calculated for each rate increment. The N rate with the highest average return to N across years is defined as the MRTN rate for each location. The MRTN results were calculated assuming a \$0.2736 kg^{-1} (\$5.58 bu^{-1}) rice price, a \$1.0248 kg^{-1} (\$0.4649 lb^{-1}) N price, and a \$0.3355 kg^{-1} (\$0.1522 lb^{-1}) custom N application cost. The MRTN results of this study apply only to public (non-hybrid, non-Clearfield) rice varieties.

Comparison of the results across locations indicates the MRTN rate and the associated MRTN yield and maximum return varies by location and/or soil texture. Silt loam is the soil texture at both the RREC and LH locations. However, the MRTN rates and average MRTN yields differ for both locations. The LH research location has the smallest MRTN rate (122 kg ha^{-1}) but also has the lowest average MRTN yield (8080 kg ha^{-1}) and consequently the lowest average maximum return (\$2045 ha^{-1}). Alternatively, the MRTN rate at the RREC location was 150 kg ha^{-1} with an associated MRTN yield of 8875 kg ha^{-1} and an average maximum return of \$2224 ha^{-1}. Thus, yield potential for the LH location is lower than that for the RREC location, and this is reflected by a lower MRTN rate at the LH location. Clay is the soil texture for both the NEREC and SEREC locations. The MRTN rates for both locations are approximately the same (181 kg ha^{-1} for the NEREC; 187 kg ha^{-1} for the SEREC). These rates are 31 to 65 kg ha^{-1} greater than those calculated for the LH and RREC locations and reflect the need to apply more N on clay soils than on silt loam soils to maximize returns. Yield potential also varies at the two clay soil locations. The MRTN yield at the SEREC location is larger than that at the NEREC location (8896 kg ha^{-1} for the SEREC location; 8422 kg ha^{-1} for the NEREC location). Thus, the average maximum return at the SEREC location (\$2180 ha^{-1}) is larger than that at the NEREC location (\$2058 ha^{-1}) even though both locations have nearly equal MRTN rates.

The MRTN method also allows the researcher to determine a range of applied N levels above and below the MRTN rate for which returns to N do not appreciably differ from the optimal return. Instances were deviations from the optimum make little difference in the decision maker's payoff are very common in agriculture. In this analysis, we arbitrarily define high and low N rates as those that produce returns within \$2.47 ha^{-1} (\$1.00 ac^{-1}) of the maximum return. The \$2.47 ha^{-1} value is the same as that used in a 2006 study evaluating MRTN rates for corn in the Corn Belt region of the U.S. Based on this arbitrary assumption, the rice producer may apply from 143 to 157 kg N ha^{-1} at the RREC; 115 to 129 kg N ha^{-1} at LH; 174 to 189 kg N ha^{-1} at the NEREC; and 180 to 195 kg N ha^{-1} at the SEREC to achieve returns within \$2.47 ha^{-1} of each respective location's MRTN assuming the same rice price and N cost assumptions listed above. The ranges for profitable N application in this study are narrower than those reported for corn in the Corn Belt study. Thus N application close to the MRTN rate appears to be more important for rice than for corn.

An Economic Comparison of Tillage and Cropping Systems in Arkansas Rice Production

Hignight, J.A., Watkins, K.B., and Anders, M.M.

Rice is Arkansas' highest valued crop and accounts for nearly 50% of U.S. production. Rice is typically rotated with soybeans although some acres are continuous rice or rotated with other crops such as corn, sorghum, cotton, and wheat. Most rice production in Arkansas is conventionally tilled (CT) which typically involves disking twice, land planning twice, and field cultivating once. No-till (NT) has been shown to reduce labor, fuel, and machinery cost but some of these cost savings may be offset by increased herbicide use and lower crop yields. Reductions of these costs should favor the use of NT cropping systems in Arkansas, but adoption has lagged the national adoption rate. The lack of adoption may be attributed to potential management issues, fear that grain yields will be significantly less than conventional-till (CT), and limited information about economic benefits and risk.

The objective of this study was to determine the yield, costs, and return differences between conventional and no-tillage cropping systems and examine the risk of each cropping system. Ten years of yield data were available for the economic analysis of five rice based cropping systems (Continuous Rice, Rice-Soybean, Rice-Corn, Rice-Wheat, and Rice-Wheat-Soybean-Wheat) under both CT and NT. The yield data come from a long term study at the Rice Research and Extension Service in Stuttgart, AR. Prices received and input prices come from the University of Arkansas, Mississippi State Budget Generator, and National Agricultural Statistical Service. Multivariate empirical distributions were created for the yields, and key input costs are simulated 500 times. The stochastic efficiency with respect to a function (SERF) method was used to calculate certainty equivalents in order to rank the five cropping systems under CT and NT over a range of risk attitudes and estimate risk premiums to no-till.

Results indicate that the optimal cropping system for highest mean net returns and lowest probability of negative returns would be the rice-soybean cropping system. The continuous rice cropping system had the highest maximum returns indicating this rotation would be the most profitable if yields and prices were high. The rice-wheat-soybean-wheat cropping system had the lowest minimum returns indicating that if yields and prices were low this rotation would be the least profitable. No-till would be favored in all cropping systems besides rice-corn by risk adverse producers. Risk adverse no-till producers would have a positive risk premium (benefit to no-till over conventional-till) of $173, $105, $102, and $216/ha for the continuous rice, rice-soybean, rice-wheat, and rice-wheat-soybean-wheat cropping systems, respectively. Risk adverse conventional-till producers would have a positive risk premium (benefit to conventional-till over no-till) of $24/ha for the rice-corn cropping system.

The results of the study should provide data to producers on risk in rice-based cropping systems. The results indicate that the rice-soybean rotation has less risk than other cropping systems and highlights why most rice grown in Arkansas is rotated with soybeans, but also indicates that continuous rice has the potential for the greatest returns. The results also provide data to producers that no-till can be more profitable and less risky for many cropping systems in Arkansas.

The State of U.S. Rice Farming: Using the 2007 Census of Agriculture to Identify Issues and Trends

Baldwin, K.L. and Childs, N.W.

Consolidation continues to be a major trend in U.S. agriculture, with rice farming no exception. Using data released in the 2007 U.S. Census of Agriculture, rice farming trends and operator characteristics are identified and compared with the other major field crops (corn, cotton, soybeans, and wheat) and with characteristics reported in previous Census. Since 1997, the number of rice farms in the U.S. has decreased, while the remaining farms have increased in size. In addition, large farms (those with at least 1,000 acres planted to rice) now account for the largest share of U.S. production. These large farms are increasingly operated by either part-time owners or tenant farmers.

U.S. rice farms have not only increased in area, but farm income receipts have risen as well. In 2007, more than two-thirds of rice farms had gross sales of more than $250,000, compared with about one-third in 2002.

The location of U.S. rice farms is also changing. Although the number of rice farms has declined in each producing State—Arkansas, California, Louisiana, Mississippi, Missouri, and Texas—the decline has been strongest in Louisiana and Texas. The increasing share of U.S. rice farming located in the Mississippi Delta, and declining share on the Gulf Coast, is a long-term trend.

In addition to changes in characteristics of U.S. rice farms, farm operator traits are changing as well. The average age of the American rice farmer has increased since 2002. Despite the increase, rice farmers have the smallest share of producers over 55 compared to producers of other major commodities. Additionally, a larger share of rice farmers now receives income from off-farm source than in 2002 or 1997. However, the share is smaller than for all other major commodities.

Economic Factors behind USDA's 2010 Domestic Baseline Forecasts for Rice

Childs, N.W. and Baldwin, K.L.

USDA's 2010 long-term annual supply and demand baseline results for the U.S. rice industry are presented for both long-grain and combined medium/short-grain rice. An all-rice baseline – an aggregate of the by-class model results – is reported as well. Emphasis is placed on forecasting area response, yield growth, export and import levels, domestic use, stock holdings, and season-average farm prices by class. Underlying economic factors driving these projections for both classes of rice are explained. Because almost half of the total U.S. rice crop is exported annually, expectations regarding the world rice market – including trading prices – affect domestic baseline forecasts as well.

Changing market conditions necessitate annual long-term baseline projections, as market participants and policy makers need updated forecasts for planning, budgeting, and decision making. Each year, USDA develops both a domestic and international 10-year supply and demand baseline for rice. By-class models are developed only for the domestic market.

The baseline effort cuts across multiple commodities including grains, oilseeds, cotton, specialty crops, dairy, livestock, and poultry. The baseline assumes normal weather over the 10-year period and that current U.S. and global farm policies remain in effect. The baseline forecasts are made under given assumptions regarding global and domestic population and income growth, interest rates, and exchange rates. The 2010 baseline forecasts were developed in November 2009.

Forecasting U.S. Season-Average Rough-Rice Prices

Baldwin, K.L., Childs, N.W., and MacDonald, S.A.

Two years after the onset of 2007/08 run-up in global rice prices, U.S. rough-rice prices remain well above their long-term average and market uncertainties persist. Existing rough-rice price models no longer provide accurate forecasts in today's more volatile environment, partly due to the omission of variables currently impacting global and domestic rice prices. Price movements since 2007/08 support the view that long-grain and medium/short-grain rice prices are typically driven by different factors, underscoring the need for separate by-class forecasting models.

In response to changing market conditions and a greater need for by-class price models, U.S. season-average rough-rice price models are developed for all-rice, long-grain, and combined medium/short-grain. The newly specified U.S. rough-rice price models incorporate both domestic and global explanatory variables, including world rice prices, exchange rates, U.S. rice acreage, and domestic stocks.

USDA's 2010 Global Rice Market Baseline Analysis

Childs, N.W. and Baldwin, K.L.

USDA's 2010 long-term annual supply and demand baseline results for the global rice market are presented. Emphasis is placed on forecasting area response, yield growth, export and import levels, domestic use, and stock holdings for 32 countries and 7 multi-country regions. Aggregated, these 39 models account for total global rice production, supply, and use. Economic factors driving long-term trends in key individual countries and regions are explained, as well as significant changes from the previous baseline.

Each year, USDA develops both a domestic and international 10-year supply and demand baseline for rice. The baseline effort stretches across multiple commodities including grains, oilseeds, cotton, specialty crops, dairy, livestock, and poultry. The baseline assumes normal weather over the 10-year period and that current U.S. and global farm policies remain in effect. The baseline forecasts are made under given assumptions regarding population and income growth for individual countries, interest rates, and exchange rates. The 2010 baseline forecasts were developed in November 2009. USDA's annual baseline projections are used by market participants and policy makers for planning, budgeting, and decision making.

Comparison of FAPRI, OECD, and USDA Rice Baseline 2009-2018

Mane, R.U., Wailes, E.J., and Chavez, E.C.

This paper analyses differences in rice baseline (FAPRI, USDA, and OECD) projections with respect to different global variables; production, ending stocks, prices, and trade. Underlying differences in macroeconomic assumptions and model structure are highlighted to explain differences among projections.

The comparison of 2009 baseline projections is made in order to identify differences and source of difference of the global rice supply and demand. Each of the three baselines is compared in order to identify the similarities as well as differences in their projections. Where large differences between rice baselines are identified the paper provides an assessment of the causes, including differences in macroeconomic assumptions and structure of the projection models.

The paper is divided into three different sections; the first section of the paper describes each model used in estimation of the baseline. Second section of the paper gives a brief overview of each baseline and the final section of the paper compares every baseline with respect to area harvested, yield, production, ending stocks, net trade and prices. Although, FAPRI, OECD and USDA baseline have somewhat similar structures and processes of developing baseline projections, but there are significant difference in their projections for global production, consumption, and prices (Wailes, 2004).

The FAPRI, OECD and USDA baselines are prepared and maintained by University of Arkansas, the Organization of Economic Cooperation and Development with the Food and Agricultural Organization (FAO) of the United Nations and U.S. Department of Agriculture (USDA), respectively. These institutions have created and maintained their own rice baselines, which make projections for 10 years. In this paper a comparison of the 2009-2018 baseline projections are made.

There are large differences in all three baselines with respect to different variables of world rice sector projections. However, the projections exhibit similar trends. We conclude that they have similar assumptions in their projections but the magnitudes of their assumptions vary. Furthermore, macroeconomic assumptions such as economic growth, expansion of bio-fuel production, and population growth rates are similar for each baseline. Similarly, there are large differences in the projections for major rice exporting and importing countries such as Australia, Indonesia and Bangladesh. Despite of variation in global projections and prices OECD and USDA baseline have same projections for net trade. Likewise, the world reference price (Thai 100 percent, grade B) for the FAPRI baseline is higher than the OECD and USDA baselines due to lower ending stocks.

Explaining the 2008 International Rice Price Spikes:
Impacts of Trade Policies on U.S. Rice and Commodity Markets

Wailes, E.J. and Chavez, E.C.

In the 2007/2008 marketing year, major rice exporting and importing countries adopted trade policies to reduce food price inflation in their domestic economies. These policies included increased export restrictions and reduced import tariffs. The objective of this study is to evaluate the impact of these policies on world rice prices, trade and the role the U.S. played in helping to stabilize this volatile market.

In order to capture the inclusive impact of trade policy modifications on agricultural commodity markets, a broad modeling system of the world agricultural sector is utilized. The models are a set of multi-market, partial-equilibrium, and non-spatial models of agricultural crops. The models cover major temperate crops, such as wheat, corn, barley, sorghum, rice, soybeans, rapeseed, and sunflower for all major producers and consumers. Extensive market linkages exist in these models, reflecting competition for land in production and consumer substitution possibilities for close substitutes.

The model structure and the elasticities used in the model are based on analysis of historical data, current academic research, and a reliance on accepted economic and agronomic relationships in the agricultural markets. The models are used to establish commodity projections for a baseline and for market outlook and policy analyses.

In this study, the analysis is based on a 2008 baseline (FAPRI) modified by specifying the 2007 export and import policy regimes that existed before the commodity price inflation. The baseline projections include supply, utilization, and prices for grains, rice, and oilseeds, including their by-products. The scenario is then generated by imposing for three years (2008/09 – 2010/11) the export and import policy changes that were adopted in response to the price inflation in 2007/08 marketing year. The difference between the baseline and scenario represents the impact of the trade policy changes.

Results are the average of the annual changes between 2008/09 and 2010/11. It is clear that the world prices for selected grains and oilseed products all increased due to higher export restrictions and lower import tariffs in the global market, except rapeseed meal. World rice price increased the most since rice is a thinly traded commodity in the global market, where less than 7% of the production enters international markets. Furthermore, trade is highly concentrated with only six countries accounting for 90% of the global rice exports. Increases in grain prices were generally higher than the increase in oilseeds and its derived products prices as more policy adjustments were executed in the grain markets.

The scenario results for rice contribute to our understanding of why international rice prices increased dramatically in the 2007/08 marketing year. The Thai 100% B world reference price for long grain rice increased from $346 per metric ton (MT) in 2006/07 to $551 in 2007/08, a 59.2% increase. The policies modeled in this analysis resulted in an increase of 36.8% in 2008/09, thus explaining approximately 62.2% of the actual rice price increase. The three-year average price impact was an increase of 24.4%. This price increase is driven by a decline in the world net trade by 1.13 million metric ton (MMT) which is approximately 4.1% of global net trade for the three-year period. The net trade was reduced particularly in the key exporting countries of India (-27.0%), Vietnam (-12.2%), Egypt (-28.0%), and Pakistan (-3.7%). Partially offsetting the net trade decline were increases in net trade by the Western Hemisphere exporters, the U.S. (+54.2%), Uruguay (+5.7%) and Argentina (+3.1%).

Competitive Costs and Policy Environment Analysis for EU and U.S. Rice Trade

Thompson, J., Wailes, E.J., and Durand-Morat, A.

Less than 7% of world rice production is traded on the world market. The European Union is one of the major importers of rice whereas the United States is a major exporter and as such they form an important economic relationship. The trade relationship between the U.S. and the EU has been one fraught with disputes about protectionism and political debates.

EU policy changed significantly in 2003 as part of the Mid Term Review of the Common Agriculture Policy in Europe. Subsidies were decoupled from production and intervention prices were drastically reduced to reflect a movement away from amber box, trade distorting, policies. Subsidies now consist of a single farm payment and historically determined decoupled payment. These changes minimally reduced production within the EU, but external factors helped to maintain price levels for EU producers at or above the new intervention price.

European rice production is concentrated in a few major producing countries including Italy and Spain. Most of the rice produced is consumed within the EU. Imports satisfy the remaining demand. Due to policies and trade barriers, the major rice export from the U.S. to the EU is husked or brown rice, which is milled within the EU. Because of the level of rice that was historically traded, after the MTR policy reforms, new trade agreements had to be renegotiated and import levels arranged. All major exporting countries associated with rice were also part of new trade agreements that conditioned new import levels at their respective tariff rates. Every six months there is a review of trade levels and the next six month period of tariffs are applied according to the previous six month trade levels.

In comparing production costs, the U.S. tends to have larger farms with higher returns. The average EU farm produces on 45 hectares or roughly 113 acres and the average U.S. farm produces on 511 acres. The average net farm income per farm is lower in the EU and represents the difference in farm size. Farms in the U.S. are typically highly specialized, whereas farms in the EU are much more diverse even in specialized cropping. The difference in production is the amount of total land devoted to rice production. The U.S. has more total acres in production than EU. The newly decoupled subsidies in the EU help maintain producer income levels at levels pre-MTR policy changes and this has helped to sustain EU production levels. Single farm payments received by EU producers are tied to historical production as well complying with food safety, animal welfare, and environmental standards.

In 2006 there was contamination of genetically modified rice that was exported to the EU market. A strain of Liberty Link rice (LL601) not approved for human consumption accidently contaminated the seed stock of several popular long grain varieties sold to farmers and eventually exported. This strain was subsequently approved by the U.S. government for human consumption, but was not approved by the EU. This caused both economic and policy ramifications. Based on the EU's adherence to the precautionary principle and asymmetrical policies regarding testing procedures between the EU and U.S., the European Union banned all rice shipments for a period of time, and when shipments were allowed the regulations in place were significant deterrents for rice exports from the U.S. EU buyers had to supplement their demand by importing from other countries such as Thailand and Uruguay, furthering the economic effects to U.S. producers from this contamination. Trade between the two countries still has not resumed to pre-contamination levels.

Because of policy decisions and market events, rice trade between the U.S. and EU has been marred since the Liberty Link GM rice contamination in 2006. While trade barriers have been lifted, the economic effects of this event still affect trade between the two states. The U.S. has a major share of rice exports on the world market and historically the EU market, but without transparent and fluid trade relations with importing countries, the effects will persist taking both political and financial tolls.

The Mexican Rice Economy: Implications of a Growing Economy on the Mexican and U.S. Rice Sectors

Sharp, M.D., Wailes, E.J., and Durand-Morat, A.

Historically there have been many factors driving Mexican rice production and that continues to be the case today. The Mexican rice economy is characterized by relatively low domestic production while domestic demand has increased over time. While current high world prices have provided an incentive for increasing rice production in Mexico, the shift away from rice into expanded production of fruits and vegetables since the inception of NAFTA has resulted in Mexico having become the largest export market for U.S. rice. Imports of rice are predominantly rough rice. This trade pattern developed early in the NAFTA implementation period as a result of tariff escalation which supported the Mexican rice milling industry.

The relative decline in domestic production of rice in Mexico is explained by various factors including physical constraints such as the availability of land and an adequate water supply. There is still a large portion of Mexican rain-fed rice production in the southern part of the country. Other constraints on rice production in Mexico include the small amount of direct government supports to rice farmers as well as the availability of competitively price rice imports from the United States. A comparative analysis of costs of production of the U.S. and Mexican governments reveals that the U.S. generally faces lower and more stable costs of production, particularly in the production of long-grain rice, than does Mexico. In general, Mexican producers face high costs of production in the areas of harvest, land preparation and the use and application of chemicals.

The gap between domestic rice production and rice demand has lead to an increasing amount of imports of rice into Mexico from the United States. Mexico has consistently remained the number one rice export destination for U.S. long-grain rough rice. Before NAFTA, Mexico was able to place high tariffs on milled rice to support local millers; now it has become very difficult for Mexico to prevent the import of rice from the U.S. because of the elimination of all tariffs. In the absence of tariffs, Mexico has resorted to other attempts to keep out cheaper milled rice by using anti-dumping complaints against the U.S. and placing restrictions on rice imports from the U.S. such as the requirement to use methyl bromide at the border to eliminate the presence of *Tilletia horrida* that temporarily stopped shipments in January of 2009. Moreover, since 1992 Mexico has prevented entry of rice from Asia due to "phytosanitary concerns" and it continues to place high tariffs, particularly on milled rice, to other countries besides the U.S.

This paper illustrates how the factors mentioned above affect Mexican rice production and the impact those factors have on trade. It examines trade flows to Mexico as well as the rice trade relationship with the U.S. over time. The comparison of rice production costs in the U.S. and Mexico provides an analysis that explains the relative competitiveness between the two rice producing countries. And finally, additional factors are analyzed to project Mexico's future in rice production and rice trade.

Increasing Adoption of Hybrid Rice and Its Impact on the Pattern of Global Production and Trade

Durand-Morat, A. and Wailes, E.J.

Growth forecasts for the next two decades point to significant population increases, concentrated primarily in developing countries where in many countries rice represents a major staple food. At the same time, if current trends continue, we expect a decrease in total rice acreage resulting from a reallocation of current rice land into other crops, such as biofuels. In this scenario, the only alternative to cope with increasing demand and shrinking factor endowments is to increase the productivity of the constraining factor.

There are many ways to improve rice land productivity, including the adoption of high yielding hybrid seeds. The hybrid technology is seen by many as a great tool to deal with the potential supply shortage given the yield improvement vis-à-vis inbred cultivars reported in experimental as well as commercial production in several regions worldwide.

This study employs a spatial partial equilibrium model of the global rice sector to assess the potential impact of further spreading the hybrid technology. In this framework, production is specified as a two-stage budgeting process, the first of which determines the conditional demand functions for intermediates and the value-added composites, while the second stage determines the derived demands for factors of production and intermediate inputs. A number of technology variables associated with the productivity of the upper level composites as well as individual factors and inputs are included. Production sectors are allowed to produce multiple commodities, whose aggregate output by commodity can be allocated into either the domestic or international market. Primary commodities can also be used to replenish stocks. Imports and domestic output are employed as inputs in the production of a composite commodity, which can be either used as an intermediate input in production or for final consumption by domestic consumers. Final consumption is represented by a demand function accounting for substitution as well as income effects. The model is flexible with regard to the specification of production technologies and consumer preferences, allowing the user to choose between some traditional production, transformation, and demand functions (CES, Cobb-Douglas, and Leontief technologies and preferences; and CET, Cobb-Douglas, and Leontief transformation functions). The model is calibrated to the calendar year 2005.

The forecasted increase in aggregate rice demand must be met by increases in supply in order for commodity prices to remain stable. However, increases in commodity supply under inelastic factor supply scenarios, primarily land and water, would be possible only by improving rice productivity. The scenarios analyzed in this study involve the adoption of hybrid rice. It is expected that those regions experiencing high adoption rates would be able to improve their self-sufficiency ratio, thus substituting imports (e.g., Indonesia and Bangladesh) or improving exports (e.g., China, India, Vietnam, the U.S.).

Decomposing Producer Price Risk: The Case of U.S. Rice

Djunaidi, H., McKenzie, A., and Wailes, E.J.

The purpose of this paper is to determine factors that affect the variability of the U.S. long-grain rough rice producer's price by decomposing the source of the volatilities. There are many sources that affect producers' price. However, this paper focuses on the effect of intra month and intra year price volatility at the port of exports. The results show that both intra month and intra year price movements at Houston and southwest Louisiana ports of export explain significantly the variability of the U.S. long grain rough rice producer's price risks. A one percent change in intra month and intra year Houston export price variability will affect the rough rice producer's price to vary about seven and one-tenth of a percent, respectively. The same results are also found when the southwest Louisiana export price is utilized in the analysis where the intra month and intra year effect is six and one-tenth of a percent, respectively. Both intra month and intra year price fluctuations at the port of exports show important source of producer's price risks. This suggests that the rice growers might be able to optimize their return by accommodating the information in their marketing decisions. Moreover, the ability to forecast intra month price variability at the port of export not only enables the rice producers to lock-in a more favorable selling price which will lead to a better return for their product, but also to help sellers to apply more effective hedging strategies which can be used further to minimize the price risks.

Analysis of U.S. Rice Export Flows: An Application of a Gravity Model

Lakkakula, P. and Wailes, E.J.

This paper analyzes the flow of the United States' rice exports to its top importing countries using a gravity flow framework. The U.S. dominates the rice exports to destinations in the western hemisphere. Although it produces only the relatively small amount (<2%) of the global rice output, its exports account for about 10% of the world rice trade. It is also the only major exporter of rough rice in the world. The study examined U.S. rice export shipments over the period of 1990 to 2008. Aggregating over this period, the top ten countries that imported U.S. rice are – Mexico, Japan, Haiti, Canada, Saudi Arabia, Turkey, United Kingdom, Brazil, Iraq and South Africa. The paper focuses on the factors that influence the export flows of the U.S. to these key importing countries. For this analysis we used data from 1990 to 2008 from the USDA, Foreign Agricultural Service, Global Agricultural Trade System (GATS) online data base.

The analytical framework used in this study is the gravity model of trade. The gravity model of trade is one of the more popular models used in international trade analysis of global trade patterns. This model is based on the law of gravity equation. The model explains that the exports from one country to another country are based on their economic sizes (GDP or GNP), their population, geographical distance and other variables such as cultural similarity and historical relationships, etc. It implies that the volume of trade can be estimated as a function of trade promoting factors such as population, income and relative production of trading partners and a decreasing function of trade resistance such as shipping distance and tariff barriers.

Specification of the U.S. rice export flows is in the form of the double-log model as an extended version of the gravity model. The variables included in the model are the GDP per-capita of the importing country, rice production in the U.S., rice production in the importing country and a dummy variable for the existence of a free trade agreement or special trade commitment between the U.S. and respective importing country. The estimation technique used is the Least Square Dummy Variable (LSDV) estimator.

The estimated model explains nearly 70% of the variation in bilateral rice trade flows from the United States to its leading rice importers. As rice has become an inferior food staple food in many countries, a statistically negative relationship was estimated for the per capita income variable in the importing country. Similarly, the level of rice production in the importing country had a statistically negative relationship. The existence of a free trade agreement or special side trade agreement has a significant positive relationship. In general the estimated effect of distance was also negative. Finally, no statistically significant relationship between U.S. rice production and bilateral trade flows was estimated.

This analysis represents a preliminary effort to assess more comprehensively rice export flows to all rice importers from all major rice exporters. The estimation technique used for this study (least squares) results potentially in biased estimates if any of the data used in estimation have zero values. For this analysis, small positive values were substituted for zero values. Alternative estimator methods, such as the standard Heckman correction for selection bias and zero trade flows, the Eaton and Tamura Tobit estimator for zero trade flows or the Poisson pseudo-maximum-likelihood technique to correct for heteroskedasticity and zero values will be used.

Food Security Responses to Instability in the Rice Global Economy for Selected Countries: Implication for the United States

Amboarasoa, M. and Wailes, E.J.

The paper examines food security, commonly measured by caloric intake, objectives and policies for selected countries including Bangladesh, Cambodia, Lao People's Democratic Republic, Indonesia and Madagascar where caloric food intake depends most heavily on rice. Specifically, the paper analyses domestic policy responses to price spikes of 2007-2008, and implications for the United States' response. The study reveals that despite the similar heavy dependence on rice for these selected countries, policies adopted by these countries differed markedly in response to rice price instability. Also, the transmission from international prices to changes in domestic prices in these countries during 2007/08 rice crisis varied to a considerable extent. While the world rice price more than doubled, only in Cambodia did its domestic price increase by double whereas the other countries succeeded in maintaining lower domestic price increases. This was primarily due to domestic policies implemented by those countries. For instance, as a short-term response, Madagascar adopted a zero tariff policy for imported rice. Moreover, the Madagascar government imported rice from India at subsidized prices in 2008, which accounted for 25 percent of 2008 rice import. That policy contributed to keeping the increase of the domestic rice price at 10% between 2007 and 2008. For Bangladesh and Indonesia, domestic rice prices increased respectively by 45% and 23%. To offset the declining supply in 2007/08, and therefore to stabilize its domestic price, Bangladesh tripled its rice imports, of which 80% were imported by the private sector. On the other hand, a net rice-exporter like Cambodia implemented an export ban on March 2008 but lifted it two months later as a result of a bumper harvest. Also the selected countries increased significantly their producer supports through subsidies, particularly Bangladesh and Indonesia. Significant increases of acreage and yields, coupled with relatively normal weather, led to historically high rice production levels for 2008/2009. Also, none of these countries explicitly control their domestic rice prices, instead they currently operate in a liberalized rice market. Nevertheless, the paper identifies rising concerns about the cost effectiveness of pursuing rice self-sufficiency policies given that these countries are likely to have budget constraints. The implications for the United States suggests that by not limiting its rice trade, the U.S. benefitted from trade policies adopted by other major rice exporters and importers. Furthermore, higher prices have resulted in a supply response in 2009/10 where the U.S. is likely to increase its global market share. The U.S. will benefit in the longer term if import deficit countries do not shift limited resources toward achieving rice self-sufficiency.

China's Rice Supply and Trade: Constraints and Potential

Lu, Q. and Wailes, E.J.

Rice is the dominant staple crop and plays a crucial role in maintaining food security in China. Meanwhile, China is the world's largest rice producing and consuming countries, and any changes in China's rice production and consumption can have a significant impact on the global rice market. Hence it is very important and necessary for us to evaluate status rice supply and demand, to examine constraints on rice supply and analyze the potential of China's rice trade. This paper provides empirical evidence on the supply, demand and stocks of China's rice sector. Econometric estimates of elasticities with respect to price and non-price factors are presented with the main purpose of identifying the key variables that determining rice supply, demand, and trade of China's rice in the foreseeable future.

We develop a system of equations including supply (yield and area), consumption (urban and rural) and ending stocks of China's rice and estimate model parameters using time series data. In terms of rice supply, the result for the regression of the yield response indicates that the elasticity values of the own price and fertilizer price are 0.046 and -0.129 respectively. The elasticity of labor wage input is -0.09, which implies that labor is a key factor of promoting rice yields. Government price subsidy has a positive but insignificant coefficient estimate. The result for the regression estimates of the acreage response show that the elasticity of wheat price relative to rice price is -0.1148, obviously, the change in relative price has an important effect on rice acreage. The acreage response elasticity of rice price is 0.161 in the short run, reflecting that farmers have a slow adjustment response to prices on planted area. The acreage response elasticity for labor price is -0.048, which partly explains the declining tendency of planted acreage in China. Wage rates have risen 5% annually since 1986.

With respect to rice demand, the equations of per capita rice consumption are divided into rural and urban populations. The equations are estimated and the result indicate that the price elasticity of demand is -0.115 and -0.140, the income elasticity of demand is -0.157 and -0.216, the demand elasticity of wheat price relative to rice price is 0.169 and 0.10 for rural and urban populations, respectively. The estimated equation for China's ending rice stocks results in an elasticity with respect to domestic rice price of -0.229, while the elasticity with respect to the international rice price is 0.937.

To forecast the production and trade of rice, we make projections in the values of each independent variable in the production and consumption function for 2003 and 2008, the basic assumption is that rice price will rise 0.77% annually, labor price will rise 5%, and rural and urban population will rise -0.94% and 4% ,income in rural and urban area will rise 6.6% and 7.6% respectively, the predicted results show that the total consumption will have a decreasing trend , but the total production will have an increasing trend. According to the predicted results, the net exports of China's rice will rise significantly in the coming decade.

Long-Term Baseline Supply and Demand Projections for Selected African Rice Economies, 2010-2019

Chavez, E.C. and Wailes, E.J.

This paper focuses on projections of rice production, consumption, trade, and price estimates for twelve selected key rice importing countries in Africa—Nigeria, South Africa, Ivory Coast, Senegal, Ghana, Cameroon, Mozambique, Guinea, Kenya, Tanzania, Sierra Leone, and Mali. Being self-sufficient in rice and a major exporter of medium grain rice to the world market, Egypt is excluded in this analysis. These projections provide baseline estimates that can be used for evaluating and comparing alternative policy and market assumptions that affect the global rice industry. Estimates are generated by adding new supply and demand equations for nine African countries to the Arkansas Global Rice Model (AGRM), a non-spatial econometric model developed and maintained in the Department of Agricultural Economics and Agribusiness at the University of Arkansas in Fayetteville. AGRM currently covers forty countries.

Catalyzed by the Alliance for a Green Revolution (AGRA), concerted efforts to achieve a uniquely African Green Revolution are currently underway. AGRA's vision is to have a "food secure and prosperous Africa achieved through rapid and sustainable agricultural growth based on smallholder farmers who produce staple food crops". The issue of food security is becoming a more pressing concern in the region, as riots related to food shortages occurred recently in a number of countries. Rice is a staple food and a major source of calories in Africa.

Over the last 10 years, the 12 countries analyzed imported nearly 50% of its domestic consumption on average. In 2009, while the 12 countries accounted for only 3.8% of global rice area harvested, 1.7% of world rice production, and 2.9% of global rice consumption---the group accounted for 21.4% of world rice net trade---thus playing a prominent role in the dynamics of world rice prices. This situation becomes more important, given the fact that rice is thinly-traded. This study aims to contribute to the better understanding of the increasing role of these African countries in the global rice economy.

Over the next decade, results of the analysis show that these 12 countries will increase their combined global share in rice--i.e., 3.9% of area, 1.9% of production, 3.8% of consumption, and 25.5% of net trade. Rice production is projected to grow annually by 2.2%, with 0.5% coming from area expansion and 1.7% coming from yield improvement. The area is projected to increase from 5.8 million hectares (mha) in 2009 to 6.1 mha in 2019. Average yield is projected to improve from 1.2 metric ton per hectare (mt/ha) to 1.5 mt/ha during the same period. The rate of yield growth could potentially be even higher, as the use of the locally-developed "Nerica" rice variety is expanded in the region. This variety is reportedly characterized by high yield, short growth duration, resistance to pests and diseases, and acceptable taste. At the forefront of research, development and partnership activities aimed at increasing the productivity and profitability of the rice sector is Africa Rice Center (formerly WARDA), an autonomous, CGIAR-supported intergovernmental association of 23 African countries based in Benin.

With combined population of the 12 countries growing annually at 1.7% and per capita rice consumption growing at 1.0% per year, total rice consumption is expected to expand at 2.7% per year over the next 10 years. Underlying this consumption growth is a relatively robust domestic economy, with real gross domestic product projected to grow annually at 4.8% on average. Per capita rice use is projected to increase to 37.1 kilogram (kg) over the same period, up 3.3 kg from the current level. Total rice consumption will expand from 12.8 million metric tons (mmt) in 2009 to 17.9 mmt in 2019. Combined rice net trade is projected to grow at 3.3 % per year.

In absolute terms, 59% of the gain in area of the 12 countries over the next decade is projected to come from Guinea and Sierra Leone. Nigeria and Mali account for nearly 50% of volume growth in production; while 43% will come from Guinea, Tanzania, and Sierra Leone. Over the same period, 32% of volume growth in consumption will come from Nigeria; and 45% is accounted for by Ivory Coast, Senegal, Guinea, Tanzania, and Mali. About 44% of volume growth in net imports is accounted for by Nigeria, South Africa, Ivory Coast, Kenya, and Mali.

Over the next decade, Africa 12 will have an increasingly important role in the global rice economy. While the green revolution efforts are expected to result in increased rice area and productivity, these gains are inadequate to offset growth in population and per capita consumption. The region will likely remain dependent on the world rice market to supply the domestic demand of its fast-growing population.

Analysis of U.S. Rice Export Markets: Long-Term Trends and Recent Developments

Bektemirov, K. and Wailes, E.J.

Although the United States accounts for less than 2 percent of global rice production, it is a leading exporter of rice in the international market, and accounted for more than 10 percent of global rice trade in 2009. The U.S. currently ranks third among major exporters, behind Thailand, and Vietnam. More than 45 percent of the U.S. rice crop is exported each year, making the U.S. market sensitive to movements in international prices. The U.S. produces medium and long grain types of rice and is in a unique position in that it can export significant amounts of both types. In the United States rice is segregated by length of grain: long, medium and short; each is sold in three degrees of processing: milled, brown, and rough. This paper analyses characteristics of the United States' rice export markets by types of rice and examines the dynamics of factors that are influencing export flows within each market in recent years for major export destinations.

The paper examines trends in U.S. rice production and use over the last 20 years. Total rice production in the U.S. has increased from 159.90 M.cwt. in 1988 to 203.73 M.cwt. in 2008, with the maximum amount of rice 232.36 M.cwt. produced in 2005. Total U.S. rice use (domestic use plus exports) has increased from 168.3 M.cwt. to 232.16 M.cwt. (rough basis) during this time period. Total volume of U.S. rice exports ranged from 2.5 MMT to 3.3 MMT (milled basis) from MY 1993/94 to MY 2008/09. However, this is well below the MY 2002/03 record of 4.1 MMT. Traditionally, U.S. rice exports include rough rice, parboiled rice, brown rice, and milled rice. Overall, the United States exports about a half of its rice crop, mostly to North and Central America, Northeast Asia, the Caribbean, and the Middle East and ships smaller volumes to Canada, the European Union, and Sub-Saharan Africa. In these regions, Mexico, Japan, Haiti, the United Kingdom and Iraq are traditionally the biggest export markets for the U.S. rice. In 2008 U.S. rice exporters picked up some additional sales to the Middle East, Sub-Saharan Africa, Oceania, and Southeast Asia.

The paper provides a description of developments in major markets for particular rice types during last 8 years. Mexico and Central American countries are the top markets for long grain rough rice. U.S. rough rice prices sharply increased in MY 2007/08, largely due to export bans that drove global prices to record highs, rapidly raising overall commodity prices, amid a weaker dollar. In MY 2007/08 Mexico accounted for more than 50 percent of total U.S. rough rice exports, but in MY 2008/09 it dropped to 38 percent. However, U.S. still supplies almost all Mexican rough rice imports. Brown rice accounted for 8 percent U.S. long grain rice exports during this time period. With the average amount of 240,147 MT imported in 1999-2006, the European Union was the top market for U.S long grain brown rice until the genetically modified rice contamination with Liberty Link 601 rice variety. The major reason the bulk of U.S. exports to the EU is brown rice was that import duties for brown rice are substantially lower than for fully milled rice.

In 2000-2008 medium and short grain rice accounted for about one third of the total U.S. rice exports. Rough rice accounted for 11 percent U.S. medium and short grain rice exports in this time period. However, volume of U.S. medium and short rough rice exports decreased significantly in MY 2008/09 with Mexico being the only market for it. Milled rice accounted for 75 percent U.S. medium and short grain rice exports, and during the last 5 years Japan was the largest market for both of them. In MY 2007/08, Japan imported about 340,000 MT of U.S medium and short grain milled rice, and accounted for more than a half of total U.S. medium and short grain milled rice exports. Over several recent consecutive years, droughts have taken Australia out of the international rice market, therefore, Papua New Guinea - historically an Australian market – become the second largest importer of U.S. medium grain milled rice. Even Australia itself imported 27,390 MT of U.S. medium and short grain rice in MY 2008/09.

Comparison of Expected ACRE and DCP Program Payouts for Rice Farms West of Houston

Falconer, L.L., Knapek, G.M., and Raulston, J.M.

The 2008 farm bill offers farmers the option to continue participation in the current program (DCP) that consists of receiving direct payments (DP), counter-cyclical payments (CCP), and loan deficiency/marketing loan gain (LDP/MLG) payments, or receive average crop revenue election (ACRE) payments, with a 20% reduction in DP and a 30% reduction in loan rates for LDP/MLG. The decision to elect ACRE is irrevocable over the life of the farm bill. Signup is for each farm unit, so farmers do not have to elect ACRE or DCP for all farm units. The decision to continue with DCP or elect ACRE must consider the farm's yield risk, the state's yield risk, and the national price risk for 2009-2012. This poster compares expected DCP and ACRE payments under the 2008 Farm Bill for representative rice farms developed by the Agricultural and Food Policy Center (AFPC) in the area west of Houston. These farms have large direct payments, which leads to difficult decisions for stakeholders when comparing the certain benefits of the DCP program with uncertain returns from the ACRE program.

Two price scenarios were developed and used in this analysis. The first price scenario uses the World Agricultural Outlook Board's World Supply and Demand Estimates (WASDE) price projection for prices received by farmers for long grain rice for the 2009/2010 marketing year followed by prices projected by the Food and Agricultural Policy Research Institute (FAPRI) for all rice adjusted to long grain rice prices using a simple linear regression model. The second price scenario is built using the WASDE estimate for 2009/2010 and the Economic Research Service's (ERS) February 2009 USDA Long-Term Agricultural Projection for the 2010 through 2012 crop years

The four representative farms were created through a focus group interview process and are maintained and updated by AFPC personnel through return visits every three years. The farms include: 1) a 546 hectare rice farm (TXR1350) located in Colorado County, Texas. This is moderate-sized rice farming operation for the region. TXR1350 harvests 182 hectares of first-crop rice and 146 hectares of ratoon crop rice. The farm generated 98 percent of its receipts from rice during 2008, 2) a 1,214 hectare, large-sized rice farm (TXR3000) also located in Colorado County, Texas. This farm harvests 486 hectares of first-crop rice and 437 hectares of ratoon crop rice annually. TXR3000 realized 100 percent of 2008 gross receipts from rice sales, 3) a 728 hectare farm located near the Texas Gulf Coast in Matagorda County, Texas (TXBR1800). TXBR1800 harvests 486 hectares of rice annually (486 hectares of first-crop rice and 486 hectares of ratoon crop rice) and realized 100 percent of 2008 farm receipts from rice sales, 4) a large 1,295 hectare farm in the Texas Gulf Coast in Wharton County, Texas (TXER3200). TXER3200 harvests 432 hectares of first-crop rice and 389 hectares of ratoon crop rice each year. The farm also grows 173 hectares of soybeans and 259 hectares of grain sorghum annually. Eighty-four percent of 2008 receipts came from rice sales. The average farm prices for long grain rice in the WASDE/FAPRI projections were $275.80 per metric ton for the 2009/2010 marketing year, $270.73 per metric ton for the 2010/2011 marketing year, $274.48 per metric ton for the 2011/2012 marketing year and $274.69 per metric ton for the 2012/2013 marketing year. The average farm price for long grain rice for the ERS projection was $256.40 per metric ton for the 2009/2010 marketing year, $235.67 per metric ton for the 2010/2011 marketing year, $225.09 per metric ton for the 2011/2012 marketing year and $219.14 per metric ton for the 2012/2013 marketing year.

The results were consistent for all four farms based on the WASDE/FAPRI price projections. As would be expected, with relatively high and stable prices the DCP program was preferred by all four farms as the ACRE program could not generate sufficient payments to offset the loss in direct program payments. However, with the lower price projections in the ERS projection, results were mixed. For the TXR1350 and TXR3000 farms, there is a 53.4% and 51.6% chance respectively of receiving ACRE payouts in the 2009 to 2012 period. These more frequent payments under the ACRE program are not sufficiently large enough on average to generate a larger expected total than the DCP program, as each farm would receive higher average payouts under the DCP program.

The ACRE Program – Determining the Impact of This Whole-Farm Payment Program on Louisiana Rice Producers

Deliberto, M.A. and Salassi, M.E.

The Average Crop Revenue Election (ACRE) program payment option is an alternative to receiving a counter-cyclical program payment and is made available to eligible producers starting with the 2009 crop year. The ACRE program is revenue-based, meaning it is designed to protect against short-term revenue loses, depending on actual crop yields as well as market prices as compared to the price-based farm income safety net of the counter-cyclical program.

ACRE is a whole-farm program, meaning that this election of participation pertains to all covered commodities produced on the farm. Producers are able to enroll into the ACRE program at any time during the life of the farm bill, but once an ACRE program election is made, the decision is irrevocable until 2012. The decision to enroll a farm into the ACRE program means that the farm would agree to a 20% reduction in direct payments and a 30% reduction in the marketing assistance loan rate. Specifically, for Louisiana rice producers, the direct payment made per hundredweight would decrease from $2.35 to $1.88. Likewise, the market loan rate would decrease from $6.50 to $4.55 per hundredweight. In addition, the direct payment limitation would be reduced by 20%. ACRE payments are tied to current plantings on the farm where counter-cyclical payments are tied to an established base acreage and yield level. ACRE uses a factor of 83.3% of the planted acres while the CCP assumes that 85% of base acres are planted in rice. Program payments under the ACRE program option will be determined by two crop-specific triggers. A state-level trigger compares current year rice revenues per acre to a recent historical average using state yield levels and national market prices.

Major differences exist with this new payment option. Therefore, there are several important aspects of ACRE that a producer must consider. The most notable difference with this new program is farm eligibility criteria and payment rate determination. The direction of rice prices through the 2009/10 marketing year will have a significant impact on the potential of any program payments from ACRE. There is no guarantee that in any given year ACRE payments would more than offset the reduction in direct and marketing loan payments. ACRE increases the income risk which rice producers would face. Changes in yields as well as market price can trigger or not trigger a payment. Both the state and farm-level triggers must be met for before an ACRE payment is made. Higher levels of crop insurance due to higher premiums will enhance the ability to meet the farm-level trigger for ACRE.

A spreadsheet-based rice farm management decision tool has been developed to evaluate rice farm program payment options. Historical and projected data on rice price, state-level rice yields, and farm-level rice yields can be entered into the designated cells to provide the necessary information needed for ACRE, DP, and CC program payment calculations. Producers can use this management tool to decide which program is most conducive to their farming operation relative to farm yields and market forces.

Abstracts of Papers on Plant Protection
Panel Chair: Tom Allen

Diseases of Rice: Review of Common Names and Causes

Hollier, C.A. and Groth, D.E.

Common names of rice diseases and their biotic and abiotic cause(s) are used extensively in the literature and in other forms of communication among rice scientists. Over time new diseases are discovered and causes are renamed. Therefore, there is a need for standardization of these names so that miscommunication is reduced.

A list of common names for rice diseases found in the United States and their biotic or abiotic causes(s) will be presented and discussed for revision. The completed list will be submitted to the Standardization of Common Names of Plant Diseases Committee of the American Phytopathological Society for inclusion in an updated list.

Excellent Blast Field Resistance in the High Yield Taggart Rice Variety

Lee, F.N. and Belmar, S.

The high yield Taggart rice variety developed at the University of Arkansas System Division of Agriculture's Rice Research and Extension Center (UA-RREC), Stuttgart, AR was released to seed growers during the 2009 growing season. Taggart has the large kernel size desired for long grain milled rice and for the parboil industry. Taggart, with one of the highest yields in the 2006-2009 Arkansas Rice Performance Trials, averaged 9432 kg ha^{-1} at 12% moisture, which compares with yields of 9533, 9281, 9180 and 8474 kg ha^{-1} for blast susceptible varieties Francis, Wells, LaGrue and the blast resistant variety Cybonnet, respectively.

Taggart's overall disease package compares favorably with that of other high-yield blast susceptible varieties. Although susceptible to all blast races commonly found in Arkansas, Taggart generally exhibits an increased blast resistance in greenhouse assays when compared with contemporary varieties such as Francis and Wells. Taggart's overall rating of susceptible to moderately susceptible in greenhouse reaction assays to race IE-1k is especially important when compared with the very susceptible, and susceptible ratings for race IE-1k for the high yield varieties Frances and Wells, respectively.

More importantly, Taggart exhibits an obvious increased blast field resistance. Summary panicle blast ratings from inoculated upland field nurseries conducted during 2005 thru 2008 were moderately resistant, very susceptible, and susceptible for Taggart, Francis and Wells respectively. During highly blast conducive environmental conditions in 2009, average visual blast severity ratings (0 to 9 scale) were 6.6, 8.9, and 8.6 for Taggart, Francis and Wells, respectively in inoculated upland field nurseries located at the University of Arkansas System Division of Agriculture's Pine Tree Experiment Station (UA-PTES), Colt, AR and the UA-RREC. Historically, the lower blast severity rating of 6.6 in upland blast nurseries translates into a better response to blast cultural control practices and results in higher rough rice yields when field conditions are conductive to the rice blast disease.

The Arkansas-2009 Year in Smut

Brooks, S.A., Anders, M.M., and Yeater, K.M.

Historically, false smut has been a minor disease of rice in Arkansas. In recent years localized infestations and increased prevalence of false smut has raised interest in this disease. Weather constraints in 2008 and 2009 led to significant numbers of rice hectares being planted later than normal, a factor that has been associated with increased incidence of false smut. In addition, the wet growing season of 2009 promoted many diseases including smuts, and false smut was a common problem, even in fields that were not delayed at planting or harvest. The combination of weather interference with on-time crop planting, disease favorable conditions throughout the season, and highly susceptible rice varieties dominating Arkansas rice hectares, has created a significant disease problem.

False smut has been a persistent disease in experimental plots at the University of Arkansas Rice Research and Extension Center in Stuttgart, Arkansas. By exploiting natural occurrence and promoting disease incidence with inoculation, cultivar performance and smut resistance were evaluated under a variety of management practices. Highly effective false smut suppression was observed under a number of alternative management schemes, particularly in furrow-irrigated rice, where the disease was nearly eliminated in susceptible rice entries. False smut suppression was not limited to specific germplasm sources, and was effective for a number of susceptible rice cultivars and hybrids. Suppression of disease severity in aerobic soil conditions appears to be unique to the rice-false smut pathosystem, which can be exploited to achieve effective field resistance to this disease.

Genotypic Differences in Straighthead Resistance of Rice Cultivars

Huang, B., Yan, Z., Yan, W., and Ntamatungiro, S.

Straighthead is a physiological disorder of rice characterized by upright mature panicles with sterile spikelets. The exact cause of straighthead is unknown. Straighthead is the most important non fungal disease of rice in the United States and the oldest rice disease in Arkansas dating back to the 1900's. When a highly susceptible variety is grown under conditions conducive for straighthead, the resulting grain yield losses can be high. Reducing the impact of straighthead in rice will greatly increase grain yield and reduce rice production costs.

Twelve cultivars and 20 new breeding strains were evaluated in a field experiment at the Agricultural Experiment Research Station of the University of Arkansas Pine Bluff (UAPB) (Latitude: 34° 15' N, Longitude: 92° 01' W, Elevation: 232 feet) during the 2008 rice growing season. The objective of the study was to cross cultivars grown in Arkansas with breeding strains. The study was planted on April 24, 2008 and was managed according to recommended management practices. During the growing season, when air temperatures were over 35° C/95° F daily (from July 27 through August 15, when rice was in the flowering growth stage), symptoms similar to those of straighthead-affected rice plants were observed on 11 cultivars and strains. Compared to straighthead-free rice cultivars and strains, grain yield of cultivars and strains affected by straighthead was greatly reduced. One cultivar (Francis) and 6 new strains (PB-2, PB-12, PB-13, PB-17, PB-4, and PB-11) exhibited good tolerance to straighthead. There were significant differences ($P < 0.001$) in yields among these cultivars and new strains. The 4 top strains (PB-2, PB-12, PB-13, and PB-17) had significantly higher yields than the control cultivar (Francis). Also, PB-4 and PB-11 tended to have higher yields than the straighthead resistant variety Francis. They also showed significant differences when compared to the other two check cultivars (Wells and M202). The grain yields of these top 6 strains (PB-2, PB-12, PB-13, PB-17, PB-4, PB-11) were 9,886, 9,849, 9,098, 7,928, 7,147, and 7,141 kg/ha, respectively. The grain setting rate of those cultivars and strains were 70.4% to 87%. However, as mentioned above, the high temperatures could have been one of the factors that caused the observed straighthead. Our findings could indicate the presence of genetic variability among rice cultivars or strains, and may well suggest a possibility for genetic improvement towards tolerance of straighthead in rice.

A Comparison of the Rice CAPS SB2 Population's Sheath Blight Phenotype Evaluations: Effects of Years, Locations, and Gremlins

Groth, D.E., Moldenhauer, K., Oard, J.H., Sha, X., Boza, E., Lee, F., and Blanche, S.B.

A major criticism of rice sheath blight resistance evaluations is the variation between years, locations, and even in trials during the same year and at the same location. The rice CAPS population SB2 was evaluated in 2006 and 2007 in Louisiana and Arkansas in sheath blight-inoculated disease nurseries to determine disease reactions and consistency between years and locations.

The SB2 population of 325 lines and two parents was planted in inoculated sheath blight nurseries at the LSU AgCenter Rice Research Station, Crowley, LA, and at the Arkansas Rice Research and Extension Center, Stuttgart, AR. The experiments were arranged in a randomized complete block design with three replications. Plots consisted of a single row 1.8 m long with a 0.17-m spacing. Standard local agronomic practices were utilized to manage the tests. Plants were inoculated at late tillering with *Rhizoctonia solani* grown on a rice hull: grain medium. Heading date and extended head plant height for each row were recorded. Entries were rated at maturity for sheath blight severity on a 0 to 9 scale.

Phenotypic data were similar between Louisiana and Arkansas. There were no significant differences in year, location, or year × location effects for days to heading and plant height. There were significant differences in year, location, and year × location effects on sheath blight severity. In 2006, there was a significant correlation (R=0.72; P=0.001) between Louisiana and Arkansas sheath blight ratings. In 2007, the correlation (R=0.58; P=0.0001) was reduced but significant. When you compare Louisiana's 2006 and 2007 data, there was a strong correlation (R=0.73; P=0.0001) between years. In Arkansas, during 2006 and 2007, there was a reduced correlation (R=0.60; P=0.0001) between years. Correlations were never above the 0.75 level, and there were always outliers where sheath blight ratings between years and locations existed. These included higher ratings in Louisiana than Arkansas and higher ratings in Arkansas than Louisiana for specific entries each year. Additional rating variation was from higher and lower ratings for 2006 and 2007 in both Louisiana and Arkansas. Some variation can be explained by differences in environments between years and locations (VXE), personnel evaluating, experimental errors, and data errors. Although most ratings were highly correlated, several years of data are necessary to obtain accurate sheath blight reactions.

An Update on Genetic Studies of Disease Resistance Genes and Their Utilization for Rice Protection

Jia, Y., Costanzo, S., Lee, S., Dai, Y., Correll, J., Roy-Chowdhury, M., Cartwright, R., and Lee, F.

The use of resistance (*R*) genes is one of the most economical and environmentally sound methods of crop protection. Most recently, through molecular analysis of a pathogenic factor *AVR-Pita* in field blast isolates from the southern United States, we demonstrated that the blast fungus is capable of overcoming resistance provided by a single *R* gene through various genetic mechanisms. These findings suggest that effective resistance to blast cannot be achieved by a single *R* gene. In the southern U.S., rice germplasm containing blast *R* genes, *Pi-ta*, *Pi-b*, *Pi-k(m/*h/s), *Pi42*(t), *Pi43*(t), *Pi-z*(t) conferring overlapped resistance to all common U.S. races of the blast fungus were introduced and used as resistant gene donors. DNA markers closely linked to these blast *R* genes and user friendly markers, "the perfect DNA markers," derived from portions of three blast *R* genes, *Pi-ta*, *Pi-b, Pi-km,* have been developed. These markers can be effectively used for developing cultivars with improved blast resistance through marker assisted selection (MAS).

Investigations on Refined Management of Rice Water Weevil in California Rice

Godfrey, L.D. and Goldman, E.B.

Studies were continued in 2008 and 2009 in ring plots and small basins to evaluate experimental insecticides versus registered standards for rice water weevil (RWW) control and to optimize the use patterns of the existing products to facilitate management. Nine different active ingredients were evaluated in ring plots and small basins to accomplish this research. Research continued on five experimental insecticide active ingredients: etofenprox (Trebon), indoxacarb (Steward), clothianidan, rynaxypyr (Dermacor), and cyazypyr. The first three products were applied as preflood or 3-leaf stage applications and the latter two products as seed treatments (clothianidan was evaluated with all application methods). Four specific questions were addressed in these studies, including are the experimental materials efficacious against RWW, how effective is the recently-registered preflood application of Warrior (lambda-cyhalothrin) and how long of a lag period between application and flooding can be used, are there viable options for RWW control in a drill-seeded system, and finally what is the effect of a sodium hypochlorite seed soak on the efficacy of seed treatments for RWW. In summary, clothianidan, etofenprox, and indoxacarb all appear to have significant potential for RWW management. Etofenprox and clothianidan are active via application at the 3-leaf stage and clothianidan also works preflood. For indoxacarb, while effective, registration in rice will not be pursued by the registrant. Clothianidan and rynaxypyr and were moderately active as seed treatments; the applicability of a seed treatment in the water-seeded production system is uncertain. The performance on the seed was influenced (reduced) by the 2-hour sodium hypochlorite seed soak used as part of the Bakane management scheme. Warrior applied preflood (immediately before the flood) was effective for RWW control; similarly, an application 7 days before the flood was also effective. Similar results were observed with Mustang. The Warrior label stipulates the application at 5 days or less before the flood so the label is consistent with maximizing performance. Rynaxypyr seed treatment was moderately effective against RWW in a drill-seeded system albeit slightly less effective than in a water-seeded system. Grain yields from the Warrior 3-leaf, clothianidan 3-leaf (two lowest rates), indoxacarb, and rynaxypyr (0.1 milligram rate without Sodium Hypochlorite) were significantly higher than in the untreated in 2008. Yields in several of the other treatments, while not statistically significant, were 1,121 kg ha^{-1} higher than in the untreated. In 2009, although RWW larval populations were very high and control efficacy was acceptable with several treatments, yields were not systematically affected by the infestations. It is important to continue to develop alternative active ingredients and chemistry class to provide cost-effective management methods for growers. Regulatory actions are a constant threat against crop protection tools in the California rice system so research needs are continual. These active ingredients have some favorable properties in terms of toxicity to non-targets, persistence, performance, and would appear to have a "fit" in rice IPM.

Efficacy of Selected Insecticides as Seed Treatments for Control of Grape Colaspis and Rice Water Weevil in Arkansas

Wilf, H.N., Lorenz, G.M., Colwell, C.K., and Taillon, N.M.

With the loss of Icon in recent years there are no current insecticides that provide acceptable control of grape colaspis, *Colaspis brunnea*, and rice water weevil, *Lissorhoptrus oryzophilus*. However, new seed treatments are currently being investigated that may provide some level of control for these pests.

Insecticide seed treatment trials were conducted in several locations in Arkansas, 2007-2009, to evaluate the efficacy of selected compounds including clothianidin (NipsIt Inside), rynaxapyr (Dermacor), and thiamethoxam (Cruiser), for control of these pests.

Forty small plot and twenty three large block replicated trials were conducted during the last three years with the majority conducted in grower fields with a history of these pests. Plant data collected included stand counts and plant heights at three weeks post emergence. Grape colaspis and rice water weevil larvae were evaluated by taking 4 core samples per plot with a 4-inch cylinder core sampler. Grape colaspis samples were taken prior to flooding and rice water weevil samples were taken 2 to 3 weeks after permanent flood. All samples then were returned to the Lonoke Extension and Applied Research Center, and processed using a wash technique.

Evaluation of plant stand counts and plant heights indicated that insecticide seed treatments had a significantly higher stand count than the untreated check. All treatments had a significantly higher plant height than the untreated check. Efficacy of rice insecticides for control of weevils indicated that all treated plots had significantly fewer weevil larvae than the untreated plots. It appears that seed treatments may be the best means to control these pests.

Rice Water Weevil within Field Larval Distribution in California Rice

Espino, L.A.

The rice water weevil (RWW) is the most important insect pest of rice in California. Current treatment recommendations for RWW control suggest applying insecticides to only 10 to 15 m adjacent to levees and field borders. This information was generated shortly after the RWW entered California and has been indirectly validated in the past. However, changes in cultivars and insecticides used, and water and weed management practices may have had an effect on the within-field distribution of this insect. Experiments were conducted to validate management guidelines and allow growers to confidently continue to limit their applications to field borders.

Studies were conducted in commercial rice fields in Colusa, Maxwell, Oroville, and Princeton in the Sacramento valley of California. At each location, plots were established 5, 30, and 60 m from one of the edges of the field within a basin. Treatments assigned to plots were insecticide application (λ-cyhalothrin applied at 33.6 g ai/ha before flooding) and distance from the field's edge. Treated and untreated plots were separated by an 2.5 m buffer. Each experiment was conducted as a randomized complete block and treatments replicated four times. In each field, plots were managed in the same manner as the rest of the field. RWW adult populations were assessed using feeding scars; RWW immatures (larvae and pupae) were assessed using a core sampler.

Based on the number of RWW immatures and adult feeding scars at different distances from the field's edge, RWW infestations appear to be more severe near field borders and levees, especially under low to intermediate population densities. In only one location was the RWW infestation widespread through the field. RWW density at this location was higher than in all other locations, averaging more than two RWW larvae per core. All other locations had an average RWW population of less than one larva per core. However, near the field's edge, number of RWW larvae per core was usually greater than one, a density commonly considered as threshold in California. These results confirm that border and levee treatments in California rice are adequate to manage RWW populations.

Activity of Chlorantraniliprole and Thiamethoxam as Seed Treatments on Rice Water Weevil

Lanka, S.K. and Stout, M.J.

Investigations to determine the mode of activity of two insecticidal seed treatments against rice water weevil were conducted under greenhouse and field conditions during summer 2009. The two insecticidal seed treatments, Dermacor (chlorantraniliprole), and Cruiser (thiamethoxam) represent two different classes of insecticides. Core samplings in field experiments revealed significant reduction in weevil larvae on three sampling dates for both chlorantraniliprole and thiamethoxam at treatment rates of 0.05 mg/seed and 120 g of ai/100 kg seed of rice. Oviposition experiments on 40-day old plants that were seed treated at two rates for both chemicals revealed significant reduction in densities of egg and first instar for thiamethoxam. However, the effect of chlorantraniloprole on densities of egg and first instars was not dramatic at tested rates. The 72-hr renewed leaf feeding assays at different treatment rates conducted during the 3 to 4 leaf stage (21 DAS) and early tillering (40 DAS) stages of rice plants resulted in a significant reduction of adult weevils due to thiamethoxam while chlorantraniliprole caused no significant reduction in adult numbers. Leaf area damage, estimated using image analysis, revealed significant feeding inhibition at the early tillering stage but no such inhibition was detected for chlorantraniliprole treatments. The studies revealed that although both classes of chemicals offer effective control of weevil larvae, the mode of accomplishing weevil reductions are different: chlorantraniliprole effects larvae feeding on roots and thiamethoxam impacts weevils by reducing the adults and first instars.

Depth of Permanent Flood Influence on Rice Water Weevil Infestation and Damage

Bernhardt, J.L.

With production costs on the rise, rice growers look for options to reduce costs. To avoid using insecticides growers may try cultural practices to reduce the infestation of insect pests below economic thresholds. Although the density of rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, larvae can vary greatly across any rice field, significant differences have been noticed in paddies with different water depths. For example, a large field in northeast Arkansas was sampled for weevil larvae three weeks after onset of flood. Between the high and low side of several paddies there was a 5 to 10 cm difference in water depth, and there was an average 88% difference in larval densities. This suggests that depth of permanent flood, a cultural practice, may have an impact on rice water weevil infestation, oviposition behavior, or larval survival. Field studies were conducted for additional information on the natural pattern of infestation by rice water weevils and any yield differences when permanent flood was maintained at two constant depths and at two depths for variable amounts of time.

In 2007, 2008, and 2009 rice plots were arranged in a randomized block design with four replications. Plots were 7.6 m long and had a seeding rate of 101 kg/ha. Each plot of rice was surrounded by levees. Flood depth treatments were: 10 cm depth maintained all season (deep water check); 5 cm depth maintained all season (shallow water check); initial flood of 5 cm depth maintained for 1, 2, 3, or 4 weeks then a 10 cm depth maintained for the remainder of the season. Plots were not treated insects and were infested by natural populations of rice water weevils. Three-soil/plant core samples 10 cm diameter by 10 cm depth were taken from each plot at three and four weeks after permanent flood and evaluated for rice water weevil larvae. In the laboratory, each soil core was washed with pressurized water to loosen soil and remove larvae from the roots into a 40-mesh sieve. The sieve was immersed in a saturated salt solution to float the larvae. Larvae were removed, sized, and counted. A central portion of each plot measuring 4 rows by 6.1 m was cut with a small plot binder and threshed in a Vogel thresher. Grain moisture was corrected to 12% prior to analyses with PROC ANOVA (Statistical Analysis System).

Herbicides were applied according to weed species present. Fertilizer was applied in recommended amounts for 'Wells' rice in a 2-way split. Plots were examined for the presence of rice blast disease.

In 2007, plots with a season-long, 5 cm flood had 33% fewer rice water weevil larvae than plots with a season-long 10 cm flood had the highest infestation. In the plots with variable depths and length of time at a depth, there was a trend of progressively lower densities where the 5 cm flood was maintained for more weeks, and plots with a shallow flood for 4 weeks had 33% fewer larvae than the season-long deep flood. The shallow flood depth and the duration of shallow flood depth tended to have an impact on rice water weevils and resulted in lower numbers of larvae. In 2008 weevil infestations were 3-times greater than the 12.5 larvae/core in 2007, yet the shallow flood season-long and shallow flood for 4 weeks averaged 29% fewer larvae than the season-long deep flood. In 2009 infestations were similar to that in 2008 and plots with a shallow flood season-long and for 4 weeks had 28 and 31% fewer larvae, respectively, than the deep flood. For each year, no significant differences were observed between grain yields for any treatment and there were no trends among treatments. With an early planting date and a low infestation of weevils, yields were greatest in 2007 and averaged 10.3 mt/ha. In 2008 yields averaged 10.0 mt/ha with a high infestation of weevils. In 2009 the test was planted late and yields averaged 8.5 mt/ha with a high infestation of rice water weevils.

These data state that a shallow permanent flood for the first 4 weeks influenced rice water weevils and lowered the infestations of larvae by 28 to 33%. Of major importance in contemplating shallow flood is the influence of rice blast disease. Rice blast is among the most serious constraints to rice grain yields worldwide. The field tolerance of rice varieties to rice blast is influenced by flood depth. Disease incidence is more severe under upland conditions but incidence declines with deeper floods. This current study attemped to recognize the importance of avoiding rice blast disease by having treatments with a 5 cm flood only during the first four weeks of permanent flooding which coincides with the known oviposition period of female rice water weevils. During this study, minimal leaf blast was observed in all plots regardless of flood depth and no neck or panicle blast was observed in any treatment.

Louisiana Rice Water Weevil Demonstration, 2008 to 2009

Hummel, N.A. and Stout, M.J.

Rice water weevil (RWW) management demonstrations were conducted during 2008 and 2009. The purpose of these demonstrations was to evaluate the use of some currently available insecticides to control rice water weevils. The rice water weevil is the most injurious insect pest in Louisiana rice production. Yield losses in excess of 25% can occur from severe infestations. Adults of this insect emerge from overwintering sites beginning in early April in southern Louisiana (later in northern Louisiana) and fly to rice fields, where they feed on young rice leaves. This form of injury is not economically important except under unusually heavy infestations or prolonged cold periods when rice grows at a slow rate. Egg-laying commences when standing water is present in a field that is infested with adults. This condition is usually met immediately after a permanent flood is applied. Young rice is preferred for oviposition. After eclosing from eggs, larvae feed under water on rice roots and pass through four larval instars and a pupal stage in approximately 30 to 40 days. Pruning of roots can result in a reduction in yield. Adults emerge from pupal casings and will either infest a nearby rice field or overwinter.

The demonstration test, conducted on commercial farms throughout Louisiana, compared the efficacy of RWW larvicide and adulticide treatments. Efficacy was assessed by recording yields and collecting RWW core samples four weeks after application of permanent flood. The larvacide, Dermacor X-100, is a seed treatment registered under a Section 18 registration in Louisiana. The use of this insecticide is restricted to rice planted into a dry-seedbed - either drill-seeded or dry broadcast. The adulticides that are labeled for use in Louisiana rice include Declare, Karate Z, Mustang MaxEW, Proaxis, Prolex, Silencer, and Trebon 3G. The adulticides can be used at different timings, depending on grower preference. Pyrethroids can be applied as a foliar spray (Declare, Karate Z, Mustang Max EW, Proaxis, Prolex, Silencer), impregnated on fertilizer (Mustang MaxEW), or as granules mixed with fertilizer (Trebon 3G). An ovicide, Dimilin 2L, can also be used for RWW management in Louisiana. In 2008, the seed treatment, Dermacor X-100 was compared to an untreated check or a pyrethroid-treated field. In 2009, the following treatments were compared to an untreated check: 1) Dermacor X-100 (applied to seed); 2) Karate Z pre-flood (0.187 L/ha); 3) Karate Z pre-flood (0.187 L/ha) followed by Mustang 1.5ec on fertilizer seven days post-flood (0.292 L/ha); 4) Mustang 1.5ec on fertilizer immediately post-flood (0.292 L/ha); 5) Trebon 3G pre-flood (10.08 kg ai/ha).

In 2008, the untreated fields had an average of 11.98 RWW larvae/core. Pyrethroid-treated fields had an average of 3.37 RWW larvae per core, while Dermacor treated fields had an average of 1.85 RWW larvae per core. In 2009, untreated fields had an average of 10.9 RWW larvae per core. Dermacor provided the best control followed in order by Karate and Mustang, Karate, Trebon pre-flood, and Mustang immediately post-flood. This test will be repeated in 2010.

The Impact of Rice Seeding Rate on the Interaction between Rice and the Rice Water Weevil

Stout, M.J., Harrell, D., Tindall, K.V., and Bond, J.

The rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, is the most widely distributed and destructive early season insect pest of rice, *Oryza sativa* L., in the United States. Economic losses result primarily from feeding by the larval stage of this insect on the roots of flooded rice plants. Prior studies and anecdotal reports suggest that infestations of rice water weevil larvae are more severe at low plant densities. Moreover, because feeding by rice water weevil larvae reduces rice plant tillering, a process particularly important to yield at low seeding rates, infestations by weevil larvae may have a greater impact on rice yields when rice is seeded at low rates. The relationship between rice plant density and rice water weevil damage has assumed greater importance in light of recent trends toward the use of lower seeding rates in rice in the southern U.S.

A total of six experiments were conducted over a three-year period in Louisiana and Missouri to investigate the impacts of rice seeding rate on levels of infestations by, and yield losses from, the rice water weevil. In two of the six experiments, rice water weevil infestations were significantly higher in rice seeded at low rates. Furthermore, in two of the three experiments conducted with Bengal (a susceptible cultivar) in Louisiana, percent yield losses were significantly higher at lower seeding rates than at higher seeding rates. Overall, these results indicate that rice sown at low rates is more vulnerable to infestation by rice water weevils and more susceptible to yield losses from weevil injury.

The Impact of Planting Date on Rice Water Weevil Management

Stout, M.J., Harrell, D., Tindall, K.V., Hummel, N., Rice, W.C., and Frey, M.J.

The rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, is the most widely distributed and destructive early season insect pest of rice, *Oryza sativa* L., in the United States. Adult rice water weevils emerge from overwintering sites and immigrate to rice fields in early spring. Early planting of rice has long been suggested as a means of temporarily avoiding damaging infestations of rice water weevils in rice fields, but the relationship between rice planting date and severity of weevil infestations has not been recently investigated in Louisiana.

A multi-year study was conducted at the LSU AgCenter Rice Research Station (Crowley, Acadia Parish, LA) to investigate the relationship between rice planting date and severity of infestation by rice water weevils in experimental rice plots. Experimental designs varied somewhat over the course of the study, but in all years rice was seeded at two or more planting dates and densities of weevil larvae on roots of rice plants were assessed three or four weeks after flooding. Early planting (early to mid-March) was often, but not always, associated with lower densities of rice water weevil larvae three to four weeks after flooding. Moreover, late planting was associated with reduced efficacy of insecticides in some years (i.e. there was a significant interaction effect of planting date and insecticide treatment on weevil densities). These data confirm the value of early planting in a weevil management program.

Impact of the Insecticide Seed Treatments, Cruiser and Dermacor on Non-Target, Aquatic Invertebrates, in Flooded Rice Fields

Fothergill, K. and Tindall, K.V.

Increasingly, agroecosystems are being examined within a conservation framework. The recent California Rice Commission's environmental and conservation audit is an example of this process and demonstrates some of the ecosystem services and societal benefits that rice production offers. The ability to demonstrate a proactive approach to and positive environmental impact from commodity production not only increases consumer acceptance and demand, but also creates a desire within communities to support the production activity - as shown by the recent Louisiana Yellow Rail and Rice festival.

Insecticidal seed treatments are efficacious in the management of rice water weevil, *Lissorhoptrus oryzophilus*. While seed treatments are efficacious in achieving the management goal, the potential exists for unintended actions that may precipitate cascading ecological effects that could reduce the agroecological value of rice production systems. This is especially so due to the interaction of insecticides and water utilized in rice production. The most likely species to experience detrimental effects from utilization of seed treatments would be soil and/or aquatic invertebrates. Additionally, the aquatic invertebrate fauna utilizing rice production systems within the Northern Mississippi Alluvial Plain is poorly known. This study was undertaken to examine and document this aquatic invertebrate fauna and determine what effect, if any, seed treatments may have on this fauna.

Drilled rice was planted in large plots with Cruiser, Dermacor, or non-treated seed in 2008 and 2009 in Pemiscot County, Missouri. A randomized complete block design with two replications was utilized. Ten subsamples per plot were sampled for aquatic invertebrates in a standardized manner 2, 3, and 4 weeks post flood. Sampled insects were identified to the family level and enumerated. Number of families and number of individuals were analyzed utilizing ANOVA in SAS. The Shannon index, a measure of biodiversity, was also analyzed between treatments.

Data from 2008 showed no difference in number of families, individuals, or Shannon indexes between the seed treatments and non-treated. Preliminary analysis of data from 2009 appears similar to the results from the 2008 studies. These data suggest that the seed treatments, Cruiser and Dermacor, have little impact on the aquatic invertebrate communities associated with rice production in Southeastern Missouri. A list of aquatic invertebrate families recovered during the study will be presented. This work demonstrates that Southeastern Missouri rice production supports a diverse community of aquatic invertebrates, which in turn helps to support a healthy agroecosystem.

Development of Pest Management Strategies for Sugarcane Borer in Louisiana Rice

Sidhu, J.K., Stout, M.J., and Hummel, N.A

The stem borer complex attacking rice in the Southern United States includes the stalk borer *Chilo plejadellus*, sugarcane borer (SCB) *Diatraea saccharalis* and Mexican rice borer, *Eoreuma loftini (*Dyar). Research on the resistance of rice cultivars to stem borers in the U.S. has been sparse due to the low incidence of the pest over many years. With the increasing impact of stem borers on rice production and the arrival of the Mexican rice borer in Louisiana, an urgent need exists to develop strategies for management including host plant resistance and chemical control. Currently, no IPM program is in place for SCB in Louisiana rice and research has been initiated to develop an IPM program for SCB. The initial phase of this research is focused on characterizing variation in resistance among commonly grown cultivars in Louisiana. This study was undertaken to determine the relative preference of sugarcane borer among commonly grown varieties and preference of plant parts for oviposition. The study objective was to identify varieties less preferred for oviposition and also help in scouting for SCB in field situations.

The study was conducted in a greenhouse at Louisiana State University. Eight widely grown varieties were used: Bengal, Cheniere, CL161, Cocodrie, Jupiter, Priscilla, XL723, and XP744. All cultivars were grown in 15 cm diameter pots containing standard soil mix (peat moss: sand: top soil in 1:1:2 ratios). Five seeds were sown per pot. Plants were thinned 15 days after sowing to one plant per pot. Slow release fertilizer was applied at the rate of 0.79 g/pot, three weeks after emergence. A randomized complete block design was used with one plant of each rice variety within each block. The plants were infested at two phenological stages, first at tillering stage and next at the panicle initiation stage. A net cage (211 cm × 112 cm × 122 cm) was used as a block with eight pots (one of each variety) randomly arranged in the center of each cage. Sugarcane borer adults were obtained from the laboratory colony at the Entomology Department. These insects were reared on an artificial diet under controlled environmental conditions. Pupae were separated by sex and placed in plastic containers for emergence. After 24 hours, forty females and forty males were selected. Eight pairs of adults were placed in a petri plate for approximately 6 hours. Eight pairs of moths per replication were released. Observations were recorded 7 days after the release. For observations, the plants were cut just near the base of the stem and the egg masses were counted and cut. The location of the egg masses on leaves was also observed. The cut egg masses were put into small cups and returned to the laboratory. Total numbers of eggs per egg mass were enumerated under the microscope.

Cocodrie and Priscilla were found to be the most susceptible cultivars for oviposition by sugarcane borer female adults and received comparatively fewer number of egg masses compared to other varieties. No significant differences were observed among varieties for preference of leaf surface. Overall, females of *D. saccharalis* preferred laying their eggs on the upper sides of the leaves of rice plants at both the tillering and panicle initiation stage. When tillering and panicle initiation stages were compared, the panicle initiation stage was more susceptible for egg laying by sugarcane borer females.

CruiserMaxx Rice: A Newly Registered Seed Treatment for Early Season Protection against Insects and Diseases

Martin, S.H., Minton, B.W., Long, D.H., Black, B.D., Holloway, J.C., and Sanders, J.C.

CruiserMaxx Rice insecticide/fungicide is a new broad-spectrum seed treatment combination from Syngenta that combines Cruiser insecticide with three proven seed-delivered fungicides. Thiamethoxam, the active ingredient in Cruiser, received registration from the EPA for use on rice on September 23, 2009. The combination of thiamethoxam and the fungicides in CruiserMaxx Rice provide comprehensive early season protection of rice seedlings from important early season insects and diseases.

CruiserMaxx Rice provides protection of rice seedlings against injury by chinchbugs (*Blissus leucopterus leucopterus*), grape colaspis (*Colaspis brunnea*), rice water weevil (*Lissorhoptrus oryzophilus*), and thrips. The rice water weevil is the most important early-season insect pest of rice in most states. For several years Arkansas rice farmers have had to deal with grape colaspis, a small beetle, whose larvae feed on the roots of rice. Grape colaspis was also found in several parishes in Louisiana in 2009. CruiserMaxx Rice is the only seed treatment to provide protection from both rice water weevil and grape colaspis.

CruiserMaxx Rice includes three proven seed-delivered fungicides: ApronXL, Maxim and Dynasty. This powerful combination will give rice producers comprehensive early season protection against *Pythium*, *Phytophthora*, *Rhizoctonia*, and seed-borne *Pyricularia grisea*. Mefenoxam, the active ingredient in ApronXL is the leading *Pythium* fungicide on the market. Azoxystrobin, the active ingredient in Dynasty, is the only systemic strobilurin seed treatment in the rice market. Dynasty adds to the *Pythium* control but also provides increased activity on *Fusarium* and *Rhizoctonia*. Additionally, Dynasty protects rice seedlings from early season leaf blast and, in concert with IPM blast control strategies, may help reduce the incidence of neck blast at the end of the season.

Data from more than 30 research trials conducted in the southern rice-growing region of the United States indicates excellent commercial potential for CruiserMaxx Rice. This presentation will provide an overview of the results collected from university and Syngenta research trials evaluating the combination of products in CruiserMaxx Rice for control of early season insects and diseases. These research trials have been essential to label development and recommendations of the component products. The specifics of the label and use recommendations of the products contained in CruiserMaxx Rice will be discussed. CruiserMaxx Rice is a promotional combination of the following separately registered product(s): Cruiser insecticide and Maxim, Dynasty, and Apron XL seed treatment fungicides.

Detection of Colaspis in Louisiana Rice in 2009

Hummel, N.A. and Davis, J.A.

For several years, Arkansas rice producers have dealt with grape colaspis, a small beetle whose larvae feed on the roots of several crops, including rice. Larval feeding on rice roots can cause 50% or more reduction in stand. In Louisiana, colaspis has never been a serious pest in rice and is mainly confined to soybean. However, in 2009, colaspis caused significant stand reduction in six rice fields in Acadia, Evangeline, and St. Landry parishes, ranging from 10% to 70%. Colaspis stand loss was first detected in a field in Acadia Parish in early May. This field was drill-planted into a stale seedbed planted to soybeans in 2008. Rice drilled into soybean stubble is particularly susceptible to damage from this pest as colaspis mates and lays eggs in soybean. While the initial damage in one cut looked extensive, the rice recovered well and overall loss appeared to be minimal. This is a typical growing scenario where you would expect to find grape colaspis. Other fields infested were also in a soybean/rice rotation, with the exception of one water-seeded field in Evangeline Parish. The damage was typically concentrated in high spots in the field that may have had lower soil moisture during the winter period.

In response to this "new" pest, training was conducted and a video prepared on how to scout for colaspis in rice. Both the training PowerPoints and the scouting video have been posted at www.lsuagcenter.com. The training was well received by the consultants according to a post-training assessment.

There are two species of colaspis that can be found in Louisiana: *Colaspis brunnae* (grape colaspis) and *Colaspis louisianae*. In order to determine species population size and distribution, we conducted a survey throughout the rice producing regions of Louisiana and parts of Arkansas. From this information, we will be able to begin to conduct research on how management tactics may differ between the two species.

In 2009, we did not have any insecticides labeled to control colaspis in Louisiana rice. Thus, we were only able to recommend applying permanent flood as soon as possible. Because these insects are not aquatic and cannot survive in a permanent flood for a prolonged period of time, a flush can provide 30% control. In 2010, we will have a registration for Cruiser seed treatment. This product has shown good control in Arkansas. Dermacor X-100 seed treatment has provided suppression of colaspis in studies conducted in Arkansas.

Influence of Intra and Interspecific Competitors on the Oviposition Behavior of the Sugarcane Borer, *Diatraea saccharalis* (F.)

Hamm, J.C. and Stout, M.J.

In Lepidoptera, choice of oviposition sites by females is crucial because hatching larvae have limited dispersal capacities and therefore are dependent on the judicious choice of host plant by adult females. Many factors can influence oviposition site selection, including host quality as well as the presence of intraspecific and interspecific competitors. We investigated the oviposition preference of the sugarcane borer, *Diatraea saccharalis*, in a series of experiments using plants with fresh egg masses, infested with conspecific larvae and larvae of the rice water weevil, *Lissorhoptrus oryzophilus*. Females chose to oviposit significantly more egg masses on plants that were previously exposed to ovipositing females compared to unexposed plants. Females also oviposited more egg masses on plants with heavy feeding damage from conspecifics. However, females did not discriminate when choosing between plants infested with immature *L. oryzophilus* and uninfested plants. Factors potentially influencing oviposition behavior will be discussed.

Tadpole Shrimp: An Emerging Pest of Rice Grown in the Mississippi River Delta Region

Tindall, K.V., Fothergill, K., and Miller, A.L.E.

Tadpole shrimp, *Triops longicaudatus* (LeConte) (Notostraca: Triopsidae), are pests in California rice production systems. Tadpole shrimp are an obligate species of ephemeral freshwater aquatic habitats and in North America were considered primarily a species of the western United States for many years. In the late 1980s an eastern range expansion was reported into Oklahoma. However, there was an earlier report filed with the Missouri Department of Conservation of tadpole shrimp observed in Missouri in 1979. There were two additional records filed in 1983 and 2007. Early reports were along the Missouri River with the 1979 and 1983 reports being from Jackass Bend (Jackson County) and the 2007 record from Darst Bottoms (St. Charles County). How tadpole shrimp came to be in Missouri is unknown, but dispersal occurs via floodwaters, wind, birds, and via the pet trade.

On June 8, 2007, a single specimen of an unknown invertebrate was brought to the Delta Research Center in Portageville, Missouri (Pemiscot County) for identification. The specimen was collected from a drill-seeded rice field in Pemiscot County (near Bakerville). The specimen was determined to be a tadpole shrimp but the species was not determined. On May 20, 2008, a phone call was received regarding a 16-hectare field in Stoddard County (located north and west of Catron), of water-seeded hybrid rice that had not emerged. The water was drained from the field and thousands of tadpole shrimp were congregated in the remaining puddles. No viable seeds were present and the field was replanted. On June 2, 2008, another call was received about multiple fields in New Madrid County (near Lilbourn) that were infested. In 2008, at least 1,600 hectares had tadpole shrimp present and of those infested, nearly 800 hectares were economically impacted and approximately 40 hectares were replanted.

Tadpole shrimp females lay an average of 81 eggs in 24 hours, but one individual laid 198 eggs in one day. Eggs are laid on either decaying or living plant material, algae, or directly into the soil. Egg hatch is affected by pH, soil type, age of egg, temperature, salinity, and depth of burial in the soil. Eggs require a desiccation period prior to hatching. When a larva ecloses, it feeds on diatoms and protozoa in the mud during early instars. Then it acquires feeding behaviors similar to that of the adult, which consumes vegetative material and aquatic invertebrates and is cannibalistic. The foraging behavior (i.e., movement in the mud) of nearly mature and adult tadpole shrimp uproots small seedlings and muddies the water. Larval development is influenced by temperature; although individuals reared at 30°C were smaller than those reared at lower temperature, they reached sexual maturity at an earlier age.

Tadpole shrimp are problematic in California water-seeded rice production systems when larvae eclose after fields are flooded. Sexually mature tadpole shrimp are found as early as 9-12 days after floods are established; therefore, rice plants have less than 9 days to break the surface of the flood (i.e., the time at which rice is no longer vulnerable), before tadpole shrimp are large enough to uproot seedling rice. Rice planted by drill-seeded or dry-seeded methods has an adequate root system when fields are flooded, and tadpole shrimp are not pests in these systems. Once rice is no longer vulnerable to tadpole shrimp damage, tadpole shrimp may serve as a biological control agent for mosquitoes and/or weeds. Hybrid rice varieties are planted at a lower seeding rate (33 to 45 kg/ha) than conventional varieties (100 to 120 kg/ha), making them more susceptible to tadpole shrimp damage than higher seeding rates. For example, losing 10% of a stand planted at 33 kg/ha is more detrimental than losing 10% of a stand planted at 110 kg/ha.

Southeastern Missouri is part of the Mississippi Alluvial Plain. Historically, the region was covered with swamp lands and heavy timber, an environment not conducive to tadpole shrimp. However, much of the land is now cropland, including rice fields that mimic ephemeral ponds inhabited by tadpole shrimp. In 2008, less than 10% of the 80,000 hectares of rice production in Missouri was water seeded. Therefore, tadpole shrimp will impact only a small percentage of hectares in Missouri. However, rice production also occurs on almost 757,000 ha in the Mississippi Alluvial Plain states of Arkansas and Louisiana, and the percentage of water-seeded rice varies each year, with many hectares of water-seeded rice in those states that could be impacted if there is further dispersal southward.

Abstracts of Posters on Plant Protection
Panel Chair: Tom Allen

Panicle Rice Mite on the UC-Davis Campus: Response and Eradication

Goldman, E.B., Godfrey, L.D., and Pearson, G.W.

Panicle Rice Mite (*Steneotarsonemis spinki* Smiley) (PRM) was discovered in the University of California at Davis (UCD) greenhouses in January of 2009. This microscopic pest (~0.025 cm in length) is capable of causing severe yield losses (up to 90 % loss has been observed in Cuba). Panicle rice mite feeds on the inside of leaf sheaths and developing grains, injecting a toxin while doing so. Noticeable symptoms of PRM infestation (but not exclusive to PRM infestation) are kernel scarring, necrotic lesions on grains and leaf sheaths, deformed panicles, spotting on shell of grain, sterility, and reduction in panicle numbers. Heavy infestations can lead to plant sterility, partial panicle infertility and grain malformation. Movement can occur via infested grain and associated debris (straw, hulls, panicles), hitchhiking on animals, humans, or machinery, or by wind or water. In 2007, the PRM was found in a rice research facility in Texas (in July) followed by detections in Puerto Rico, Louisiana, Arkansas, and New York in August. These infestations were primarily in greenhouses and field plots. Eradication efforts were initiated by USDA-APHIS to eliminate these infestations. Since 2007, annual inspections of greenhouse facilities in California have not detected any PRM. The first occurrence of PRM in CA was on rice in the UCD greenhouses in January 2009. California Department of Food and Agriculture personnel sampled 1% of the commercial rice fields in 2009 for PRM.

The discovery of PRM in UCD greenhouses was responded to by treating infested plants with an appropriate miticide, followed up by the harvest/destruction of infested plants or movement to the Contained Research Facility (a highly controlled and contained research facility designed for work with exotic organisms) until maturity for the most critical plants. A month long host-free period (April-May) was enforced to attempt to exterminate any PRM remaining in the greenhouses on plants or equipment. Prior to planting, all rice seed is frozen at -8°C for 72 hours, then fumigated with Phostoxin. All old, unwanted seed on campus was promptly destroyed. Greenhouses harboring rice research are monitored using sentinel rice plants (untreated plants to be sampled on a regular schedule to monitor the presence/absence of PRM in any greenhouse), regularly treated with miticides (regardless of whether PRM is present), and apart from one another (to prevent the spread of PRM). Thus far (Dec. 2009) no additional infestations have been identified.

2008 Louisiana Rice Insects Survey

Hummel, N.A. and Meszaros, A.

The purpose of this survey was to determine which insects were the most important pests in Louisiana rice production in 2008. A total of 176 datasheets were processed in this survey. Respondents from the following Parishes completed surveys: Acadia, Allen, Avoyelles, Beauregard, Calcasieu, Cameron, Chicot, Concordia, Evangeline, Franklin, Jeff Davis, Lafayette, Morehouse, Rapides, Richland, St. Landry, St. Martin, Vermillion, and West Carroll. Rice farmers (75%), consultants (10%), dealers (3%), and others (12%) e.g. county agents, researchers, manufacturer representatives, marketing managers, and land owners participated in the survey. The questions focused on rice invertebrate pest management. We also gathered some basic demographics and production information. We are particularly interested in rice water weevil management strategies and how crawfish rotation effects producer decisions.

The following is a general summary of the demographics of our respondents: 43% of survey respondents have been involved with rice production for 26 to 40 years. The majority (69%) of survey respondents produced or consulted on over 202 hectares of rice. A total of 29% of the rice farmers water-seeded their rice, 10% estimated that less than one quarter of their rice hectares were planted into a dry seedbed. Only 39% of respondents had more than 75% of their rice planted into a dry seedbed. Clearfield varieties were also important in this survey: 41% of respondents had more than 75% of their rice planted with Clearfield varieties and 12% did not plant Clearfield varieties in 2008. Only 10% of respondents estimated that less than one quarter of their rice hectares were planted with Clearfield varieties.

Rice water weevil (93.7 %) and rice stinkbug (78.3%) were the most commonly reported insect pests. The next most important insects in order of percent that treated fields included armyworms (30.3%), chinch bugs (18.9%), rice leaf miner (14.1%), and rice stalk borer (12.3%). The following insects were reported by less than 10% of the respondents: aphids, grasshoppers, sugarcane borer, rice levee bill bug, rice seed midge, and South American rice miner. An interesting trend was identified with respect to the appearance of rice water weevil and rice stink bug in northern and southern parishes. In Acadia, Calcasieu, Cameron, Jefferson Davis, Lafayette, St. Martin, Vermilion parishes, where the rice water weevil was detected in 96% of surveyed fields, rice stinkbug occurred less frequently. In Northern parishes, more rice stinkbugs were found more frequently than rice water weevils. The most common methods used to control or prevent rice water weevil were drained field (43%), pre-flood treatment with a foliar spray of pyrethroid (39%) and, or post-flood treatment with a foliar spray of pyrethroid (36%). Respondents without rice fields in a rotation with crawfish production accounted for 32% while 24% estimated that they had less than 25% of their rice acreage in rotation with crawfish. Finally, 53% of respondents reported that rotation with crawfish effects their rice water weevil management decisions. A follow-up survey will be distributed to Louisiana rice producers in 2010 to assess the insect problems during the 2009 field season. This survey will also be delivered in Arkansas, Missouri, and Texas.

Disease Reaction of Southern U.S. Rice Germplasm under Arkansas Field Conditions

Robinson, J.C., Yingling, J.A., Parsons, C.E., and Cartwright, R.D.

Numerous foliar diseases of rice in the southern United States continue to represent one of the most important yield constraints for the crop. Host resistance, when available, is a valuable trait of modern rice cultivars and a mainstay of successful breeding programs in each major rice producing state. Unfortunately, breeding for resistance is complex and often the actual reaction to a particular disease may not be discovered until the cultivar is exposed to multiple field environments. As a result, each state conducts extensive field testing of developing rice lines in order to provide the best information on risk performance to growers when cultivars are released, and to guide the breeding program and prevent the release of cultivars highly susceptible to one or more diseases. Plant pathologists with the University of Arkansas Division of Agriculture assess many cultivars and advanced lines each year under a multitude of field situations in the state, sometimes with surprising results. Results from the past three years were summarized and disease notes related to rainy weather in Arkansas for 2009 conveyed.

Replicated yield plots of commercial cultivars were planted on 10 to 15 cooperating farms across the rice production region of the state in each of the past three years. These plots were managed by the cooperating grower using their respective production practices, and diseases noted and evaluated at heading each year. These on-farm plots were not inoculated. In addition, non-replicated observation plots of entries in each year's Uniform Regional Rice Nursery (URRN) were planted on a cooperator farm in the Grand Prairie region of the state and on a research farm in northeast Arkansas. The URRN sites were inoculated each year with the bacterial panicle blight pathogen or the stem rot pathogen to encourage these diseases, and additional diseases developed depending on the year and location from natural inoculum. At least two on-farm sites of the Arkansas Performance Trial entries were also evaluated each year. Visual evaluations were made during heading to grain fill at all sites and diseases were identified and assessed using standard 0-9 visual rating scales. Data were summarized and provided to the Arkansas rice breeding program and used to construct a disease reaction table each year for cultivars and hybrids of interest.

Diseases most noted under field conditions in Arkansas during 2007 to 2009 included bacterial panicle blight, black sheath rot, false smut, kernel smut, sheath blight, straighthead, and stem rot. Other diseases included narrow brown leaf spot, brown spot, leaf smut, aggregate sheath spot, and sheath spot. RiceTec hybrids were the most resistant to diseases over the three years, followed by medium grain cultivars. Long grain conventional cultivars had the most problems, but varied widely in reaction. The new cultivar, CL 111, was very susceptible to sheath blight and stem rot, and susceptible to blast and straighthead. CL 261, a new IMI tolerant medium grain cultivar, appeared susceptible to bacterial panicle blight and straighthead, but reasonably resistant to sheath blight, stem rot and other diseases in 2009. CL 181, a semidwarf long grain, was detereemined to be highly susceptible to bacterial panicle blight while CL 142 was more susceptible to blast than originally thought. Over three years, Jupiter was observed to be more susceptible to sheath blight than other medium grains, and more susceptible to blast than originally believed. Jupiter has remained resistant to bacterial panicle blight to date; however, Neptune was inconsistent in resistance to bacterial panicle blight and has recently been rated susceptible. A potential long grain cultivar, RU0801076, with high yield potential was intermediate in reaction to most diseases but highly susceptible to false smut under 2009 conditions. A potential semidwarf release, RU0801030, was also intermediate in reaction to many diseases but reasonably resistant to stem rot at multiple locations. The new cultivar, Templeton, remained highly resistant to blast across Arkansas but was more susceptible to straighthead than once anticipated. Taggart, a new release, was intermediate in reaction to many diseases and no highly susceptible reactions were noted. Catahoula was highly susceptible to sheath blight in Arkansas but remained resistant to blast over the last three years. Jazzman and JES, aromatic cultivars, tended to be intermediate in reaction to most diseases in our state but susceptible to stem rot.

Efficacy of Novel Fungicides for Control of Sheath Blight Disease

Parsons, C.E., Robinson, J.C., Yingling, J.A., and Cartwright, R.D.

Sheath blight is the most important disease of southern United States rice production, including Arkansas, and is the primary reason that foliar fungicides are used in rice in the U.S. Since the initial registration of azoxystrobin fungicide for rice in the U.S. in 1997, the total rice hectares sprayed in Arkansas with fungicides has risen from about 10% to more than 80% each year. The use of IPM decision making systems has also decreased during that time, and the majority of rice fungicide applications are now made preventatively based on growth stage of the crop. While modern rice cultivars and hybrids vary considerably in reaction to sheath blight disease, all are considered somewhat susceptible under conditions favorable for disease development. Long grain, semidwarf rice cultivars are most susceptible and are sprayed routinely from 7 to 14 days past panicle differentiation to minimize damage from sheath blight. The increased use of foliar fungicides in U.S. rice and the strong interest by industry in fungicides for other field crops including soybeans, corn and wheat has helped maintain continued development and testing of "new" or reformulated fungicides targeted to rice. In recent years, there has also been an active interest in "biopesticides" for disease control in a number of crops, including rice. All products need unbiased field testing under conditions typical of modern rice production in the south in order for the industry and growers to best utilize the products, should they be registered, or to select those with the most potential. Extensive field testing is conducted in Arkansas each year of new and developing rice fungicides, and this presentation summarizes results from the past two years.

A total of 10 replicated field trials were conducted over the two years of these studies. Trials were located on a typical rice production field in Lonoke County, part of the Grand Prairie rice production region of the state. The cultivar used in 2008 was CL 161 and in 2009, CL 131 – both semidwarf long grain cultivars considered susceptible to sheath blight disease. In both years, plots were 7 row (17.8 cm spacing) × 6.1 m long with a seeding rate of 100 kg/ha at 1 cm depth in a Dewitt silt loam conventional seedbed. Trials were planted in early April in both years and treatments arranged in a randomized complete block design with 4 replications. Irrigation, weed and insect control were performed by the experimental site manager following University of Arkansas Cooperative Extension Service guidelines. Plots received 185 kg/ha N (as urea) in 2008 as a 3-way split and 202 kg/ha N as a 3-way split in 2009. All plots were inoculated with 100-200 ml floating calcium alginate beads containing hyphal pieces of *Rhizoctonia solani* AG1-1A isolate RS 407 at panicle initiation by hand sprinkling between the center plot rows in late June of both years. Preventative fungicide treatments were applied 7 to 10 days after panicle differentiation both years, following initial infection but before noticeable sheath blight development up the plants. Treatments were made using a compressed air, self-propelled plot sprayer calibrated to deliver 93.5 l/ha volume using flat fan tips. Plots were visually evaluated 28 days after fungicide application in both years, and vertical progress of disease rated using a 0 to 9 rating scale where 0 = no symptoms and 9 = 90% or more of the plot canopy with symptoms. Plots were harvested with a small plot combine at grain maturity in September of both years. Other diseases were minimal and no phytotoxicity was noted for any of the tested products. Harvested grain was weighed and yield calculated based on standard weight at 12% grain moisture. Subsamples were processed by Riceland Foods to obtain head and total milled rice using GIPSA procedures.

In both years, a new formulation of azoxystrobin + propiconazole, now registered as Quilt Xcel, consistently controlled sheath blight and resulted in a significantly higher yield than untreated plots. Plots treated with 1,225 or 1,470 ml/ha of the formulated product reduced sheath blight severity 44 to 57% and had 9.3 to 30% higher yield in all trials over two years; and 3 to 5% higher head rice in some trials – compared to the untreated plots. Results over two years were not significantly different from azoxystrobin (Quadris) applied at 840 ml/ha as the commercial fungicide standard for comparison.

Residues of Fungicides and Insecticides in Rice Grains and Plants, and Irrigation Water

Teló, G.M., Marchesan, E., Ferreira, R.B., Avila, L.A., Peixoto, S.P., Zanella, R., and Cogo, J.P.

Pesticides are used in agriculture in order to protect and improve the production and quality of crops. On the other hand, consumers may be exposed to pesticide residues that can be harmful to their health. Therefore, there is a need for elucidating the dissipation period of pesticides used in agriculture. The objective of this study was to quantify the presence of fungicides and insecticides in rice irrigation water, plants and grains in raw and cooked conditions.

The experiment was conducted during the 2007 to 2008 growing season, at the research area located at Universidade Federal de Santa Maria (Federal University of Santa Maria, RS, Brazil). The treatments consisted of applications of 5 pesticides used in irrigated rice, which were three fungicides (azoxystrobin, difenoconazole and trifloxystrobin) and two insecticides (lambda-cyhalothrin and cypermethrin). The fungicide treatments were applied subsequently at booting stage (R2) and anthesis (R4), while the insecticides were applied at panicle exertion stage (R3). Samples of rice field water and plants were collected at 1, 3, 5, 7, 10, 15, 20, 25, 30, 35, and 40 days after pesticide application. Sampling for fungicide residues began following the first application (R2) while sampling for insecticide residues began after the application at R3. Post harvest, the whole grain rice was obtained by removing the caryopsis, without polishing, while the polished white rice was obtained by removing the bran layer. Tests were also conducted on the rice hull. Grains were cooked in a 1:2 proportion of grain/water (mass/volume) solution, for approximately 30 minutes at 100º C. The analysis of the pesticide residues was accomplished through analytical determination, whereby the pesticides were extracted from the samples using a modified QuEChERS method, and the detection was performed with gas chromatography by electron capture (GC-ECD).

A validation method was applied to determine the pesticide residues present in water samples, as well as the sampled plant and grain from paddy rice. Concentrations of azoxystrobin were detected in the irrigation water during the 40 day monitoring period. The greatest concentration of azoxystrobin (8.4 ug/L) was detected on the third day following application. In addition, pesticide concentrations of 6.5 ug/L were observed in sampling conducted 20 days post-application. These results are related to the second application of azoxystrobin that was conducted 15 days after sample initiation. The other pesticides were not detected in water samples. Concentration of pesticides in rice plants varied over time. Azoxystrobin was detected up to 10 days following application and trifloxystrobin up until the 15th day. The lambda-cyhalothrin, a pyrethroid insecticide, was detected in the plant tissues until 10 days following application, with the highest concentration on the 3rd day. Pesticide residues were not detected in the rice grain, but were detected in rice hulls. Azoxystrobin and cypermethrin were detected in the rice hull. The measured concentration of azoxystrobin (30 μg kg^{-1}) was below the maximum residue limit for rice grains allowed by Agência Nacional de Vigilância Sanitária (ANVISA). For cypermethrin the concentration observed in rice hulls (120 μg kg^{-1}) was 2.4 times higher than the concentration allowed by ANVISA, considering the presence in grains. However, for grains independently of the industrial process (whole-grain or polished), or the thermal process (raw or cooked), residues of pesticides were by the method used, which had a 20 μg kg^{1} limit detection for all pesticides analyzed in hull and grains. It should be reinforced that the detection limits of the method performed were below the maximum pesticide residue limits allowed by ANVISA.

Concentrations of azoxystrobin were detected in irrigation water during the entire monitoring period (40 days). In addition, pesticides were also detected in plant material until 15 days post-application, while in grains, cooked or raw, there were no residues of the applied pesticides detected. Azoxystrobin and cypermethrin were detected in rice hulls.

Response of Foliar Disease to Variety Resistance and Fertilizer Use in Organic Rice Production

Zhou, X.G. and McClung, A.M.

Organic rice production has increased significantly in the United States with approximately 14,164 hectares currently under production. Texas organic rice acreage has been increasing steadily over the last 10 years with the total number of hectares in 2009 exceeding 6,474 hectares which accounts for approximately10% of the total Texas rice hectares. Management of pests including weeds and diseases in organic rice is a particular challenge due to the lack of effective organic pesticides. Little information is available on the impact of organic management on the development of diseases in rice. The objectives of this research were to evaluate the effects of organic versus conventional management of common foliar diseases on rice varieties and to examine the impact of organic fertilizers on severity of narrow brown leaf spot in organic rice.

Twenty-four rice varieties and lines were grown under recommended organic or conventional management systems at Beaumont, TX in 2009. Brown leaf spot (*Cochiobolus miyabeanus*) and narrow brown leaf spot (*Cercospora janseana*) were commonly present in organic and conventional field plots. However, severity of these diseases in general was significantly higher in organic than conventional plots, with an average of 9- and 6-fold differences for brown leaf spot and narrow brown leaf spot, respectively. Cocodrie and Presidio were rated susceptible to both diseases under organic conditions while they were rated moderately susceptible to brown leaf spot and moderately resistant to narrow brown leaf spot under conventional conditions. In organic plots, CL171 and Sierra were among varieties with highest the levels of the two diseases. All varieties and lines except Jasmine, Milagro Fillipino, and Tesanai 2 were rated susceptible to brown leaf spot. Bengal, Cocodrie/LQ275a, IAC600, Jasmine, MCRO2-1572, PI312777, PI338046, Rondo, Sigoendaba, and Tesanai 2 were highly resistant to narrow brown leaf spot. Leaf smut (*Entyloma oryzae*) was less severe in organic and conventional plots relative to brown leaf spot and narrow brown leaf spot. However, CL171, Cybonnet, Jazzman, Sierra, and Wells were rated very susceptible to leaf smut under organic conditions.

A separate organic trial comparing the fertilizers AgriCycle (4-2-7, N-P-K), Nature Safe (13-0-0) and Rhizogen (7-2-1) at 0, 186, 373, and 559 kg/ha was conducted using the rice variety Presidio in Beaumont, TX in 2009. Percentage of flag leaf blade area affected by lesions of narrow brown leaf spot at rice maturity was significantly lower with the addition of any of the fertilizer treatments, except AgriCycle at 373 kg/ha, compared to the unfertilized control. Disease tended to increase as the rate of each fertilizer product decreased. Disease severity also quantitatively increased with a decrease in total amount (0 to 73 kg/ha of N) of net nitrogen applied.

The results of these trials indicate that organically produced rice is more vulnerable to the infection of foliar diseases than under conventional management. This may be partially due to nitrogen deficiency as a result of using slow release organic fertilizers. Developing organic cropping systems which enhance soil nutrient quality may be a means for improving yield under organic management as well as improving foliar disease control.

Utilizing Antagonistic Bacteria for Suppression of Rice Bacterial Panicle Blight

Zhou, X.G., Kloepper, J.W., Reddy, M.S., Zhang, S., and Groth, D.E.

Bacterial panicle blight, primarily caused by *Burkholderia glumae*, poses a threat to rice production in the southern United States. Yield and quality losses depend on year and location, and estimated yield losses can be as great as 50%. The pathogen is seed-borne and causes leaf lesions, panicle blight, seedling blight, and sheath rot. Most commercial varieties are susceptible. No effective chemicals have been developed or registered for use in the management of bacterial panicle blight. Hence, currently there are no effective recommended disease management options available. We have initiated a biocontrol study with the aim of utilizing antagonistic bacteria as one of the effective components for integrated management of bacterial panicle blight of rice.

Two pathogenic *B. glumae* isolates, one each from Louisiana and Texas, were used to select potential antagonists to the pathogen based initially on antibiosis on agar plates. A suspension of the pathogens was incorporated into agarose (0.5%) and poured onto King's B agar medium to form a thin top layer to encourage uniform growth of the indicator bacteria. The following 19 bacterial strains were spotted on the *B. glumae*-applied medium for testing their antimicrobial activities: eight *Bacillus subtillis* subsp. *subtillis* strains, five *B. safensis* strains, two *B. amyloliquefaciens* strains, and one strain of each of *B. macauensis, B. pumilus, Lysinibacillus boronitolerans,* and *Paenibacillus peoriae*. All of these test antagonists previously demonstrated antibiosis against other plant pathogens. After 3 days of incubation, five strains of *B. subtillis* subsp. *subtillis* and two strains of *B. amyloliquefaciens* showed strong antagonistic activity against both pathogenic bacterium isolates with clear inhibition zones of up to 6 mm in radius.

The seven bacterial strains that resulted in antagonistic activities *in vitro* were further evaluated in the greenhouse. Panicles of the rice variety Cocodrie at the flowering stage were sprayed with suspensions of antagonistic bacterial cells and then spray inoculated with a cell suspension of the pathogenic bacterium isolate. Among seven antagonistic bacterial strains evaluated, two strains of *B. subtillis* subsp. *subtillis* reduced bacterial panicle blight severity by more than 57% over the untreated treatment. The performance of these two *B. subtillis* subsp. *subtillis* strains under field conditions will be evaluated.

First Report of Rice White Leaf Streak in Texas

Zhou, X.G., Tabien, R.E., and Way, M.O.

Rice white leaf streak, caused by *Mycovellosiela oryzae* (syn. *Ramularia oryzae*), was first identified in Papua New Guinea in 1960. The disease also has been reported from Nigeria, North Borneo, Sierra Leone, and the Solomon Islands. In 1996 and 1997, rice white leaf streak was observed to occur on rice in Louisiana. In 2009, symptoms similar to rice white leaf streak were observed on several rice varieties and breeding lines including Cocodrie, Cypress, and Lemont in Beaumont, TX. The objective of this study was to determine if the observed disease was caused by the rice white leaf streak pathogen.

Rice leaves with typical symptoms were collected and three fungal isolates were isolated from the lesions. Lesions usually appeared on lower leaves and were short, linear with wide (up to 2 mm) whitish or grayish centers surrounded by a narrow brown or dark brown margin. Some lesions on heavily infected leaves were long whitish streaks parallel to the midrib. Conidiophores were observed to be produced on external mycelium growing out through stomata on the lesion surface. Conidiophores were hyaline, short and straight, with conidial scars. The colonies of these isolates grew slowly on potato dextrose agar and their radial growth averaged 0.8 mm/day at room temperature (≈ 22˚C). The colonies were dense and grayish in color and did not produce pigments. Conidia were formed singly or in chains and measured 12 to 30 µm long. They were hyaline, straight, cylindrical, typically with 0 or 1 septum, a few with 2 to 3 septa, and had a hilum and tapered ends. Greenhouse pathogenicity of these three isolates was conducted on the varieties Cocodrie, Cypress, and Lemont at the late tillering stage. After 4 weeks of inoculation, typical symptoms similar to those observed in the field developed. *M. oryzae* was reisolated from symptomatic plants. On the basis of disease symptoms, fungal morphology and pathogenicity, it was confirmed that the observed disease was white leaf streak. This is the first report of white leaf streak on rice in Texas and the second report in the U.S. The occurrence of the disease in Texas is of concern because most Southern rice varieties including Cocodrie are susceptible or moderately susceptible to white leaf streak based on a previous study and symptoms of white leaf streak are similar to those of narrow brown leaf spot caused by *Cercospora janseana*.

Soil Salinity Increases Rice Seedling Disease Severity Caused by *Pythium* species

Eberle, M.A., Rothrock, C.S., Slaton, N.A., and Cartwright, R.D.

Stand establishment problems consistently cause production losses and management problems in Arkansas rice fields. The reasons for stand problems are often difficult to determine; thus practices that would eliminate or reduce the amount of losses are not able to be implemented. Stand problems have been associated with environmental and soil factors, herbicides, insects, and seedling diseases. Species of *Pythium* are the most common seedling disease pathogens isolated from rice seedlings from production fields in Arkansas. *Pythium arrhenomanes* and *P. irregulare* are the most frequently isolated and virulent of the *Pythium* sp. in Arkansas. Non- or less virulent *Pythium* sp. include *P. catenulatum*, *P. diclinum*, and *P. torulosum*. Soil salinity is another soil factor that may affect rice stand establishment. Rice is extra sensitive to increased soil salinity levels, with the seedling stage being more sensitive than other growth stages. The objective of this study was to examine the role of soil electrical conductivity (salinity) in rice stand establishment and severity of rice seedling disease caused by *Pythium torulosum*. The importance of soil salinity on seedling disease caused by *P. torulosum* was examined in an experiment using two infestation treatments, non-infested and infested, and five salinity treatments in a factorial treatment arrangement. Electrical conductivity (EC) was adjusted with a 1 *M* calcium chloride ($CaCl_2$) solution to reflect a range of EC levels found in soil samples from rice fields previously collected (400 to 5,000 µS/cm). The cultivar 'Wells' was planted in each pot and pots were arranged in a randomized complete block design with four replications. The experiment was conducted in the greenhouse, with an average temperature of 24°C. Containers were watered with deionized water when the soil matric potential reached levels between -10 J/kg and -30 J/kg. Plant stand was recorded at two and five weeks after planting. At the termination of the experiment (five weeks), seedlings were removed and leaf number, root weight, root discoloration, percent leaf necrosis, and aboveground seedling dry weight were recorded. Electrical conductivity levels in the experiment averaged 428 µS/cm for the field soil. Soil EC levels for the other treatments receiving increasing amounts of $CaCl_2$ were 1,144 µS/cm, 2,022 µS/cm, 3,543 µS/cm, and 4,862 µS/cm. Seedling emergence after two weeks averaged 4.2 plants of the 6 seed planted for soil infested with *P. torulosum* and 3.7 plants for the non-infested control across salinity treatments. Emergence was reduced in soil having an EC > 2,022 µS/cm. There was a significant salinity by infestation interaction for final plant stands at five weeks after planting ($p = 0.0493$), indicating the effect of *P. torulosum* on rice was dependent upon soil salinity. In the presence of *P. torulosum*, stands were reduced at salinities as low as the 1,144 µS/cm salinity treatment, but differences between infested and non-infested treatments were most apparent in the 2,022 µS/cm salinity treatment. For soil having an EC of 2,022 µS/cm, stands for the infested treatment (0.5) significantly differed from the *P. torulosum* 428 µS/cm salinity treatment (5.2) and the non-infested treatment for that salinity (3.5). In soil that did not have any $CaCl_2$ solution added, *P. torulosum* had a stand of 5.2 compared to 4.2 for the non-infested control suggesting that this species of *Pythium* is not important in rice stand establishment under conditions when rice is not affected by an additional stress. Results of this study suggest that in fields having soil with moderate salinity problems, damage from *Pythium* sp. will be more severe. Stand losses due to salinity were not significantly different from the control for the non-infested treatments until a salinity treatment of 3,543 µS/cm. In addition to stand losses, soil having ECs ≥ 2,022 µS/cm had increased root discoloration compared to the control (428 µS/cm). Root and shoot weights were decreased and leaf necrosis increased at 3,543 µS/cm compared to the control. This research is similar to previous research reporting that soil salinity is important in rice development. The research also suggests that salinity may be a significant factor affecting rice stand establishment as a result of its interaction with seedling disease pathogens commonly found in soils. The salinity effect is most likely producing a stress on the plant increasing its susceptibility to *Pythium* spp. rather than salinity increasing the activity of the pathogen. Information on the effect of soil salinity on the virulence of seedling disease pathogens could be a useful tool to assist producers in determining environmental conditions that may limit stands and seedling development in the field and help to select appropriate management practices.

Examination of Toxin Production and Pathogenicity/Virulence Among a Diverse Collection of *Rhizoctonia solani* and Related Species

Castroagudín, V.L., Brooks, S.A., Cartwright, R.D., and Correll, J.C.

Sheath blight (SB) of rice, caused by *Rhizoctonia solani* AG1-1A, is one of the most economically important diseases of cultivated rice (*Oryza sativa* L.) worldwide. Rice cultivars vary considerably in the level of resistance or tolerance to SB, but no cultivars are immune to infection. Initial work described the effect of a specific toxin produced by the sheath blight pathogen in a rice leaf bioassay (Brooks, Phytopathology 97: 1207-1212). To examine the broader potential for toxin production and the effect of the toxin on pathogenicity and virulence, a diverse collection of isolates of *R. solani* and related species were examined. A core collection of 75 isolates, which consisted of *R. solani* (anastomosis groups (AGs) 1, 2, 3, 4, and 11), *R. oryzae, R. oryzae-sativa* and *Sclerotium hydrophilum* were examined. A subset of isolates was also tested for their ability to produce the specific toxin, the effect of the specific toxin in a rice leaf bioassay, and their relative pathogenicity/virulence on rice in a greenhouse inoculation test.

For toxin production, the isolates were grown in a rice grain broth medium (0.6 g ground raw rice [grain and hull] in 150 ml water) for 10 days at 24˚C under constant light. The liquid fraction of the culture was recovered, filtered, and concentrated to 5 times the original concentration (5× TOX) *in-vacuo* at 50˚C with a Rotavapor R-205 (Buchi Labirtechnik AG, Switzerland). One ml of the 5× TOX solution was run on an HPLC (three Showdex OH-Pak columns in series) and toxin production was assessed by the occurrence of a characteristic peak at the 73-minute retention time (rt), previously reported to be associated with a specific toxin. To test rice for sensitivity to the toxin, a leaf infiltration bioassay was performed on the cultivars Cypress (susceptible to SB) and Jasmine 85 (relatively resistant to SB). For the assay, 100 µl of the 5× TOX preparation was infiltrated in leaves of 7-week old rice plants with a Hagbord device. Ten replications were done per isolate × cultivar treatment combination. Sensitivity was evaluated on the degree of necrosis in the infiltrated leaf area on a scale of 0 to 2 where 0 = no necrotic reaction; 1 = intermediate necrosis; and 2 = a strong well defined necrotic circle at the infiltrated leaf area. The relative pathogenicity/virulence among isolates in the core collection also was examined. Pathogenicity tests were conducted by inoculating 3-week old plants of the cultivar Lemont using a micro-chamber method. Disease was scored 16 days after inoculation using a disease index (DI) where DI = (lesion height/plant height) × 9. Two replications were used with three plants per replication. Numerical values of DI were analyzed with the GLM procedure and Fisher's least significant difference test at $P = 0.05$ in SAS 9.2 (SAS Institute, Cary, NC).

Results of the 5× TOX assay indicated that there was considerable variation in detection of the toxin among the isolates examined. The 73 minute rt HPLC toxin peak was detected for some isolates of *R. solani* as well as *S. hydrophilum. R. oryzae,* and *R. oryzae-sativa*. Some isolates of *R. solani* produced no signature peak in the assays performed thus far. However, the toxin assay appears to be sensitive to a number of variables and additional tests are necessary to fully evaluate the qualitative and quantitative nature of the specific toxin produced. Although there were some exceptions, the rice leaf infiltration tests indicated that most isolates that produced the specific toxin also caused a moderate to strong necrosis in the leaf bioassay on the cultivar Cypress. No necrotic reactions were observed on the Jasmine 85. There was some correspondence between the ability of a given isolate to produce the toxin, for the toxin to produce a positive reaction in the leaf bioassay in the leaf infiltration test, and the ability of the isolate to cause SB on rice in a greenhouse inoculation test. However, there appear to be some exceptions as some isolates which do not produce a detectable level of toxin are pathogenic and some isolates which do produce the toxin do not appear to be pathogenic on rice. Clearly, a more robust examination of toxin production, leaf bioassays, and detailed examination of pathogenicity may help dissect the involvement of the signature HPLC toxin on SB disease development.

Sheath Blight Disease Monitoring Using RiceTec Hybrid Rice

Simpson, G.D., Correa, F.J., McNeely, V.M., Bobba, V.L., Hamm, C.E., and Grymes, D.H.

Sheath blight (*Rhizoctonia solani*) is an ongoing problem for flooded rice culture in terms of cost, quality, and yield. Field observations and long term pathology studies led to the design of a RiceTec line evaluation grown in the presence of the sheath blight fungus. RiceTec hybrid rice exhibits improved field tolerance to the progression of sheath blight. Environmental conditions such as temperature and relative humidity do influence disease development.

RiceTec has performed 3 years of field studies using RiceTec hybrid rice, varietal checks, pathogen inoculum, and 3 rates and timing treatments of fungicide following pathogen inoculum application. Field studies were conducted at The RiceTec Alvin, TX headquarters, the RiceTec Arkansas business center, and at on farm locations at The Phillip Rizzo farm near Shelby, MS in 2008 and the Jim Whitaker farm near Jerome, AR in 2009. In 2007, 2008, and 2009 small plot variety tests were planted according to RiceTec protocol and recommendations.

Rhizoctonia solani inoculum was produced by the RiceTec pathology group from naturally occurring strains isolated from local infected rice fields. The inoculum was grown on sterile rice hulls. Rice hull inoculum was applied by hand to field plots at the green ring growth stage at or near midseason as possible dependent upon local conditions. Quilt Fungicide (azoxystrobin 75 g/L, propiconazole 125 g/L) was then applied at 3 rates and timings. Treatment 1: Quilt at 0.4L/ha applied 7 days after inoculum application, Treatment 2: untreated check, Treatment 3: Quilt at 0.2L/ha applied 14 days after inoculum application. Grain yield, lodging score, milling yield, and disease incidence and severity were rated.

Results indicate that environmental conditions do influence disease development. However, in most cases RiceTec hybrid rice exhibits better disease tolerance and slower progression of the sheath blight under field conditions. Results also suggest that RiceTec hybrids can be treated with reduced rates of fungicide and a wider application window and still preserve yield potential.

Ontogenetic Changes in Vitamin C in Selected Rice Varieties

Lisko, K.A., Hubstenberger, J.F., Belefant-Miller, H.B., Phillips, G.C., and Lorence, A.

Vitamin C (ascorbic acid, AsA) is essential for human health; however, despite our dependency on plants as dietary sources of this key nutrient, little is known about its metabolism in crops of agricultural importance. As the most abundant antioxidant in plant tissues, AsA protects cells and organelles from oxidative damage by scavenging reactive oxygen species (ROS) that are produced in response to abiotic and biotic insults. Ascorbate is also a cofactor of many enzymes, controls cell division, and affects cell expansion. In addition AsA is a substrate for the production or tartaric and oxalic acids, and is a modulator of plant senescence. Biosynthesis of AsA in plants is carried out by a complex metabolic network with at least four branches.

Our laboratory has determined that *Arabidopsis thaliana* lines over-expressing enzymes that participate in the *myo*-inositol pathway accumulate 2 to 3 times more AsA, and are tolerant to multiple abiotic stresses such as salt, cold, and heat compared to wild type controls. Our studies have also detected a positive influence of elevated AsA on the growth of both above and belowground tissues. In *Arabidopsis* and related mustards, vitamin C metabolism has been characterized to an extent. In these model systems AsA is known to peak in young tissues and decrease throughout development. Multiple studies also indicate that the size of the AsA pool depends on light intensity.

With the goal of gaining a deeper understanding on the basal steady state AsA levels and the metabolism of this key molecule, in this work we studied ontogenetic changes in vitamin C in selected rice varieties. These varieties were selected based on agronomical and biotechnological characteristics as well as differences in regeneration potential. Rice seeds were planted in soil, and grown under controlled conditions; leaf samples were collected at specific developmental stages and quickly frozen and stored at -80˚C for subsequent extraction. Ascorbate was extracted using *meta*-phosphoric acid and total, reduced and oxidized AsA pools were measured using a spectrophotometric-based method. Our results with eight cultivars indicate that metabolism of vitamin C in rice follows a very different pattern from that seen in *Arabidopsis*, tobacco, tomato, and morning glories, among other species. In rice, AsA peaks at two developmental stages: early during vegetative growth (V2) and at the beginning of the reproductive phase (R4). Our findings also indicate significant variation in AsA foliar levels among accessions. Ongoing experiments involve a more detailed analysis of the AsA content of other tissues and sampling at additional developmental stages. These studies are paving the way to identify varieties with naturally high-AsA levels that can be used in the future as breeding materials to generate germplasm that is able to flourish under stressful conditions.

Over-Expression of Ascorbate Biosynthesis Genes for Improved Protein Production and Stress Tolerance in Rice

Underwood, J., Wilson, G.A., Dolan, M.C., Srivastava, V., and Lorence A.

Plants are considered an excellent platform for producing protein whether as a nutrient source in crop plants or as a “factory” for pharmaceutical- and industrial-valued recombinant products. However, under both cases, plants are subject to intense metabolic processing that can significantly increase levels of reactive oxygen species (ROS) and plant stress often resulting in reduced protein quality and protein accumulation. We and others have shown that strategies that elevate vitamin C levels (ascorbic acid, AsA) *in planta* lead to enhanced scavenging of ROS and improved overall plant stress tolerance.

In this study we used a transgenic approach to enhance ascorbate levels in a rice cell culture model. With a goal of improving accumulation of protein content and enhancing overall stress tolerance in plant cells, we expressed two separate AsA biosynthetic genes, *myo*-inositol oxygenase (MIOX) and gulono-1,4-lactone oxidase (GLOase) in rice. Insertion was targeted to a selected genomic position using a Cre-*lox* mediated transgene integration approach to mitigate gene silencing effects. Upon confirming the transgenic status of multiple callus lines, total, reduced, and oxidized pools of AsA were measured using an enzyme-based spectrophotometric method. Our analysis revealed a 2- to 4-fold increase in total AsA levels in selected callus lines. Studies including Western immunoblot experiments to determine expression levels of target AsA biosynthetic proteins in elite callus lines as well as regeneration of full plants from the MIOX and GLOase over-expressers are in progress. This proof-of-concept work paves the way for determining if enhanced vitamin C levels can improve both recombinant protein production in plant cells and enhance field performance and yields of agronomically important seed crop plants in the future.

Abstracts of Papers on Postharvest Quality, Utilization, and Nutrition
Panel Chair: Elaine Champagne

Single-Pass Drying of Rough Rice Using Glass Transition Principles

Ondier, G.O. and Siebenmorgen, T.J.

A recently developed approach to drying rough rice using high temperature air comprises controlling the relative humidity of the air such that the kernel periphery remains in a rubbery state just as would the kernel core during the drying process, thereby avoiding intrakernel state property differences. According to previous work involving glass transition principles, such drying would allow single-pass drying without fissure occurrence. A series of drying trials were conducted in which rough rice samples were dried in a single pass from an initial moisture content of approximately 18.1% to a desired 12.5% moisture content using air at 70 – 90°C and 13 – 83% relative humidity. The milling quality of the dried samples was evaluated in terms of head rice yield. Results showed that head rice yields of samples dried at 70, 80, and 90°C and low relative humidity (13 – 43%) were near zero, but increased rapidly as the relative humidity of the drying air increased above 43%. There were no significant differences in milling quality of dried samples and that of controls when the relative humidity of the drying air was equal to or greater than 63, 73, and 83% at 70, 80, and 90°C, respectively. Grain temperature profiles mapped onto the glass transition diagram of rough rice, for a temperature of 70°C, showed that at 63% relative humidity or greater, the kernel periphery remained in a rubbery state, whereas at lower relative humidity, a substantial portion of the kernel periphery transitioned into the glassy state; a condition that has been shown to cause kernel fissuring. Therefore, the improved milling quality of the single-pass dried samples, observed at the high relative humidities, was attributed to controlling the kernel periphery material state according to glass transition principles.

Equilibrium Moisture Contents of Rough Rice Dried Using High-Temperature, Fluidized-Bed Conditions

Ondier, G.O. and Siebenmorgen, T.J.

Equilibrium moisture contents of long-grain rough rice with initial moisture content of 20% and dried in a fluidized-bed system at temperatures ranging from 60 to 90°C and relative humidities from 7 to 75% were measured. Rice sample mass and drying air conditions were recorded throughout the drying duration for each test until there was no further change in mass. The Page equation, with experimentally-determined drying parameters, was used to describe the drying data. Equilibrium moisture contents were determined as asymptotic values of the Page model. Equilibrium moisture content data were also used to estimate empirical constants of the Modified Chung-Pfost and Modified Henderson equilibrium moisture content equations. The resulting Modified Chung-Pfost equation predicted the experimental data with a Root Mean Square Error of 0.6416 percentage points and a Coefficient of Determination of 0.94.

Desiccant Drying of Small Rice Samples

Wiedower, A.C., Ondier, G.O., and Siebenmorgen, T.J.

After harvest, most rough rice research samples are dried using ambient air, the temperature and relative humidity of which oscillates. Fluctuations in environmental conditions produce variation in the final moisture contents (MCs) of samples, yielding inconsistent functional properties. The goal of this study was to develop an alternative method for drying small rough rice samples capable of yielding accurate and precise final MCs while maintaining grain quality. Silica gel's potential for drying such samples was specifically investigated. Drying experiments incorporated a combination of 1- and 5-g moisture-permeable, silica gel packets mixed with rough rice samples in plastic bags.

The average adsorptive capacity of the packets in closed rough rice samples was established as 25 – 27% (i.e., 0.25 – 0.27 g of water/1 g of silica gel). A desired final MC (12.5%) was achieved with minimal variation (standard deviation of 0.1 percentage points) for silica gel-dried rice samples; the milling quality of these samples, expressed as head rice yield, was not significantly different from that of air-dried samples.

Moisture Diffusivity Measurement of Major Fractions of Rough Rice

Bingol, G., Prakash, B., Pan, Z., and Thompson, J.F.

Moisture gradients produced in the kernel during pre-harvest and post-harvest operations can cause it to fissure and thus, reduce crop value. To model the moisture changes within the kernel when exposed to different humid and dry environments, the diffusivity of different components of rice kernel such as endosperm, bran and husk need to be known.

In this study, we conducted dynamic vapor sorption (DVS) experiments to find moisture isotherm characteristics of different components of Californian rice varieties M202 and M206 and characterized them according to the Brunauer *et al*. classification. The relative humidity (RH) was changed from 0 to 97.9 % and then to 0%, at 20% RH steps at 25°C. It was observed that the equilibrium for rough and brown rice was attained faster at 20 and 40% RH steps; on the contrary, the equilibrium for white rice was obtained faster at RH steps of 60, 80 and 97.9%. It was seen that for rough, brown and white rice attaining equilibrium at 0% RH took longer than 1500 minutes. The equilibrium for husk at all RH steps was easily obtained within 500 minutes.

A finite element model (FEM) was developed to predict moisture content within the rice kernel during any absorption or desorption process from environment. Moisture change data with time recorded in the DVS experiments were used in the model to determine diffusivity of each component.

Prediction of Surface Lipid Content and Color Parameters Using Near Infrared Spectroscopy: A Basis for Predicting Rice Degree of Milling

Mohammed, S., Meullenet, J.-F., and Siebenmorgen, T.

Degree of milling (DOM) is a measure of the extent to which rice bran has been removed from brown rice during milling. Visual examination is the current standard method used by GIPSA to determine DOM and is also a common practice in the milling industry. Even with standard line samples, this method is relatively subjective, inherently incorporating both color and level of oil remaining on kernels; there is a need for reliable instrumental methods capable of predicting milled rice DOM and/or grade.

Near-infrared spectroscopy (NIR) is an analytical technique that has been used for the past twenty years to quantify the level of various cereal grain constituents, including moisture, protein, and oil. With regard to rice, NIR has been used to predict apparent amylose, protein, and surface lipid contents. Although the technology has shown success for predicting surface oil content in rice, it has not been used in an attempt to assess rice color.

Consequently, the objective of this project was to develop NIR based calibrations to predict SLC in multiple cultivars, harvested in multiple locations across four harvest seasons and to assess the potential of NIR to predict milled rice color.

The rice samples used in this research were harvested between 2004 and 2008. In total, 1782 samples, taken from numerous cultivars and hybrids, from the Southern United States rice region, and milled to various degrees of milling, were used. The samples were harvested in the range of 17-21% MC (moisture content) and dried to approximately 12%. They were cleaned, placed in sealed buckets and stored at room temperature. For each sample, duplicate 150 g samples were milled for durations ranging from 10-60 seconds in a McGill #2 laboratory mill. After milling, samples were assessed for surface lipids using a Soxtec system (Avanti 2055, Foss North America, Inc., Eden Prairie MN) while kernel color was assessed using a color meter (Colorflex, Hunterlab, Reston, VA). The instrument used for NIR scanning was a Near Infrared Reflectance instrument (Diode Array 7200, PERTEN

Instruments, Springfield, IL). Reflectance was measured in the range of 900 to 1700 nm in 2 nm intervals. Samples were held in a spinning sample cup while the NIR spectrum was collected. Two scans per samples were collected. NIR, color and lipid content data were processed using the multivariate regression software Unscrambler (Version 9.2, Camo, AS, Norway). The spectral NIR data was used to predict SLC and color using Partial Least Squares (PLS-I) and the Jack-knife optimization options of Unscrambler.

Results indicated that the prediction of both SLC and rice color, especially lightness (L) was possible across cultivar, harvest location and harvest year. SLC ranged from 0.102 to 1.379% across samples. The correlation between observed and NIR predicted values was high (R=0.972) and the average error of prediction relatively low (RMSEP=0.052), a value similar to previously reported prediction errors. For lightness (L), data ranged from 59.78 to 77.64 and the predictive models were also satisfactory. The correlation between observed and NIR predicted L values was 0.968 and the prediction error low (RMSEP=0.629).

This research establishes the potential of NIR for the prediction of rice surface lipids and color. Further research should concentrate on the establishment of a NIR based grading system for rice.

Genetic Diversity of Grain Mineral Concentrations among Diverse Rice Germplasm Grown under Aerobic and Anaerobic Field Conditions

Pinson, S.R.M., Tarpley, L., Salt, D.E., Zhang, M., Baxter, I., Guerinot, M.L., and Punshon, T.

Rice provides the major source of nutrition for a large proportion of the world's population. Mineral nutrients such as Ca, Fe, and Zn play critical roles in human health, with over 3 billion people suffering from Fe and Zn deficiencies. Unfortunately for those who rely on rice for subsistence, rice grain is not a good source of these nutrients and can contain toxic elements such as As and Cd. As such, alterations in the mineral content of rice grain to either increase or decrease levels of various elements would impact human health. The first step toward breeding commercial rice lines with improved nutritional value is to identify germplasm having extreme nutritional traits.

The USDA Core Rice Collection is a subset of 1797 rice lines randomly selected from among the more than 17,000 accessions in GRIN. This Core subset contains rice accessions from 112 countries in 14 geographical regions, and was randomly selected in order to represent the wide genetic diversity contained within the larger set of rice lines contain in the USDA National Small Grains Collection (NSGC). We grew the 1700 *O. sativa* and *O. glaberima* members of the USDA Core Rice Collection in Beaumont, TX under both flooded and unflooded field conditions over two years (2007-2008), two replications per year. ICP-MS was used to analyze the harvested brown rice for variation in accumulation of 16 elements, namely Mg, P, K, S, Ca, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Mo, and Cd.

Because the soil redox state greatly affects the availability of soil nutrients, we grew the 1700 Core accessions under both flooded, and unflooded conditions, two replications per year, over two years. It was important to grow the accessions closely together in the field to minimize soil variance within the study. Five seed per accession were drill-seeded into hillplots. The hillplots were arranged in rows, with 5 hillplots per row-grouping, 61 cm between hillplots within each row, and 25 cm between rows. This distance between hillplots not only allowed for walking between plots for field management and harvest, but also minimized the variance of nutrient and sunlight availability between the hillplots inside versus on the ends of the field rows. Fifteen repeated check-plots paired with fifteen soil samples per paddy were grown/collected in a grid pattern. This allowed us to document that the impact of environmental variance within each paddy was small compared with genetic impact on grain element content. Twenty fully mature, non-diseased seed were selected per hillplot for ionomic analysis using ICP-MS. The standard rubber coating on huller rollers was found to contaminate seed samples with Zn during the hulling process. Therefore, we first replaced this rubber coating with a PU40 Polyurethane plastic. Standard coin envelopes with gummed flaps were used to contain the dehulled brown rice samples, after first verifying no elemental contamination of seed from their usage. Grain content of each of the 16 elements was averaged per water treatment across replications and years.

Large (> 5x) ranges in grain content were found for each of the 16 elements studied. Three element x element correlations were found to be significant and > 0.5, in particular P – K (r=0.56), P-Mg (r=0.66), and Zn –Ca (r=0.64). Both K and Mg were more directly correlated with P than with each other (r=0.35). The average grain concentration was highly dissimilar between the elements. For example, the average grain concentration of Cd was 0.15 ppm, Fe averaged 15 ppm, and Ca averaged 100 ppm. In order to more easily compare elements with such diverse grain concentrations, we calculated Z-scores for each element, which reflect standard deviation from the population averages. In prior *Arabidopsis* studies, major-gene mutations were found to large shifts in seed element phenotype, resulting in Z-scores ≥ 3. We used a Z-score threshold of +/-3 for identifying accessions to be used as crossing parents to create segregating F2 progeny populations in which to pursue future gene mapping studies. The unflooded field condition revealed more extreme phenotypes than did the flooded field condition. For all elements, the grain content histograms were skewed with significantly more accessions having > average content than those having < average content. Several lines for each element were found to have Z scores > 3, but for 11 of the 16 elements, no accessions were found to have Z scores < -3 (significantly low concentration). The accessions identified as having high concentration of a particular element were sometimes found to come from geographically similar regions. For example, four of the five lines highest in Mo content came from Malaysia. The common origin of the high-Mo accessions is exciting in that it provides internal replication to our study that strengthens the supposition that we have identified rice accessions containing a heritable gene that results in their developing seed having high Mo content. It also suggests that we can study just one segregating progeny population, or combine data between the four related segregating progeny, in order to efficiently identify molecular markers linked to the high-Mo gene(s).

Relationship of Cooked Rice Nutritionally-Important Starch Fractions with Other Physiochemical Properties

Patindol, J.A., Guraya, H.S., Champagne, E.T., Chen, M.H., and McClung, A.M.

Starches in food can be classified into three major fractions according to *in vitro* digestibility as rapidly-digestible (RDS), slowly-digestible (SDS), and resistant starch (RS). SDS and RS have significant implications on human health. SDS goes through a slow but complete hydrolysis in the small intestine and its potential health benefits are linked to a stable glucose metabolism, diabetes management, mental performance, and satiety. RS escapes digestion in the small intestine but is partially or entirely fermented in the colon. It shows promising physiological impact in the prevention of colon cancer, postprandial glycemia and insulinemia, hyperlipidemia, gall stone formation, and cardiovascular diseases. Previous research with rice mainly focused on RS and less on SDS.

Uniform Regional Rice Nursery samples, consisting of sixteen rice cultivars that represented five cytosine-thymine repeat (CTn) microsatellite genetic marker groups were analyzed for their cooked-rice nutritionally-important starch fractions (NISF, which consists of RDS, SDS, and RS), basic grain quality indices (apparent amylose, crude protein, alkali spreading value, and gel consistency), pasting characteristics (peak, final, breakdown, and setback viscosity), and thermal properties (gelatinization temperature onset, peak, range, and enthalpy). Chemometric tools (including bivariate correlation, principal component analysis, multiple linear regression, and partial least squares regression) were used to establish the association of NISF with other milled rice physicochemical properties.

CT_{11} was generally associated with high percentages of resistant starch (RS) and slowly digestible starch (SDS), and a low percentage of rapidly digestible starch (RDS). CT_{14} was associated with low SDS; whereas, CT_{17} and CT_{18} were associated with low RS. The CT20 samples were similar to CT_{11} in SDS and RS; and to CT_{14}, CT_{17} and CT_{18} in RDS content. RDS, SDS, and RS were loaded on three different quadrants of the principal component similarity map. RDS was not significantly correlated with any of the physicochemical properties; whereas, SDS was positively correlated with gel consistency. RS was positively correlated with apparent amylose, setback viscosity, total setback viscosity, and peak gelatinization temperature; and negatively correlated with breakdown viscosity. Multivariate techniques indicated lack of robustness in predicting RDS and SDS as the models only explained <50% of the variance. More robust regression models were obtained for RS, explaining >60% of its variation. Basic grain quality indices explained NISF variations better than pasting and thermal properties.

Volatile Profiles of Aromatic and Non-Aromatic Rice Cultivars using SPME/GC-MS

Bryant, R.J. and McClung, A.M.

Rice (*Oryza sativa* L.) is enjoyed by many people as a staple food because of its flavor and texture. Some cultivars, like scented rice, are preferred over others due to their distinctive aroma and flavor. The volatile profile of rice has been explored by many investigators, some of whom have determined a corresponding aroma using GC/Olfactometry. Although it has been shown that storage conditions can affect the aroma and flavor of rice, little research has been done to determine if aromatic rice cultivars from different genetic backgrounds produce flavor volatiles, other than 2-acetyl-1-pyrroline (2-AP), that would make them more desirable over others cultivars when cooked. It would also be important to see if volatiles profiles change with time and temperature.

In this study, seven cultivars developed from different aromatic sources [Aromatic se2 (Basmati 370 source); Dellmati (Domsiah or Della source); Dellrose (Della source); IAC 600 (Japan source); Jasmine 85 and JES (Khao Dawk Mali 105 source); and Sierra (Della or Basmati 370 type)] and two non-aromatic cultivars (Cocodrie and Wells) were grown in a replicated trial in Stuttgart, AR in 2008. Rough rice samples were harvested at maturity and double bagged in Ziploc freezer bags and stored at 30oC, 4oC, and -10oC. Each sample was examined for their volatile profile both before storage and every thirty days thereafter for 3 mo. using solid phase microextraction (SPME) fibers in conjunction with gas chromatography/mass spectrometer (GC-MS). Twenty mg of whole milled rice kernels were placed in a 2ml vial and 20ul of ultra-pure water containing 1ng of 2,4,6-Trimethylpyridine (internal standard) was added. The SPME fiber (1cm 50/30 divinylbenzene/carboxen/polydimethylsolaxane stableflex) was allowed to equilibrate for 18 min. at 80oC and then desorbed in the GC injector for 25s at 260oC. Each compound was identified by the presence of selected ions and their ratio, and comparison of the MS spectra obtained in the full scan mode to reference spectra in the National Institute of Standards and Technology mass spectral database.

Eleven aldehydes, 15 alkanes, 10 alkenes, 10 ketones, 19 alcohols, 4 amines, 5 acids, and 19 miscellaneous compounds were identified. Of the 93 volatile compounds identified, 64 had not been previously reported in rice. Differences were found in volatile compounds of aromatic and non-aromatic rice other than 2-acetyl-1-pyrroline (2-AP). Most of the volatile compounds were present in freshly harvested rice and rice following storage with very few new compounds being identified only after storage. Dellrose, an aromatic cultivar, and Cocodrie, a non-aromatic cultivar, had the most complex volatile profiles (over 64 volatiles). Wells had the fewest (51) volatile compounds. Sixteen compounds were found only in aromatic cultivars and some volatiles were found to be unique to specific aromatic cultivars. JES contained more compounds that have the potential for production of off-flavors, whereas, Jasmine 85 and Sierra contained the least. However, no distinctive pattern was observed that would identify a cultivar as being derived from Basmati, Khao Dawk Mali 105 (i.e. jasmine), or other sources of aroma. This study showed that there is a great diversity of volatiles in both aromatic and non-aromatic rice cultivars and, with further research, this may lead to a better understanding of the combination of compounds that gives a cultivar a unique flavor.

Measuring the Aroma in Aromatic Rice

Grimm, C.C., Lloyd, S.W., and Champagne, E.T.

The compound, 2-acetyl-1-pyrroline (2AP) is the predominant odor active compound in fresh aromatic rice. Originally reported by Buttery and co-workers in 1982 to be present in aromatic rice at concentration levels ranging from 10-90 ppb, subsequent analyses have been shown 2AP to be present in amounts of several hundred parts per billion to as much as several parts per million. 2AP has also been reported in non-aromatic rice but at concentration levels of only a few parts per billion. Analysis at these lower levels is problematic and the lack of a ready available supply of standard of 2AP has hindered progress. Improved analytical techniques would aid in the detection of adulterated high valued aromatic rice with lower cost rice and aid breeders in assessing the quality of new varieties. 2-AP in rice was analyzed in a variety of forms including brown rice, milled rice, and flour. Extraction methods included solvent extraction, solid phase microextraction, dynamic headspace extraction, and stir bar sorptive extraction. Analysis of volatile compounds was accomplished by GC/FID or GC/MS. 2AP was synthesized via published methods and concentrations in aqueous and organic solutions were determined by comparison of relative peak areas with 2,4,6-Trimethylpyridine (TMP) using an FID detector. GC/MS was employed to ensure identity and to enhance sensitivity. Sensitivity for the FID detector was ~1 ng, while sensitivity for the MS detector was at the pg level.

Recovery levels were obtained by first measuring the 2AP in selected rice samples employing $MeCl_2$ extraction method and then comparing to the 2AP/TMP ratio obtained by SBSE. The average recovery level from 5 samples was only 3%. Repeated sampling of the same vial with successive Twister stir bars gave similar concentrations rather than decreasing amounts. This is consistent with low levels of recovery but does permit re-sampling should the need arise. A 10 fold increase in sensitivity for 2AP using SBSE relative to SPME was observed. This is less than one might expect with a 50 fold increase in stationary phase but probably results from the use of the PDMS on the SBSE, which is the only stationary phase currently available. Optimal sensitivity with SPME was obtained using the carboxen/PDMS/DVB stationary phase on the fiber. Precession of the SBSE method was similar to SPME (10-20%) and inferior to the $MeCl_2$ extraction method (<5%). 2AP was not detected in non-aromatic rice using the SBSE method.

Phytonutrients in Rices of Different Bran Color

Min, B., McClung, A.M., and Chen, M.-H.

The consumption of whole grain has been linked to the reduced incidence of chronic (cancer, diabetes, cardiovascular disease) and various inflammatory diseases. The phytonutrients/antioxidants contained in the whole grain, specifically in the bran layer, contribute to these health benefits. Rice bran is a rich source of lipophilic antioxidants, including tocopherols, tocotrienols, and γ-oryzanols. Many studies have reported that these lipophilic phytochemicals have strong antioxidant capacities and show various health-beneficial effects, including reduction of total plasma cholesterol, increase of HDL cholesterol level, and prevention of cancer and cardiovascular disease. In addition, the simple phenols extracted from light brown colored rice have a potential chemopreventive effect. Studies have shown that the majority of phenolic compounds in cereals are actually bound to cell-wall components and cannot be extracted by solvents. These bound phenolic compounds can be liberated by digestive enzymes and micro-flora in the colon providing their health-protective effects on site and/or to other body parts after absorption. A recent study showed that, in an animal model system, diets supplemented with the cell wall-bound fraction of rice bran reduce hypertension, hyperlipidemia, and hyperglycemia. Recent interest has been focused on pigmented rice, and especially on the purple and red colored bran rice varieties because of their abundance of anthocyanins and proanthocyanidins, respectively. These sub-groups of phenolics have strong antioxidant capacities related to health-promoting potentials such as obesity prevention, anti-cardiovascular disease, anti-inflammation, and anti-cancer effects.

The objective of this study was to comprehensively determine the profiles of lipophilic, hydrophilic (free), and insoluble, bound phytochemicals in different colored rice brans (1 white, 2 light brown, 2 brown, 1 red, and 2 purple). Three antioxidant-capacity assays based on different mechanisms were used for evaluating the antioxidant capacity of the hydrophilic (free) and insoluble-bound fractions: the DPPH radical scavenging capacity, the oxygen radical absorbance capacity (ORAC), and the iron chelating capacity.

Concentration ranges of tocols (sum of homologs of tocopherols and tocotrienols) and γ-oryzanols were 319-443 and 3861-5911 μg/g bran, respectively. The total anthocyanin concentration in purple rice bran (IAC600; 33.68 mg kuromanin equivalents/g dry wt basis) was 4 times higher than that in blueberry ($P<0.05$) (dry wt basis). Total proanthocyanidin concentration was the highest in red rice bran (IITA119; 22.61 mg (+)-catechin equivalents/g dry wt basis) ($P<0.05$) and small in other rice brans, broccoli, and blueberry (0.09-1.31). Red and purple rice brans had 3-25 times higher total phenolic and flavonoid concentrations and total DPPH radical capacity, and ORAC (sum of those in free and bound phenolic fractions) than did blueberry, broccoli, or light-colored rice bran. The bound phenolic fraction accounted for more than 45% of total hydrophilic ORAC antioxidant capacity in bran of the light color bran rice. The bound phenolic fraction of red and purple rice brans had higher bound phenolic and flavonoid concentrations and total antioxidant capacities than that of light-colored rice bran ($P<0.05$).

Converting the concentration of anthocyanins in bran to cooked rice (without accounting for any cooking effect), the purple rice of IAC600 would contain 170 mg of total anthocyanins in 100 grams of cooked rice versus 124 mg/100 g in fresh blueberry. In conclusion, whole grain rice is an excellent food source with well balanced macro and micro-nutrients and phytonutrients, and the red and purple rices are exceptionally high in phytonutrients, with levels comparable to blueberry, the dietary phytonutrient yardstick. Whole grain rice merits increased use as table rice and in nutraceutical and functional food applications.

Color between Raw and Cooked International Rice Varieties in Relation to Amylose and Protein Contents

Lea, J.M., Bett-Garber, K.L., Champagne, E.T., Fitzgerald, M.A., and Thomson, J.L

Traditionally, the color of milled rice is economically important, because consumers determine visual rice quality on whiteness. The whiter it is the more value it has in the market place. Cooked rice color is an important sensory parameter, also. There has been minimal research reported on what affects the color of milled rice. Degree of milling affects the color; and there is indication that storage temperature of paddy rice affects color. Nothing has been reported on the effects of amylose and protein levels on color.

Two premium commercial cultivars from eight rice producing countries, with an additional year of samples from Brazil were sent to SRRC. Each country pair was identically milled. Apparent amylose content was determined by the simplified iodine assay method and protein contents were determined by the combustion method on a nitrogen determinator (LECO, FP-428). Rice was prepared according to customary cooking procedures within the country of origin. Tristimulus color values (L*, a* and b*) were measured using the Hunter Miniscan XE Plus colorimeter on the rice before and after cooking.

Usually, L* value (whiteness) in the cooked rice was higher than in raw rice. The exceptions were Japanese Koshihikari, Pakistani Basmati 385, Chinese Zhongzheyou 1, and Philippino IR 64. In all cultivars, a* value was higher (more red), and b* value was higher (more yellow) in raw rice. The a* value decreased (red to green) the most in the Indian (Samba Mahsuri and Swarna), Iranian (Hashemi and Khazar) and one Pakistani samples (Basmati 385). The b* value decreased (from yellow to blue) the most in these same rice samples. These samples were all fairly high in amylose (~22%) and intermediate in protein (~9%). These five rice samples also had the greatest change in a* value (from green to red) upon cooking. One sample from China (Zhongzheyou 1) exhibited a significant increase in L* value (whiteness) upon cooking. It, also, had the least change in b* value (yellow to blue) when cooked, and had a low amylose (15%) and low protein (7%) content.

Low Oil-Uptake Rice Batters

Shih, F.F., Daigle, K.W., Bett-Garber, K.L., and Champagne, E.T.

Crispy coatings are a critical part of the acceptance of fried foods. However, whereas fried batters may enhance the sensory quality of the coated food, they also may introduce undesirable effects to the consumers. Normally, fried batters contain high amounts of oil and contribute to oil-related health problems such as obesity and heart disease. These batters may also contain elevated amounts of acrylamide formed during frying. Thus, reduction of both oil uptake and acrylamide is a target for development of improved batters. This paper summarizes the development of low oil-uptake rice batters at the Southern Regional Research Center, their oil absorption and frying properties, their acrylamide content when fried, applications, and recent commercialization of the product.

Oil-uptake was determined after frying under standard conditions for non-coating batters and those coating chicken drumsticks and okra. A batter base was prepared containing 1.0% sodium bicarbonate, 3.0% sodium chloride, 0.72% pyrophosphate, 95.28% rice flour, or a mixture of rice flour and various additives. A slurry was prepared by mixing 100 g of the batter base with various amounts of water (96-150 g) for 5 min at room temperature. The appropriate amount of water provided a Rapid Viscoanalysis Unit (RVU) viscosity reading of 115-130 (1380–1560 cP).

Oil retention ranged from 27.6% for pure rice flour batter to 49.3% for the pure wheat flour batter. Rice flour has better oil resistance than the wheat flour. As the rice flour content was increased, the fried batter became more brittle, less fluffy, and harder to chew. Also, batter slurries high in rice flour were low in viscosity. Batters from long grain rice flour with the lower amylopectin/amylose ratio retained substantially less oil than batters from the waxy rice flour. The addition of protein to batters enhanced oil uptake during frying due to emulsifying effect.

Replacement of a control batter composed of equal ratios of rice and wheat flours with 5 – 10% phosphorylated rice starch resulted in lower oil uptake for the fried batter. When the modified starch with 1.64% phosphorus was used, the oil uptake was reduced to 19% at 15% replacement. In comparison, the control rice-wheat batter had oil uptake of 46.3%. There was also a general trend of decreased oil uptake with increased moisture retention: 22.7% moisture retention for 15% replacement with modified starch having 1.64% phosphorus compared to 1.5% moisture retention for the control. The phosphorylated starch, which has superior pasting and film-forming properties, enhanced the batter's water-holding ability and made it a more effective oil barrier during frying. Viscosity of the batter also increased with the addition of phosphorylated starch. The control had a viscosity of 85 RVU; 15% replacement with modified starch having 1.64% phosphorus resulted in a viscosity reading of 350 RVU.

Testing the 100% rice batters containing phosphorylated rice starch (0.95-2.86%) as coating on chicken resulted in oil uptake being reduced by 59-62%. Addition of pre-gelatinized rice flour (6.8%) to rice flour was also effective and reduced oil uptake by 58%. Rice-based batters were found to work best in the 100-150 RVU viscosity range and at 12-24% dry pickup. The 100% rice-based batters with phosphorylated rice starch or pre-gelatinized rice flour had viscosity and dry pickup within these ranges. Rice batter containing 5% pre-gelatinized rice flour applied to okra resulted in a 51% reduction in oil uptake. When evaluated for sensory properties, appearance and surface attributes were found to be superior or equal to those of the wheat batter and rice batter without pre-gelatinized rice flour. Its golden brown color was considered to be more desirable than the lighter yellow color of the other 2 entities. Hardness and crispiness of the rice flour formulations were higher and cohesiveness lower than wheat flour formulations, but within the normal range of commercial products. The distinctive crispiness of the rice batters was considered a positive attribute.

Following frying, acrylamide content of long-grain rice, waxy rice, wheat, and corn batters were 180, 194, 298, and 378 ng/g, respectively. The increase due to frying was 82, 108, 211, and 263 ng/g in the long-grain rice, waxy rice, wheat, and corn batters, respectively. Therefore, the acrylamide content of the rice batters before and after frying were markedly lower than those of wheat and corn. A new company CrispTek, LLC has licensed this ARS technology. The first product line was introduced in June, 2009 with the trade name Choice Batter (www.choicebatter.com). The ARS team, led by Fred Shih, is continuing collaborative research with CrispTek to expand the product line.

Abstracts of Posters on Postharvest Quality, Utilization, and Nutrition
Panel Chair: Elaine Champagne

A Comparative Study between the McGill No. 2 Laboratory Mill and Commercial Milling Systems

Graves, A.M., Siebenmorgen, T.J., and Saleh, M.I.

The degree of similarity between rice milled in a McGill No. 2 laboratory mill and commercial milling processes was evaluated using eight physical, physicochemical, and end-use properties. The sample set comprised 29 lots taken from commercial mills located in five states. There was no statistical difference between the two milling systems with respect to color parameters L^* and a^*, final viscosity, texture, and end-use cooking properties (α = 0.05). Overall, the kernel dimensions of length, width, and thickness were less in the McGill No. 2 laboratory-milled rice than the same rice milled commercially. The incidence of bran streaks and peak viscosity values were each greater when the rice sample was milled commercially in twenty-seven, and twenty-eight, respectively, of the 29 samples by means comparison. The decrease in kernel dimensions and lesser incidence of bran streaks in the laboratory-milled rice were attributed to the more aggressive nature of the single-pass, batch milling system of the McGill No. 2 mill as compared to multi-pass, continuous milling systems that are used commercially. Across all samples, as surface lipid content (SLC) decreased, L^* increased, and a^*, b^*, and the incidence of bran streaks decreased for both milling systems.

Control of the McGill No. 2 Mill by Near Infrared Spectroscopy

Graves, A.M, Saleh, M.I., and Siebenmorgen, T.J.

Surface lipid content (SLC), as a measure of rice degree of milling (DOM), was instantaneously predicted with near infrared (NIR) spectroscopy while rice was being milled inside a McGill No. 2 laboratory mill. The McGill No. 2 mill stainless steel cover was fitted with a synthetic sapphire window to allow NIR light exchange with the rice. Calibration curves were built to link the spectral scans of long- (n=554) and medium-grain samples (n=315) while the rice was being milled to DOM reference values measured by the Soxtec SLC of head rice. The calibration curve for the long-grain samples produced a coefficient of determination (R^2) of 0.757 and a standard error of prediction (SEP) of 0.054 percentage points (PP) with respect to the reference values. The calibration curve for the medium-grain samples produced an R^2 of 0.802, and a SEP of 0.052 PP with respect to the reference values. Pooled, the long-, and medium-grain sample (n=869) calibrations produced an R^2 of 0.713, and a SEP of 0.065 PP with respect to the reference values. Modeling parameters included partial least squares (PLS) of the 1st derivative, multiplicative scatter correction (MSC), and seven factors. This study provides the basis for laboratory mill control using a target SLC value. Reduced variability in SLCs among laboratory-milled samples will reduce post-milling quality measurement variability.

Spatially Resolved Elemental Mapping of Two U.S. Rice Core Collection Grain Accessions with Diverse Arsenic Accumulation Characteristics via Synchrotron X-Ray Fluorescence Microscopy (SXRF)

Punshon, T., Guerinot, M.L., Lanzirotti, A., Pinson, S.R.M., Tarpley, L., Salt, D.E., Zhang, M., and Baxter, I.

The discovery of arsenic (As) in higher than expected concentrations in rice grown in the South Central United States and worldwide has prompted further study to ensure the safety of rice, and rice based products such as infant cereals. In the U.S. As is thought to originate from former arsenical pesticides that were used to control boll weevil when the land was used for cotton. However it has recently been found that As uptake in rice plants occurs through the silicon transport system as a result of the size and charge similarity between arsenous acid and silicic acid in flooded paddy soils. Rice plants are considered natural silicon accumulating plants, taking up far more silicon than other cereal crops such as oats, wheat or barley.

Inorganic As species (arsenate and arsenite) are considered more toxic to humans, but As can also exist as monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) and there is little information about the uptake of these methylated forms in plants, or whether they form as a result of plant metabolic processes. Market basket surveys of U.S. rice have shown that approximately half of the As in rice grain is inorganic, in comparison with rice grown in the As-impacted regions of Bangladesh, which is 80% inorganic. Further testing showed that these differences in As speciation were maintained when rice varieties from different countries were grown on the same As-contaminated soil, suggesting a genetic component in arsenic metabolism.

An understanding of the concentration, tissue localization and speciation of As are vital not only to address safety concerns, but also to aid in the search for the genes involved in As uptake, transport and storage. Once genes have been found and characterized, they can be manipulated via genetic or more traditional breeding techniques to reduce their expression or their ability to transport As; excluding As from the grain.

We analyzed two rice accessions sampled from the U.S. Rice Core Collection for the distribution and speciation of As; one accession that accumulated As when grown in flooded soils, and one accumulating As in non-flooded soils, with the hypothesis that their As characteristics may differ as a result of the contrasting As speciation in flooded and unflooded soils. We analyzed sections of rice grains through the embryo and endosperm with a synchrotron x-ray fluorescence (SXRF) microprobe, at the National Synchrotron Light Source, Brookhaven National Laboratory. This technique can be compared to medical x-ray or CAT scanning, which enables images of bones or tissues to be captured without the need for surgery. In this case, different absorption characteristics of the x-rays by bones and tissues with different densities allows a structural image to be created. In SXRF, higher energy x-rays are used, causing elements to fluoresce. Measurement of the energy and intensity of this fluorescence allows us to collect elemental information in the form of maps or images on the sub-micron scale from samples on up to 10 elements at a time simultaneously, without requiring intrusive sample preparation or sectioning.

We found that As was present in the endosperm and embryo of both accessions, although the distribution differed between the accessions. Measurement of the speciation of As in the endosperm of rice grown in unflooded paddy rice indicated that it was in a highly reduced form (arsenite) possibly involving binding to thiol groups.

Production of Functional Polypeptides from Rice Protein

Ma, H., Pan, H., Hao, Z., He, R., and Qu, W.

To develop value-added product from rice protein, in this research, we studied the effect of ultrasonic treatment on the yield and conformation of protein and antihypertensive capability of rice protein based polypeptides. When ultrasonic treatment was applied to protein extraction from rice flour, the extracted protein yield increased with the increase of its power level and extraction time. The yield was about 2.2 times higher than that of conventional extraction. The ultrasonic treatment did not change UV spectra of proteins indicating that the protein structure was not degraded. However, the florescence spectrometry of the treated protein varied after the protein was treated with different levels of ultrasonic power, indicating the change in conformation of protein. The solubility of rice protein was also increased after the ultrasonic treatment. Ultrasound treated rice proteins were hydrolyzed using six different proteases. The polypeptides produced with alkaline protease had the highest ACE inhibitory rate of 50% among the products produced using the different enzymes. The result also demonstrated that the rice protein based polypeptides had strong antihypertensive capability. When the polypeptides were fed to the spontaneously hypertensive rats (SHR), the blood pressure of SHRs were significantly lowered. The in-vivo tests also demonstrated that rice protein based polypeptides had strong antihypertensive capability.

Development of Gluten-Free Rice Batters and Their Coated Foods with Improved Textural and Sensory Properties

Shih, F.F., Bett-Garber, K.L., Champagne, E.T., Daigle, K.W., and Lea, J.M.

Fried batters enhance food sensory quality, but they can also be a health concern. Fish contains little fat, for instance, but the batter that coats the fish could soak up a substantial amount of oil during frying. As excessive oil consumption is known to cause health problems, pressure has increased from governmental and consumer groups to restrict the sources of oil and fat in foods. Oil uptake in fried batters is inevitably a target for oil reduction studies. No less important is the issue of gluten in foods. The prevalence of celiac disease (CD), an intolerance of gluten, has been reported to be as high as one in 200 of the world population. It is a serious health issue and a challenge for food scientists, because it can only be treated by strict adherence to a gluten-free diet. Rice is naturally gluten-free and rice flour has been used to prepare food products, such as breads and cakes, which are traditionally made with wheat flour.

In this research, we developed rice batters using rice flour and small amounts of pregelatinized rice flour (PGRF). In addition to being gluten-free, the new batters were found to absorb about 50% lower oil during frying than the traditional wheat batters. When okra was coated and fried with the rice batter, the product had sensory properties superior or equal to those of the wheat-coated counterpart. When gluten-free beer was used as a solvent, replacing water, in the formulation for both rice and wheat batters, the resulting fried batters had up to 18% higher oil uptake, slightly decreased hardness, and increased crispness. With or without beer, the oil uptake remained substantially lower for rice batters than wheat batters during frying. Sensory evaluations show similar trends as with textural analysis, though to a lesser extent, that fish and onion ring coated with batters were softer but crispier with beer than without. Overall, the effect of beer battering is more pronounced in improved frying properties such as crispness for rice batters than wheat batters.

In conclusion, our research provides information on the development of gluten-free rice batters and their coated foods with improved textural and sensory properties. The information is useful to people interested in the improvement of fried food qualities and to the food industry for new food developments.

Identification of Low Postharvest Yellowing Rice Cultivars

Miller, H.

Postharvest yellowing (PHY), or stackburn, reduces the value of rice. The identification of a low PHY rice cultivar would be desirable for breeding purposes, as well as for understanding of the PHY phenomenon. A laboratory method was used to survey different cultivars of rice for their ability to undergo PHY. Milled rice was placed in test tubes, the rice was rinsed with water, then heated to 70^{o}C for four days. Color was measured with a colorimeter. Two different cultivars, Terunishiki and Akinishiki, have low levels of PHY, consistent across two growing seasons and could be valuable for further studies and as breeding material.

Rice Yield Potential Algorithms Based on Canopy Reflectance Measured at Different Sensor Head Orientations

Tubaña, B.S., Harrell, D., Walker, T.W., Teboh, J.M., Lofton, J., Fluitt, J., and Phillips, S.

Remote sensors utilize several spectral domains from the visible to short-wave infrared regions of the electromagnetic spectrum, which are reported to be specifically sensitive to crop biophysical properties such as canopy structure variables (e.g., leaf area index and cover fraction) and leaf elements (e.g., chlorophyll content and temperature). Canopy reflectance readings from these regions are used to develop vegetation indices both in ratios and normalized forms that can effectively characterize vegetation of crops such as rice. A study was initiated in 2008 to develop an on-site midseason nitrogen (N) decision tool for rice production in the mid-south USA using a handheld active, ground-based remote sensor. The proposed on-site decision tool utilizes the concept that the mid-season N requirement of a rice crop can be projected if grain yield level and available soil N are known. This approach first requires establishing the relationship of grain yield and midseason canopy reflectance readings. However, rice under flooded condition may pose a challenge in obtaining good quality sensor data. Normalized difference vegetation index (NDVI) is the most widely used spectral vegetation index computed from canopy reflectance readings within the visible (400 to 700 nm) and reflective infrared (700 to 1350 nm) spectral domains. The typical reflectance spectra of clear water and turbid water show lower % reflectance readings at these two regions (red and near infrared) compared with bare soil. Therefore, water as a background may alter the canopy reflectance readings of a rice crop, especially when accumulated biomass is small or at early stages of growth. The overall goal of this study was to develop sensing guidelines for optimal characterization of rice biomass and grain yield. The specific objectives were to: 1) determine if GreenSeeker™ sensor head orientation would affect the quantitative relationship of grain yield and sensor readings and 2) determine which orientation is optimum for sensing rice.

Sensor readings were collected from several variety x nitrogen trials located at different sites: LSU AgCenter Rice Research Station in Crowley, LA; Colvin Farm in Rayville, LA; and Mississippi State University Delta Research and Extension Center in Stoneville, MS. Treatments included nine preflood N rates (0, 34, 68, 100, 134, 168, 202, 235, and 302 kg N ha^{-1}). Varieties were Catahoula, Neptune, and Clearfield 151. Collection of sensor readings was done on a weekly basis for five consecutive weeks starting at panicle initiation. Aboveground plant samples were collected at panicle differentiation (PD) and 50% heading. Plant samples were taken from a 0.9 m section of the middle drill row. Three sensing schemes based on the orientation of sensor head (nadir 0º, tilted back at 45º, and twisted orientation at 45º) above the rice canopy were used. Grain yield was determined using a small plot combine. For each sensing date and scheme, quantitative relationships among sensor data, biomass, and grain yield were determined using regression analysis. Prior to regression analysis, a two-step correction procedure was performed: first, the sensor readings collected from the three sites were grouped based on cumulative growing degree days, and then, sensor data across sites were normalized using the number of days from seeding to sensing.

Biomass samples collected at PD and at 50% heading were correlated with grain yield with coefficient of determination (r^2) values of 0.65 and 0.63, respectively. This implies that information on biomass production as early as PD can be used to project in-season grain yield. Remote sensing, therefore, can be a powerful tool to non-destructively acquire this information instantly. When sensor readings were regressed with actual biomass, the tilted-sensing scheme earned the highest r^2 value of 0.38 at PD while the nadir-sensing scheme obtained the highest r^2 value (0.40) at 50% heading. The regression models that best fitted the sensor readings and grain yield data were either exponential or power. The degree of correlation between these two parameters changed with sensing scheme. The nadir-sensing scheme obtained r^2 values that ranged from 0.32 to 0.50. The relatively lower r^2 could be attributed to the high degree of variability of the sensor readings generated from a larger amount of red light that was either reflected back to the detector or was scattered by surface water. Furthermore, the degree of turbidity of the water also affected sensor readings. The reduction of watery background in the sensor field of view resulted in lower water interferences on canopy reflectance hence NDVI readings. With the tilted- and twisted-sensing schemes, r^2 values between sensor readings and grain yield were higher than the nadir-sensing scheme, which ranged from 0.55 to 0.58 and from 0.46 to 0.66, respectively.

A more accurate prediction of grain yield using early to midseason canopy reflectance can be achieved when the water background is reduced. This is especially important in low yielding areas where accumulated biomass is relatively small with respect to the water background within the sensor field of view.

Nitrification Contributions to Nitrogen Losses from Preflood Urea in Delayed-Flood Rice Culture

Golden, B.R., Slaton, N.A., Norman, R.J., DeLong, R.E., and Wilson, C.E.

The majority (96%) of rice (*Oryza sativa* L.) cultivated in Arkansas is produced utilizing a direct-seeded, delayed-flood production system. Nitrogen losses in the delayed-flood system most frequently occur through gaseous emissions of NH_3 and N_2/N_2O. Ammonia volatilization losses prior to flooding are generally regarded as the primary N loss mechanism in this rice production system and have garnered much attention. The importance of nitrification and denitrification in fertilizer recovery efficiency are less clear, especially when N fertilizer is applied far in advance of flood establishment or irrigation capacity is low resulting in an extended time between N application and flooding. The primary objectives of this research were to examine i) rice yield response to N sources and application times and ii) the nitrification rate of two eastern Arkansas soils commonly used for rice cultivation. The ultimate goal was to develop alternative N fertilization strategies for rice that result in efficient N uptake and involve different application times and N fertilizer technologies (e.g. nitrification inhibitors).

Field experiments were established during 2008 and 2009 at the Pine Tree Branch Station (PTBS) on an alkaline Calhoun silt loam and the Rice Research and Extension Center (RREC) on a slightly acidic Dewitt silt loam. 'Francis' (2008) or 'Wells' (2009) rice was drill seeded at 112 kg seed ha^{-1}. Near the 2-leaf stage, SuperU [urea + dicyandiamide (DCD) + N-(n-Butyl)-thiophosphoric triamide, Agrotain Int.] and urea were applied at 67 and 134 kg N ha^{-1}. In 2008, 2-leaf N applications were incorporated with flush irrigation. Each N source was also applied at the 5-leaf stage, 2 d before establishing a permanent flood, to plots that did not receive N at the 2-leaf stage. Each study included an unfertilized control (0 kg N ha^{-1}). Grain yield was determined by harvesting the middle rows of each plot with a small-plot combine. Each field experiment was a randomized complete block with a 2 (N source) x 2 (N rate) x 2 (application time) factorial treatment structure. Each treatment was replicated four times and site-years were analyzed separately. Soil from the PTBS and RREC was collected, air-dried, crushed, and used to determine nitrification potential. Subsamples of each soil (100 g) were weighed into 120 ml incubation vessels and brought to uniform soil moisture content (25% w/w). Two prills of urea or SuperU were weighed and placed 2 cm below the soil surface and covered with soil. The fertilizer application rate approximated adding 100 mg N kg^{-1} soil. Vessels containing soil or soil plus N fertilizer were incubated at 25°C for a total of 30 days and extracted for inorganic N every 5 days. Inorganic N recovered from soil receiving no N was subtracted from the inorganic-N recovered from then-amended soil to account for organic-N mineralization and estimate the percentage of fertilizer-N recovery [(Net inorganic-N ÷ total N added) x 100]. The proportion of fertilizer-N recovered as NO_3- and NH_4-N was calculated and expressed as a percent of the fertilizer-N recovered. The incubation study was analyzed as a randomized complete block with a 3 (N source) x 2 (soils) 6 6 (sample time) factorial arrangement of treatments and included three replications. Means were separated using Fisher's Protected LSD at the 0.05 level of significance. All statistical analyses were performed with the general linear model procedure in SAS version 9.1.

Rice grain yield was significantly affected by N rate at three of four site-years. In general, averaged across N sources and application times, grain yield increased as N rate increased. Grain yield of rice grown on the Calhoun soil, in both 2008 and 2009, was influenced by time of N application. Averaged across N rates and sources, rice yield was greatest when N was applied preflood. Grain yield was unaffected by N source at all site-years, suggesting the DCD contained in SuperU had no benefit to rice grain yield. The soil x N source x sample time interaction was highly significant for N fertilizer recovered as NO_3-N in the laboratory incubation. Within each sample time, the percent of added N recovered as NO_3-N was greatest for the Calhoun soil and lowest for the Dewitt soil. In the Calhoun soil, nitrification was complete by 10 and 15 days after incorporation (DAI) for urea and SuperU, respectively. In the Dewitt soil, nitrification was similar in soil amended with urea or SuperU for 20 DAI. Thereafter, soil amended with SuperU had a lower percentage of recovered N present as NO_3-N.

The nitrification rate of fertilizer N differed for two silt loam soils. Nitrification proceeded slower in the Dewitt soil when compared with the Calhoun soil, regardless of N source. Nitrification of SuperU-N was slower than when urea-N was applied in both soils. Results from experiments with the Calhoun soil show that applying N as early as 7 days before flooding could reduce rice grain yield, with N loss being attributed to rapid nitrification rate, followed by denitrification after flooding. Results from the Dewitt soil suggest that urea-N could be applied weeks in advance of flooding without appreciable yield loss.

Nitrogen Content in Floodwater of Drill-Seeded, Delayed-Flood Rice Following Fertilization at Preflood and Midseason

Norman, R.J., Enochs, A.J., Roberts, T.L., Slaton, N.A., Wilson, Jr., C.E., Frizzell, D.L., and Branson, J.D.

Nitrogen (N) fertilizer has the potential to enter streams, rivers, and lakes via irrigation return flow from rice [*Oryza sativa* (L.)] fields. This study was conducted to determine how many days after urea fertilization the floodwater should be held to minimize N loss via irrigation return flow. The effects of fertilizer N rate and fertilizer N application timing (preflood vs. midseason) on the extent and persistence of N in rice floodwater were investigated with a dry-seeded, delayed-flood cultural system at the Rice Research and Extension Center near Stuttgart, Arkansas, on a Dewitt silt loam (fine, smectic, thermic Typic Albaqualf).

The preflood N was applied onto dry soil at four N rates (0, 67, 134, and 202 kg ha^{-1}) arranged in a randomized block design and replicated four times. Water samples were collected 0, 1, 3, 4, and 6 days after preflood N fertilization and then weekly for the duration of the growing season. The midseason N study was a 2 (preflood N rate) x 5 (midseason N treatments) split plot arrangement with two preflood N rates (67 and 134 kg ha^{-1}) and midseason treatments that consisted of two single application rates (67 and 134 kg ha^{-1}), a control (0 kg ha^{-1}), a split application (34 + 34 kg ha^{-1}), and a plot with no rice receiving a single 67 kg ha^{-1} application arranged in a randomized complete block design and replicated four times. The midseason N was applied by hand directly into the floodwater beginning at internode elongation and 1 week later for the split method. Samples were collected 0, 1, 2, 3, 4, 5, 6, and 7 days after midseason N fertilization and once a week for the rest of the growing season.

Floodwater N concentrations 1 day after preflood N applications were elevated compared with the control with the 134 and 202 kg ha^{-1} rates being similar and significantly higher than the 67 kg ha^{-1} rate. Total N concentrations in the floodwater declined after day 1 for all N fertilizer rates. Floodwater N concentrations (18.9 mg N/L maximum) from preflood N rates of 67 and 134 kg ha^{-1} decreased to control levels (0 kg ha^{-1}) within 6 days of application. Application of 202 kg ha^{-1} at preflood caused floodwater N concentrations to remain above control levels for up to 11 days after fertilization.

Floodwater N concentrations after midseason fertilizer application were not significantly related to preflood N fertilizer rate. Midseason N fertilizer applications had higher floodwater N concentrations compared with preflood N fertilizer applications. Floodwater when 34 kg ha^{-1} was applied at midseason reached a maximum 1 day after fertilization near 14 mg N/L and decreased to control levels within 4 days after fertilization. The 67 kg ha^{-1} rate applied at midseason with and without rice behaved similarly. When 67 kg ha^{-1} was applied, the floodwater N concentration (32 mg N/L) peaked 1 day after fertilization and reached control levels within 5 days after fertilization. Results from this study indicate a prudent recommendation would be to retain floodwater on rice fields for at least 6 days after application of typical preflood and midseason N rates and up to 11 days after atypically large preflood N application rates.

Nitrogen Fertility Management in Alternative Rice Establishment Systems of California

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Herbicide-resistant weeds represent a considerable management challenge for California rice growers. Alternative rice establishment techniques that integrate cultural and chemical weed control practices have been developed to provide growers with tools to effectively manage herbicide-resistant weed populations. These techniques utilize minimum tillage and stale seedbed practices, where a field is flushed in the spring to promote weed seed germination followed by subsequent weed treatment with a broad spectrum herbicide prior to planting. Spring tillage is avoided to minimize disturbance of the soil after the stale seedbed has been implemented, ensuring that remaining weed seeds are not brought to the soil surface. Recent field trials have demonstrated that alternative rice establishment systems have the potential to control herbicide-resistant weeds while maintaining grain yields comparable with conventionally tilled, water-seeded systems. However, required changes in pre-season water management, tillage, and nitrogen (N) application practices may impact N cycling in these systems, and improved N management guidelines are needed. The objectives of this study were to determine the optimum rate, timing, and source of N fertilizer applications to maximize grain yields and minimize N losses in minimum tillage, stale seedbed rice establishment systems.

Nitrogen fertility trials were conducted over a 2-year period (2008-2009) at the California Rice Experiment Station (RES) in Biggs, CA, and at four on-farm locations in the Sacramento Valley. Nine N treatments were applied at each site, with rates ranging from 0 to 224 kg N ha^{-1}. Nitrogen sources included urea, as well as one ammonium sulfate treatment of 112 kg N ha^{-1}. Fertility trials were established at the RES using a split-plot experimental design in which water-seeded conventional, water-seeded stale seedbed, and drill-seeded stale seedbed systems were main plot treatments and N rates were sub-plot treatments. On-farm fertility trials were conducted in fields testing alternative stale seedbed systems under grower management practices. Four N treatments were split between preflood and mid-tillering to determine if split applications resulted in increased yields and N use efficiencies as seen in previous studies. All other N treatments were applied prior to the permanent flood. The fertility trials were harvested at physiological maturity to determine grain yields and N use efficiencies.

Nitrogen applications significantly increased grain yields in all systems at the RES and on-farm sites. The split-plot analysis of variance indicated that N fertilizer behaved differently within establishment systems at the RES. The wet-seeded conventional system reached maximum yields at N application rates of 112 kg N ha^{-1} and above, while both stale seedbed systems appeared to require 168 kg N ha^{-1} or more to achieve maximum yields. The highest yields in wet-seeded stale seedbed systems occurred at 224 kg N ha^{-1}. Yields for preflood and split N applications were similar within each system and N rate (112, 168, or 224 kg N ha^{-1}) at the RES. Urea proved to be a better source of N for stale seedbed systems compared with ammonium sulfate, which on average yielded 500 kg ha^{-1} lower than other preflood 112 kg N ha^{-1} treatments. The four on-farm sites, which were all water-seeded stale seedbed systems, exhibited similar trends with slightly lower N responses than the RES. Preflood N applications of 112 kg N ha^{-1} produced yields similar to higher N rates, but split rates of 28 to 84 kg N ha^{-1} produced significantly lower yields at three of four grower sites. Preflood and split N applications within the 168 and 224 kg N ha^{-1} treatments had equivalent yields. Ammonium sulfate treatments performed better in growers' fields; they did not produce significantly different grain yields compared with preflood 112 kg N ha^{-1} urea treatments at three of four on-farm sites.

This research contributes to our understanding of efficient N fertilizer use with respect to water management and tillage practices for improved weed control in flooded rice systems. Results from the RES and four on-farm sites suggest that minimum tillage, stale seedbed establishment systems have higher N fertility requirements than conventionally tilled, water-seeded systems. Alternative systems continue to respond to N rates between 168 and 224 kg N ha^{-1}, depending on seeding practices and location. Urea appears to be a more reliable N source than ammonium sulfate and may be more attractive to growers due to a higher N analysis and ease of application. Finally, since preflood N applications generally produced similar yields to split N applications at equivalent rates across sites, these results suggest that a single N application prior to the permanent flood is sufficient to meet N fertility needs in alternative rice establishment systems.

Stale Seedbed Effects on Rice Production in Texas

Dou, F., Tarpley, L., and Way, M.O.

Although a stale seedbed has potential economical advantages compared with a tilled seedbed, more information is needed to optimize this management practice for use with the heavy clay soils of east Texas. This study is focused on the effect of tillage practices on N and P rates and pest management in rice production in Beaumont, Texas, from 2006 to 2009 (pest control only in 2006). Treatments included a spring stale seedbed and tilled seedbed, N and P applications (168, 202, 247 kg N ha^{-1} and 0 and 56 kg P ha^{-1} for N and P, respectively), and rice water weevil control (control, Icon 6.2FS, Karate Z, and not planted). Greater N applications significantly increased rice yield through all years except 2006. On average, rice yield was 7869 kg ha^{-1} and 8397 kg ha^{-1} for 168 kg N ha^{-1} and 247 kg N ha^{-1}, respectively. Unlike N fertilizer, P application generally decreased rice yield. Rice yield was 8397 kg ha^{-1} and 8172 kg ha^{-1} for 0 kg P ha^{-1} and 56 kg P ha^{-1}, respectively. Tillage did not have a consistent effect on rice yield. The stale seedbed treatment produced a greater rice yield than did the tilled seedbed treatment in 2006 and 2009, but the opposite was observed for 2007 and 2008. The stale seedbed treatment had a lower immature rice water weevil (RWW) population than the conventional tilled seedbed, but the difference was only significant at the late-sampling dates. Icon 6.2FS treatment significantly decreased immature RWW population for both tillage treatments compared with the control. Our results indicate that stale seedbed treatment produced fewer immature RWW populations compared with conventional tillage. Additionally, given the application rates, nutrient availability seems not to be the limiting factor in stale seedbed practice. However, to fully explore the benefits of adopting stale seedbed on the clay soils of east Texas, further studies addressing the interactions between weather and tillage are needed. We appreciate the generous support of the Texas Rice Research Foundation for aspects of this research.

Rice Yield and Nutrient Uptake as Affected by Phosphorus and Potassium Fertilization in the Fall, Winter, or Spring

Slaton, N.A., DeLong, R.E., Norman, R.J., and Wilson, Jr., C.E.

Phosphorus (P) and potassium (K) fertilizers usually are broadcast applied several days or weeks ahead of rice (*Oryza sativa* L.) planting in the early to late spring. Questions regarding whether P and K fertilizers can be applied in the fall or winter before planting rice the following spring are frequently asked. Application of P and K fertilizers in the fall or early winter may be advantageous if fertilizer prices are expected to increase the following year or prices are discounted to reduce year-end inventories. Our research objectives were to determine the effects of P and K fertilizer application rate and time on P and K uptake and yield of rice grown on a silt loam soil.

Two adjacent research areas, one each for P and K, were established in fall 2008 on a Calhoun silt loam that had been previously cropped to soybean. The seedbed was tilled and floated in November 2008 and left undisturbed until rice was drill seeded. Composite soil samples were collected from the 0- to 10-cm depth from selected plots in December and February and from all plots in April. Soil samples were oven-dried, crushed, extracted with Mehlich-3 to determine nutrient availability index, and analyzed for soil water pH. In each trial, P or K fertilizer was broadcast applied to the soil surface (no incorporation) in December 2008, February 2009, and April 2009 (before planting). At each application time, triple superphosphate was applied at rates equivalent to 20 and 40 kg P ha^{-1} (45 and 90 lb P_2O_5 $acre^{-1}$). For the K trial, muriate of potash was surface applied at rates equivalent to 37 and 74 kg K ha^{-1} (45 and 90 lb K_2O $acre^{-1}$). Rice was drill seeded in April into an untilled seedbed. Whole-plants (aboveground) were harvested from a 0.9-m section of an inside row at the midtillering stage in the P trial and the late boot stage in the K trial. Dry matter, whole-plant P and K concentrations, and nutrient uptake were determined. Grain yield was determined at maturity and expressed at a uniform moisture content of 130 g H_2O kg^{-1}. Each trial was a randomized complete block design with treatments replicated six times and arranged in a 2 (nutrient rate) x 3 (application time) factorial structure and compared with an unfertilized control (no P and K). Fishers protected LSD was used to separate means for significant effects at the 0.10 level using SAS v9.1.

Potassium fertilizer rate significantly affected rice grain yield (P=0.0686), but neither time of K application nor the rate by time interaction influenced yield (P>0.10). Rice yields, averaged across application times, were lowest when no K fertilizer was applied (7787 kg ha^{-1}, LSD = 323), intermediate for rice receiving 37 kg K ha^{-1} (8019 kg ha^{-1}), and greatest for rice fertilized with 74 kg K ha^{-1} (8301 kg ha^{-1}). Whole-plant K concentrations and aboveground uptake at the late boot stage were not affected by K application rate, time, or their interaction, but K concentration and uptake increased numerically as K rate increased.

Despite a low soil-test P level (11 ppm Mehlich-3 P), P fertilization had no significant effect on rice yield, with mean rice yields ranging from 8618 to 9072 kg ha^{-1}. Tillering rice receiving no P had a tissue P concentration of 0.166%, suggesting soil P availability was indeed low. Rice P concentration and uptake at the midtillering stage were influenced by the P application rate by time interaction (P<0.10). The P concentration of rice receiving P was always greater than rice receiving no P. Application of 40 kg P ha^{-1} increased rice P concentration compared with rice fertilized with 20 kg P ha^{-1} when P was applied in December and February, but not in April, which tended to have the lowest numerical P concentrations of all application times.

Results of these single site trials suggest that P and K availability was not compromised when applied 3 to 5 months ahead of planting. The results provide some evidence that application of P fertilizer several months ahead of planting may be advantageous in fall-prepared seedbeds by perhaps allowing more time for vertical P movement where rice roots are located. Potassium application rate appears to be the primary factor influencing rice yield. Additional research on this topic is warranted.

Soil Phosphorus Fractions in Natural Wetlands and Conventional and Organic Rice Fields

Linquist, B.A., van Kessel, C., Hill, J.E., and Ruark, M.D.

The biogeochemistry of P in wetland systems is not well understood. In particular, the fate of P in wetland soils is poorly understood, whether the origin of P is from inorganic or organic fertilizer, residues, or incoming water. Understanding the fate of P in these systems will assist in the development of improved soil test methods, improved P fertility management, and assist in developing practices that reduce off-site pollution.

The objectives of this study were to (1) examine the effect of crop rotation, residue management, and fertilizer inputs in conventional and organic systems on soil P fractions and (2) compare these results for rice systems with those of natural wetland systems. Soils were collected from 79 sites: 64 conventional rice fields, 6 organic rice fields, and 9 natural wetlands. Soils were then subjected to a modified Hedley sequential P fractionation scheme to obtain the following inorganic (Pi) and organic (Po) P fractions: $NaHCO_3$ Pi and Po (labile), NaOH Pi and Po (Fe and Al bound), HCl Pi and Po (Ca bound), and Residual P (recalcitrant).

Measured across all soils, the total amount of P ranged from 165 to 784 ug g^{-1} of soil and averaged 415 ug g^{-1}. On average, there was roughly twice as much inorganic as organic P (226 versus 115 ug g^{-1}, respectively). As a percentage of total P, total Pi was 52%, total Po was 29%, and residual P was 19%. There was a large effect of soil type on total P (Mollisols had significantly more P) and P fractionation (Mollisols had significantly more Ca-P). Due to the potential for soil type to be a confounding factor in our analysis of management effects on P fractions, only Vertisols were considered (total of 54 sites: 41 conventional rice fields, 6 organic rice fields, and 7 natural wetlands). In these soils, we evaluated the effect of continuous rice cropping vs rotational rice cropping (rice grown every 2-5 years); organic vs conventional; straw burning vs straw retention; and natural wetland systems vs rice systems on the fractionation of P in soils (total and relative P within each fraction).

Continuous rice systems had the lowest amount of total P. The differences in total P was because of lower total Pi in the $NaHCO_3$ and HCl fractions relative to the rotational system. On a percentage basis, continuously cropped rice systems had less P in the total-Pi fraction and more P in the total Po fraction than either rotational rice system or wetland system.

Organic rice systems had 31 and 16 ug g^{-1} more $NaHCO_3$-Pi than in the conventional rice and natural wetland systems, respectively. Organic rice systems also had 41 and 20 ug g^{-1} more NaOH-Pi than the conventional rice and wetlands systems, respectively. Similarly, on a percentage basis, more P also was found in these fractions in the organic systems.

Residue management did not affect total P, but burning rice residues decreased HCl-Po, which lead to a decrease in total Po. The absolute amount of HCl-Po was roughly 30% (11 ug g^{-1}) of what was found in the straw incorporated (38 ug g^{-1}) and natural wetland (33 ug g^{-1}) fields. As a percentage of total P, there also was less P in the HCl-Pi and Po pools but more P in the NaOH-Pi fraction- 23% compared with 17% in the fields where straw was mostly incorporated or in wetland systems where residues are allowed to naturally decompose. In addition, the relative amount of P in the HCl-Po was higher in fields where straw was mostly incorporated (9.2%) than in the burned fields (3.7%). Significant differences among P fractions were found relative to the intensity of rice cropping, how fertility is managed (organic vs inorganic sources), and how residues are managed. These differences, reflecting the different fates of P as affected by management, suggest that we could improve our soil tests and recommendations for P fertility.

Rice Yield and Uptake Response to Zinc Fertilization on a High pH, Low Zinc Soil

Harrell, D.L., Lofton, J., and Tubaña, B.

Zinc (Zn) deficiency is considered as one of the most common micronutrient deficiencies in commercial rice production throughout the midsouthern United States. Plant availability of Zn can be affected by native soil levels and changes in soil pH. Mehlich-3 extractable Zn levels below 1 mg kg^{-1} are considered to be low in soil test Zn using current LSU AgCenter recommendations. Solubility and plant availability of Zn decrease with increases in soil pH. Commonly, Zn deficiencies in rice are found on soils that have pH above 7. Zinc deficiency can also be aggravated after flooding as the soil changes from an aerobic to anaerobic condition. Further research is needed to refine Zn fertilizer recommendations for rice on silt loam soils that have a high pH and are naturally low in soil Zn.

The objectives of the current study were to: 1) determine the optimum Zn fertilization rate when zinc-sulfate is surface broadcast at planting and the field is not drained after the flood is established at the 4- to 5-leaf stage of development; 2) determine if the nitrogen (N) source used prior to permanent flood establishment affects the rice yield response to Zn fertilization; and 3) to evaluate the rice nutrient content as affected by Zn fertilization on a high pH, low Zn silt loam soil with a history of severe Zn deficiency.

A trial was established in 2009 on a Crowley silt loam soil just north of Crowley, Louisiana. Mehlich-3 soil test Zn was 1 mg kg^{-1} and soil pH was 7.9. Five rates of Zn (0, 5.6, 11.2, 16.8, and 22.4 kg ha^{-1}) and two N sources (urea and ammonium sulfate) were used. The trial was arranged in a randomized complete block design with four replications. Zinc sulfate was used as the Zn source and was surface broadcast immediately after drill-seeding Neptune rice into a stale seedbed. Fertilizer N was applied at a rate of 168 kg ha^{-1} immediately before permanent flood establishment. Ammonium sulfate was applied at 112 kg ha^{-1} to all plots prior to seeding. Aboveground biomass samples were taken from a 1-m section of the middle drill row just prior to permanent flood establishment and again at the 50% heading stage of development. Nutrient content of the samples was determined using a nitric acid-hydrogen peroxide digest and ICP analysis.

Zinc fertilization rate had a significant ($P<0.0001$) effect on rice grain yield. Rice grain yield increased with increasing Zn and was optimized at the 16.8 kg ha^{-1} Zn application rate. Grain yield was not affected by N source or by the Zn rate by N source interaction.

Tissue aluminum (Al), iron (Fe), calcium (Ca), magnesium (Mg), manganese (Mn), potassium (K), phosphorus (P), and Zn concentrations were all affected by Zn fertilization at the 4- to 5-leaf stage of development. In general, concentrations of Al, Fe, Ca, Mg, Mn, and P were greatest when no Zn fertilizer was applied and decreased with increasing Zn fertilization, while K and Zn increased with increasing Zn fertilization. Toxic levels of Al (1222 mg kg^{-1}) and Fe (1992 kg ha^{-1}) in the aboveground biomass were observed at the 0 kg ha^{-1} Zn rate.

Tissue concentrations of Al, Fe, Ca, Mg, Mn, K, and P at the 50% heading stage of development were not significantly affected by Zn application rate. However, tissue concentrations of Zn increased with increasing rates of Zn fertilization.

Results from the current study indicate that a rate of 18.8 kg ha^{-1} is needed to eliminate yield losses associated with Zn deficiency at this location when zinc sulfate is the Zn fertilizer source. Further research using other Zn fertilizer sources on other high pH, low Zn soils is needed to improve soil testing derived fertilizer recommendations.

Comparing In-Field Distribution for Zinc and Phosphorus in Plant and Soil Resulting from Applications of Composite and Mixed Fertilizers

Dunn, D.J., Ruffo, M., and Olson, R.

Zinc (Zn) deficiency in rice may be a problem in some production fields. Elevated soil pH levels often encountered on rice soils can contribute to low Zn availability. Visual symptoms of zinc deficiency are usually encountered after permanent flood establishment. At this time, remedies are generally costly. Because of the relatively low application rates (5.6-11.2 kg ha^{-1} actual Zn), uniform distribution of Zn fertilizers may be a problem in some commercial rice fields. As Zn moves slowly by diffusion in the soil, rice roots must grow into new soil areas to obtain the necessary Zn. This process is inhibited by cool wet conditions often found early in the growing season in Missouri, resulting in Zn deficiency.

Fertilizers containing Phosphorus, Zn, and Sulfur composited in one granule are commercially available. In this study, a composite fertilizer, MESZ (12-40-0-10S-1Zn, Mosaic Fertilizer, LLC, Riverview, FL) was compared with a mixture of di-ammonium phosphate (18-46-0) and zinc sulfate (0-0-0-20S-40Zn) for the ability to produce uniform distributions of P and Zn in soil and plant tissue. In a small plot evaluation, multiple soil and plant tissue samples were systematically collected from each plot and analyzed for P and Zn content. The mean value and coefficient of variability for each plot were determined and statistically compared. Plots treated with the composite fertilizer were found to have lower coefficient of variability than those treated with the mixed fertilizers.

Influence of Seeding Date on Yield of Selected Rice Cultivars in Arkansas

Wilson, Jr., C.E., Frizzell, D.L., Branson, J.D., Norman, R.J., and Slaton, N.A.

Each year, growers must make decisions about production practices, including tillage, cultivar, seeding rates, fertilizer rates, etc. One decision that must be made is seeding date but is often not totally in the control of the producer. Producers normally strive to plant during the time that provides optimum yields with the least amount of risk. However, weather can prevent producers from seeding at the preferred time. Assessment of the impact of seeding dates on rice yield helps growers select the appropriate cultivars for the situations they face. Variety selection can be the difference in significant profit and major loss, particularly in the extremes of the seeding date window.

Seeding studies were conducted at the University of Arkansas Rice Research and Extension Center (RREC) near Stuttgart, Arkansas, on a DeWitt silt loam soil between 1993 and 2009. Typically, 20 cultivars are included each year, and cultivars are maintained in the study for a minimum of 4 years. The plots were drill-seeded at a rate of 430 seeds/m^2 in nine-row (18-cm spacing) plots, 4.8 m in length, except the hybrids, which were sown at 172 seeds/m^2. Four seeding dates ranging from March 15 to June 15 were utilized each year. All plots received 134 kg N/ha as a single preflood application of urea at the 4- to 5-leaf growth stage. The permanent flood was applied and maintained until the rice reached maturity. Data collected included: seedling emergence, number of days and DD50 thermal units required to reach 1.3-cm internode elongation, 50% heading, and maturity. At maturity, 3.66 m of the center five rows of each plot was harvested, the moisture content and weight of the grain were determined, and a subsample of harvested grain saved for milling purposes. Grain yields were adjusted to 120 g/kg moisture. A 125-g sample of the dried rice was milled for 30 sec. with a McGill No. 2 rice mill to obtain percent total white rice and percent head rice. Each seeding date was arranged as a randomized complete block with three replications. Data were summarized across each year by calculating relative grain yield as a percentage of the highest yield obtained by each cultivar in a given year. These data were then regressed against seeding date expressed as day of the year. Polynomial equations were used to fit most cultivars while a few selected cultivars were expressed as a linear function.

Current recommendations for optimum seeding dates for rice in central Arkansas to achieve maximum yields begin approximately March 25 and end on May 20. Seeding rice after May 20 is considered late and more than 10% yield loss is expected. These dates are supported by data from the seeding date studies presented, although yields tend to decline below 90% after May 10. Differential response by cultivars was observed. The optimum window for some cultivars, such as Bengal, is rather wide with yield potential maintained throughout the seeding window. However, other cultivars, such as CL 171AR, decline linearly with seeding date and result in significant yield loss when seeded after May 1. Data have been used to develop recommendations for cultivar selection dependent on seeding date.

Impact of Land Improvements and Seed Selection in the RRVP, 2006-2009

Mazzanti, R., Runsick, S.K., Wilson, Jr., C.E., Watkins, K.B., and Hignight, J.A.

The Rice Research Verification Program (RRVP) was created in 1983 and represents a public demonstration of the implementation of research-based recommendations in actual field-scale farming environments. The goals of the RRVP are to: 1) educate producers on the benefits of utilizing University of Arkansas recommendations to improve yields and/or net returns, 2) to conduct on-farm field trials to verify research-based recommendations, 3) to aid researchers in identifying areas of production that require further study, 4) to improve or refine existing recommendations that contribute to more profitable production, 5) to incorporate data from RRVP into Extension educational programs at the county and state level. The RRVP has been conducted on 319 commercial rice fields in 33 rice-producing counties in Arkansas. Data used in this study came from 70 rice fields over the previous four years.

Until recently, data from the RRVP have only been subjected to analyses based upon the current year results. This study uses the previous four years to analyze the impact of land improvements and seed selection on yields and profitability. Land improvements in this study are categorized as being precision leveled to a slope or zero graded. Seed selection is categorized as conventional, hybrid, Clearfield conventional, and Clearfield hybrid. Using ordinary least squares (OLS) regression, yield estimates were calculated using the above mentioned qualitative variables along with year variables. The intercept was set to estimated yield on a contour levee field using a conventional cultivar.

The R square for the regression was 0.26, indicating that the estimated parameters only explained a small percentage of actual yield variability. This was expected since factors such as fertility, soil productivity, planting date, crop rotation, and other farming conditions can vary widely across Arkansas rice producing areas. The intercept (contour levee field with conventional seed), hybrid, and Clearfield hybrid parameter estimates were significant at the 0.05 level of significance, and year 2007 was significantly different from the intercept at the 0.10 level of significance. Precision leveling, zero grade, Clearfield conventional, 2008, and 2009 year parameters were not significantly different from the intercept.

Yield estimates from the regression in 2009 for contour levees, precision leveled, and zero grade were 8,566 (170), 8,875 (176), and 8,753 (174) kg/ha (bu/ac), respectively. Using estimated cost for 2009 and a $0.2695/kg ($5.50/bu) rice price, precision leveled, zero grade, and contour levee fields were estimated to have a net return of $1,000 ($405), $995 ($403), and $882/ha ($357/A), respectively. Yield estimates by seed selection on a contour field were estimated to be 8,566 (170) for conventional, 9,583 (190) for hybrid, 7,633 (151) Clearfield conventional, and 9,427 (187) kg/ha (bu/A) for Clearfield hybrid. Using estimated costs, hybrid rice had the highest return at $1,020/ha ($413/A) followed by conventional ($882/ha, $357/A), Clearfield hybrid ($859/ha, $348/A), and Clearfield conventional ($504/ha, $204/A). Clearfield hybrid use has been increasing in Arkansas over the previous few years. The results of this study indicated that the Clearfield technology is not economically optimal unless red rice is a problem. The study also indicates zero grade cost savings may not pay for themselves compared with precision leveled fields but full economic considerations for land improvements must account for the entire cropping system.

Field Performance of Commercial Rice Varieties in Texas

McCauley, G.N. and Samford, J.L.

Varietal development, management, and performance are major concerns for rice researchers and producers. Commercial varieties, hybrids, and developing lines are tested for their response to soil, climate, fertility, disease, insects, etc. at multiple locations each year. These small plot tests are repeated and refined year after year. Rice researchers and producers also question how these cultivars perform in large fields and under producer management. Colorado, Wharton, Matagorda, and Jackson counties in Texas provide a good location to evaluate the field performance of commercial rice cultivars. Sixty-five percent of Texas rice is grown in these four counties. A large part of the rice goes to commercial dryers. The area stretches from the coastal regions of Matagorda and Jackson counties over three counties to the northwest region of Colorado County. There is a wide range of soils, pressures from insects, disease, and weeds, slopes, technology development, and management in these counties. Varietal performance in these counties should be representative of the state and region.

Each year, since 2005, a survey has been conducted. Survey response has represented from 65 to 80 percent of the certified acreage each year. Data were collected from dryers, marketing offices, and a few producers. Data source is maintained so information can be verified if necessary. Each data set was evaluated to eliminate questionable or duplicate entries. Each set contains source, harvest date, cultivar, field size, dry yield, total milled grain, and whole milled grain. Questionable data that cannot be resolved were deleted. Data from the male lines of hybrid seed fields were eliminated. Cultivars with less than four fields across all sources were eliminated from the cultivar performance section. Entries are eliminated only if multiple key inputs are missing. Comparisons evaluate yield by harvest date, whole milled grain by harvest date, maximum-minimum-average yield by variety, and maximum-minimum-average whole milled grain by variety and the impact of planting before, during, and after the recommended planting window. Harvest dates for rice planted on the beginning and end of the recommended planting window were estimated using a DD50 model. The state average yield was collected and plotted with technology introductions noted.

Yield vs Technology: The first recorded state average yield was about 2016 kg ha^{-1} in 1895. State yield reach 2250 kg ha^{-1} in about 1905 then declined for the next 10 years. State yield increased for about 20 years until the start of World War II, which lead to rapid expansion of rice acreage. Following the war, a steady yield increase was fueled by the release of Bluebonnet, Century Patna 231, and Bluebonnet 50 and the introduction of Propanil in the early 60s. Also in the early 60s, the combination of Belle Patna and ratoon cropping resulted in a 60% yield increase in less than 5 years. This was the first time for yields to exceed 5000 kg ha^{-1}. Yields maintained an erratic plateau for the next 20 years until the introduction of Lemont. The semidwarf fueled another rapid yield increase of about 50% in a 4-year period. This was followed by a second erratic yield plateau that lasted about 15 years. The release of Cocodrie and the introduction of main crop cutting height fueled a 20% yield increase that ended about 2000. Currently, the yields appear to be on a third erratic yield plateau. CLEARFIELD technology and hybrids have failed to shatter this third plateau.

Yield: Survey response represents 2,008 fields, 192,214 acres, and 30 varieties from 2005 to 2008. The large data set has been difficult to access and analyze. Data organization and analysis are an ongoing process. A plot of yield vs harvest date across varieties indicates 1) a general decline of yield with time, 2) no apparent penalty for planting early, 3) lowering yielding fields starts to increase about midway through the recommended planting window, and 4) the number of high yield fields was greatest within the optimum planting window. A frequency distribution was used to evaluate the yield distribution in the fields planted early, optimum, 1-week late, and 2-week late fields. The analysis indicated that early planting was not detrimental. The early planted fields had the greatest percentage above 7,000 kg ha^{-1}. The percent of fields yielding above 7,000 kg ha^{-1} decreased from the early planted fields through those planted 2 weeks after the optimum window. The average, maximum, and minimum yield and number of fields and acreage was determined for each variety. The average yield for the seven specialty varieties and XP 744 was about 6,000 kg/ha. Cocodrie the dominate variety by acreage averaged about 6600 kg ha^{-1} on 1051 fields and 106,826 acres. CLXL 745 had the highest yield and was about 1000 kg ha^{-1} higher than CL131. XL 723 was the highest yield, non-Clearfield variety, and outyielded Cheniere by about 700 kg ha-1.

Whole Milled Grain: A plot of whole milled grain vs harvest date across varieties indicates 1) a general decline of whole grain with time, 2) no apparent penalty for planting early, and 3) extremely low milling yields only occurred when planting late. Frequency distribution showed that whole milled grain generally declined as planting date increased. Average whole milled grain for 10 varieties was less than 60%. CL171 AR had the highest whole milled grain averaging 63%. Several varieties averaged about 62%.

Rice Production under Limited Water Availability

Anders, M.M. and Brooks, S.A.

Nearly all rice production in Arkansas is irrigated using flood irrigation. Approximately 80% of the irrigated rice in the state is watered using groundwater from a shallow aquifer. By 2009, significant areas of the state's rice production lands have been designated as "critical water zones." It is imperative that new strategies for producing rice under limited water be developed if rice production is to be continued at current levels. A series of studies have been conducted to evaluate row-watered rice production.

In 2006 and 2007, a study was carried out using two rotations (R-S, rice-soybean; R-R, continuous rice), two water management strategies (flood, row-water), and three nitrogen (N) sources (urea, Agrotain, sulfur-coated urea). All N treatments were made as a single preflood application at 134 kg N ha^{-1}. In 2006, RiceTec CLXL 730 was used while CLXL 729 was used in 2007. In both years, there were no differences between rotation treatments. Water treatments were significantly different in both years, and there were no differences among N sources. Grain yields were low in 2006 with the row-water treatment averaging 5544 kg ha^{-1} and the flood 7963 kg ha^{-1}. Grain yields in 2007 averaged 10382 kg ha^{-1} for the flooded plots and 8921 kg ha^{-1} for the row-watered treatment.

In 2008, Agrotain was used as the N source at four rates (0, 112, 157, and 202 kg N ha^{-1}). Water management treatments were significantly different as were N rates. For the flooded plots, grain yields were 3780, 8467, 8618, and 7762 kg ha^{-1} for the 0, 112, 157, and 202 kg N ha^{-1} treatments, respectively. Grain yields in the row-watered plots were lower at 1411, 4939, 5796, and 6199 kg ha^{-1} for the 0, 112, 157, and 202 kg N ha^{-1}, respectively.

In 2009, a study was established using four irrigation treatments (row-water, flooded, row-flood, and flood-row) with the row-flood and flood-row treatments changing at the half-inch green ring growth stage. Four varieties were used (CLXL 729, XL 723, Bengal, and CL161). Each plot was split into two N treatments (112 and 202 kg N ha^{-1}) applied as a single preflood application. Fertility and slope position did not significantly affect grain yield. Over all variety and fertility treatments, grain yields were greatest in the flooded treatment followed by the row-flood treatment and lowest in the row-water treatment. Of the four varieties used, XL 723 and CLXL 729 had the highest grain yields across all treatments while CL161 had the lowest. This work will continue.

Center Pivot-Irrigated Rice: Nitrogen Management and Disease Control

Stevens, G., Vories, E., Heiser, J., Rhine, M., Wrather, A., and LaRue, J.

Rice fields are normally flood irrigated but center pivots may be used to expand rice production to fields with soils that cannot be flooded. Nitrogen and disease management programs for center pivot rice are being tested at the University of Missouri-Delta Center in Portageville. Blast disease in sprinkler-irrigated rice tends to increase because of the wetness of the foliage after watering. In the 1980s, several researchers studied pivot-irrigated rice but stopped developing the technology because of low yields resulting from blast. At that time, effective fungicides and blast-resistant rice cultivars were not available. In experiments at Portageville in 2008, blast disease was not found. However, in 2009, center pivot plots were decimated by blast in non-resistant cultivars such as 'Wells' and 'Francis' with no fungicides. In plots planted with the blast-resistant cultivar 'Templeton,' rice yields ranged from 7560 to 10483 kg ha^{-1}. Yields were highest in blast-susceptible varieties when fungicides were applied by chemigation using an injection pump at early boot stage to deliver fungicide in irrigation water through the pivot.

The research project was begun in 2008 using a 7.3-ha center pivot donated by Valley Irrigation. The first challenge of the test was weed control, in particular palmer amaranth. Clearfield technology using imazethapyr and imazamox herbicides did not provide satisfactory broadleaf control because of Acetolactase Synthase (ALS) resistance in the pigweeds. Fortunately, alternative programs were developed using clomazone, propanil, quinclorac, halosulfuron, acrifluorfen, and bentazon. In 2009, our main program was clomazone pre-emergence followed by applications of propanil and quinclorac when the pigweeds were in the 2- to 4-leaf stage. The spray timing was very critical for weed control.

The main focus of the project is evaluating nitrogen fertilizer programs using dry urea and weekly fertigation applications with 32% UAN through the center pivot. Splitting N with fertigations produced more uniform plant height and green color rice across the field than a 2-way split with urea alone. In 2009, the highest yielding nitrogen fertility program for cultivars Templeton, CL 171, and RiceTec RTCLXL729 was a 38 kg N ha^{-1} dry urea application at first tiller growth stage followed by five 22.7 kg N ha^{-1} fertigations spaced in 1-week intervals, for a total of 151 kg N ha^{-1}.

Irrigation has been a learning process. The field where the pivot test is located has silt loam soil intermingled with large sandy areas. In 2008, irrigation timing was based on the visual appearance and feel of the surface soil. In 2009, the Arkansas Irrigation Scheduling Program was modified to include an experimental water-use function for rice and used to schedule irrigation throughout the season. In addition, soil moisture sensors were installed at 15- and 30-cm depths and transmitted to a computer server for the internet. Dr. John Travlos at MU-Columbia set an electronic alarm system to call cell phones if the soil became too dry.

Reducing Rice Irrigation Water Use Using RiceTec Hybrid Rice

Simpson, G.D., McNeely, V.M., Hamm, C.E., and Grymes, D.H.

Efficient irrigation water use is necessary because groundwater is a limited resource. Efficiency needs to be maximized in rice irrigation to reach sustainable use of groundwater resources for crop production. RiceTec hybrid rice exhibits higher water use efficiency than self pollinated cultivars in side-by-side comparisons and higher yield when irrigation water use is limited or reduced. RiceTec hybrid rice can be useful in an integrated approach to reduce irrigation water use.

Five field studies have been conducted over 4 years at the RiceTec Arkansas business center, 1 year at the Gary Sitzer Farm in Poinsett County, Arkansas, and 3 years at the RiceTec headquarters, Alvin, TX, to compare water use, grain yield, and other agronomic issues using irrigation methods: permanent flood irrigation, intermittent flood irrigation , and furrow irrigation. Sprinkler irrigation has been used over 2 years and at seven locations in northeast Arkansas and southeast Missouri in RiceTec hybrid rice field studies as a means to reduce irrigation water use.

In side-by-side comparisons, water use measurements were made using a Great Plains manufacturing analog screw-type irrigation flow meter . Water use was recorded at each application, and season-long records for rainfall and irrigation water applied were recorded for each irrigation method. Randomized and replicated variety tests were planted within each irrigation treatment at each location. In the sprinkler-irrigated variety test, there was no comparison of irrigation methods. However, in every case under sprinkler irrigation, water use was reduced for the season totals and for individual applications when compared with typical water use measurements from flood irrigation methods or furrow irrigation method.

Four-year mean water use for the 'Permanent Flood' irrigation treatment was 0.2488 ha-cm (24.1 acre-in). The intermittent flood irrigation treatment 4-year average was 0.1887 ha-cm (18.3 acre-in)..The furrow irrigation treatment mean was 0.1494 ha- cm (14.9 acre-in). The 2-year sprinkler irrigation treatment mean was 0.1099 ha-cm (11.0 acre-in). In all cases, RiceTec hybrid rice had higher water use efficiency than recommended cultivars in side-by-side comparisons. In all irrigation methods, water use was reduced when compared with permanent flood irrigation.

A Model to Predict Safe Rice Field Draining Dates and Field Tests of the Model Predictions in the Arkansas Grand Prairie

Counce, P.A., Watkins, K.B., Moldenhauer, K.A.K., Anders, M.M., and Siebenmorgen, T.J.

Because of the cost of extracting water, effective and efficient utilization of irrigation water for rice (*Oryza sativa* L.) is critical to rice farm profitability. A computer program has been developed to predict the stage of development for draining rice at which the risk of reduced grain yield or milling quality from insufficient water is considered to be near zero. The parameters of the model are (1) temperature projections during rice reproductive growth stages (RRGS) starting at R3, (2) timing of various RRGS, (3) amounts of water used by the rice crop at each growth stage, and (4) the water held in the soil profile after draining that is available to the rice crop. A central assumption of the model is that a soil water deficit, which leads to plant water deficits prior to completion of grain filling, can lead to yield and quality reductions. The central goal of the model is to allow draining at an RRGS in which (a) danger of reducing yield and quality from water deficits is near zero and (b) water is conserved and land conditions for harvest are improved. The study was conducted on Arkansas Grand Prairie locations on DeWitt and Stuttgart silt loam soils. Experiments were conducted at the Rice Research and Extension Center at Stuttgart, Arkansas, from 2005 through 2009. The experiments at Stuttgart had two treatments: (1) drained at the safe stage of development predicted by the growth stage model computer program and (2) drained at 28 days after heading (or later). Representative areas (2.5 m by 9.2 m) were harvested by hand at Stuttgart. In 2006 through 2009, additional combine harvested areas were also measured. Each plot at Stuttgart was bordered by its own normal earth levees. Experiments were also conducted in farmers' fields at Gillett, Arkansas, in 2005 and 2006 and in farmers' fields at DeWitt, Arkansas, in 2006 and 2007. There were two treatments in the experiment at Gillett and DeWitt: The plots were 1.22 by 2.45 m areas. In the farmers' fields, Treatment 1 plots were bordered by 14 gauge sheet metal 200 mm above the soil surface and driven into the soil to the depth of the plow layer. Two treatments common to each experiment were (1) drained at the safe growth stage as determined by the growth stage model computer program and (2) drained as the farmer drained the field (this was a control treatment without a frame with the same plot dimensions as plots of Treatment 1). Each study consisted of four replications arranged in randomized complete blocks. With the exception of one experiment (the experiment conducted at Gillett in 2005), the rice cultivar was Wells. In the experiment at Gillett in 2005, the cultivar was Francis. Grain yield and milling quality were measured in all experiments in the study. In no case was yield or milling quality reduced by draining by Treatment 1 (the treatment drained by the predictive program) compared with the control treatment.

Draining at stages of development predicted by the model did not affect yield or milling quality relative to the control for any year or location. Pumping costs savings were near zero to \$29 ha^{-1}. Predicted water savings from one less 76 mm irrigation ranged between \$9.81 to \$46.49 ha^{-1}, depending on pump depth. Implementation of the program by farmers can save money, increase soybean yields, reduce tillage costs, lessen management problems associated with red rice, and reduce unnecessary depletion of the aquifers.

Spatial Variability of Yield for Sprinkler-Irrigated Rice

Vories, E., McCarty, M., Tacker, P., and Stevens, W.

Most of the rice in the Mid-South is produced in a flooded culture for much of the growing season and generally requires more irrigation water than other crops produced in the region. By 1915, the alluvial aquifer, the principal water source for agriculture in eastern Arkansas and surrounding areas, was already being tapped at a rate that exceeded its ability to recharge. The problem was exacerbated as Arkansas rice production increased to >650,000 ha, and rice production also increased in neighboring states of Mississippi, Louisiana, and Missouri, with more than half of the U.S. rice crop currently produced in the Mid-South. Different production systems have been investigated to reduce the water requirement for Mid-South rice production, including furrow irrigation, delayed flooding, intermittent flooding, and multiple inlet rice irrigation with varying levels of success. Rice production under center pivot irrigation was investigated in the 1980s but was not widely adopted. However, in 2009, Zimmatic (Lindsay Corp., Omaha, Nebr.; mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture) and Valley

(Valmont Irrigation, Valley, Nebraska) worked with Mid-South farmers and researchers to revisit the potential for center pivot rice production. Among the questions being addressed: can rice yields comparable with flooded production be obtained with sprinkler irrigation; can center pivot rice be produced economically; can water be saved relative to flooded production; and will highly variable Mid-South soils negatively impact the spatial distribution of yield with sprinkler irrigation?

When rice is produced in a flooded culture, water is uniformly available across the field. With sprinklers, however, the distribution uniformity of the irrigation system impacts how much water is delivered to an area, while soil variability leads to site-specific differences in how much of that water is available to the plants. Center pivot systems typically have high application efficiencies, with published values as high as 90%. However, the combination of alluvial, wind, and seismic activity over the years has resulted in highly variable soils in the Mid-South. It is common to have soil mapping units ranging from sand to clay within the same field. One such field located near Osceola, Arkansas, is managed by McCarty Farms. The Mississippi County Soil Survey reports that the approximately 60-ha, center-pivot-irrigated field contains large areas mapped as Convent fine sandy loam, Steele loamy sand, Commerce silt loam, Tunica silty clay, and Sharkey-Steele complex (approximately 70% Sharkey silty clay or silty clay loam and 30% Steele loamy sand extruded during the New Madrid earthquakes of the early 19th century). Smaller areas were mapped as Jeanerette silt loam and Sharkey-Crevasse complex (approximately 50% Sharkey, 30% Crevasse loamy sand also extruded during the New Madrid earthquakes, and 20% Steele and Tunica soils). Such a field should be a perfect place to investigate the spatial distribution of yield when rice is produced with center pivot irrigation.

In 2009, working with local and national Zimmatic representatives, McCarty Farms planted the southern half of the field, approximately 30 ha, with the hybrid 'Clearfield XL745' (RiceTec, Inc., Alvin, Texas). Water was applied with the pivot to germinate the seed and incorporate herbicide. During the typical flood period, 18-mm applications were made approximately every other day in the absence of rain for a total of 464 mm of water applied to the crop. A published estimate of the pumping requirement for rice in Arkansas is 760 mm, based on several years of on-farm observations. However, the large areas of sandy soils in the field (primarily Convent and Steele) suggest that more water would be required to maintain a flood in this field than the typical rice field.

Yield monitor data from one of the two JD 9770 STS combines (Deere & Company, Moline, Illinois) used in the harvest were analyzed to investigate spatial yield variability. Yield data were "cleaned" with the USDA-ARS Yield Editor program (v. 1.02) to remove erroneous data points, and the average yield for the combine was assumed to be the field average dry yield of 9.7 Mg ha^{-1} (192 bu A^{-1}). Yield from the two largest contiguous blocks (4.8 and 3.8 ha) was analyzed for uniformity. The larger block contained areas mapped as Tunica (38% of the block), Steele (51%), and Sharkey-Steele complex (11%). The average yield for the block was 9.7 Mg ha^{-1}, and the yields from the individual mapping units ranged from 9.6 Mg ha^{-1} (Tunica) to 9.9 Mg ha^{-1} (Sharkey-Steele complex). Similarly, the smaller block contained areas mapped as Steele (30%), Commerce (67%), and Convent (2%). The average yield for the block was 10.2 Mg ha^{-1}, and the yields from the individual mapping units ranged from 10.2 Mg ha^{-1} (Commerce) to 10.6 Mg ha^{-1} (Convent). Furthermore, interpolated yield maps did not indicate any patterns that corresponded to the mapping units. Although additional work remains, the preliminary answers to the above questions are: yields comparable with flooded rice were obtained with sprinkler irrigation; rice was produced economically (not addressed in this report); water was saved relative to flooded production; and highly variable Mid-South soils did not appear to impact the spatial distribution of yield with sprinkler irrigation. Additional studies are planned.

Impact of Enhance 250 on Cocodrie Production in Texas

Samford, J.L., McCauley, G.N., and Vawter, L.J.

Farmers are continually looking for ways to increase yield while reducing costs and labor. Enhance 250 is a product being marketed in Texas at a cost of $21.00 ha^{-1} at a 0.58 l ha^{-1} rate ($8.50/A at an 8 oz/A rate) with claims to impact pests and plant health in rice and other crops. Reports of tests in Asia have shown that Enhance 250 increased rice yield, decreased days to harvest, and decreased the infestation of leaf blast and sheath blight disease. Field research was initiated in 2009 to determine the effects of Enhance 250 on Cocodrie rice production at the David R. Winterman Rice Research Station near Eagle Lake, Texas (N 29 deg 37.267’, W 96 deg 21.940’).

A randomized complete block design was utilized with four replications. Treatments included an untreated check and Enhance 250 applied at 0.58 l ha^{-1} or 1.17 l ha^{-1} at four-leaf (4LF), preflood, panicle differentiation (PD), or a combination of these stages. The test was planted 5 May 2009 and was fertilized with 281 kg ha^{-1} 19-19-19 preplant. A rate of 90 kg N ha^{-1} as urea was applied preflood and a rate of 79 kg N ha^{-1} as ammonium sulfate was applied at PD. All plots were harvested on 27 August 2009.

Untreated plots produced a mean yield of 8518 kg ha^{-1}. Statistical analysis showed no significant differences in mean yield among the treatments. The treatments showing a numerical increase in mean yield were Enhance 250 applied preflood at 0.58 l ha^{-1} or 1.17 l ha^{-1} (9072 kg ha^{-1} and 8933 kg ha^{-1}, respectively) and sequential applications of Enhance 250 applied at 0.58 l ha^{-1} at 4LF stage followed by 0.58 l ha^{-1} preflood stage then 0.58 l ha^{-1} at PD (8761 kg ha^{-1}). The late planting date of this test may have caused a reduction in yield, and testing will be conducted again in 2010 with a timely planting date. Early testing suggests that Enhance 250 has no advantageous effect on Cocodrie rice production in the Western Area of the Texas Rice Belt.

Effects of High Night Temperature and Plant Growth Regulators on Rice Productivity

Mohammed, A.R. and Tarpley, L.

For crop scientists, the biggest challenge is to increase crop production in the future. The increase in global temperature is projected to continue to decrease crop productivity per hectare, thereby decreasing supplies of global food production simultaneously with increased demands due to population growth. Moreover, as a result of global warming, night temperatures are predicted to increase more than day temperatures and have been implicated in lowering current yields throughout the world. The presence of seasonally high night temperatures (HNT) in the rice-growing areas, occurring during the critical stages of development, could reduce rice yield and quality. Much of the rice acreage in the U.S. mid-south, with its hot and humid climate, is susceptible to periods of HNT. The objective of this study was to determine the effects of HNT and plant growth regulators (PGR; vitamin E, glycine betaine [GB], salicylic acid [SA]) on growth, development and physiology of rice plants. The information will be used to suggest possible screening mechanisms for use in development of heat-tolerant rice cultivars, as well as to develop potential management factors that can provide near-term alleviation of heat-stress effects on rice yield in the U.S. mid-south.

Plants were grown under ambient night temperature (ANT) (27°C) and HNT (32°C) in the greenhouse. They were subjected to a HNT through use of continuously controlled infrared heaters, starting from 20 days after emergence (DAE) until harvest. Night temperatures were imposed from 2000 h until 0600 h. Plants were treated with PGRs 20 DAE. Net photosynthesis (P_n) of the penultimate leaves from three plants in each treatment was measured between 1000 h and 1200 h using a LI-6400 portable photosynthetic system (LI-COR Inc., Lincoln, Nebraska, USA) at the pre-boot, boot, early grain-fill, and mid-dough stages. Respiration rates were measured on the penultimate leaves between 2400 h and 0200 h using a LI-6400 at the boot, early grain-fill, and mid-dough stages. Membrane stability was determined at the boot stage, and total antioxidant capacity was determined using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay at the boot and mid-dough stages. Pollen germination was determined *in vitro*. Spikelet fertility was defined as the ratio of filled grains to total number of grains in the panicle. Grain length and width of brown (dehulled) rice were determined using a Winseedle, which uses image analysis of scanned color images of the grain to calculate these parameters. Grain nitrogen concentration was measured using a FP-528 Nitrogen/Protein analyzer.

The results indicated no effects of HNT on photosynthesis; however, HNT increased respiration rates and grain nitrogen concentration and decreased membrane stability, pollen germination, spikelet fertility, grain length, width, and weight. In addition, HNT hastened the crop development rate, as indicated by the dates of panicle emergence. All the above parameters contributed towards decreased rice yields under HNT. Rice plants treated with GB or SA showed an increase in total antioxidant capacity and yield compared with untreated plants, when grown under ANT or HNT. In conclusion, HNT decreased rice yields and exogenous application of GB and SA partially negated the negative effects of HNT possibly acting through increased antioxidant levels, which might have protected the membranes and enzymes against heat-induced ROS-mediated degradation.

RiceTec Hybrid and Conventional Rice Yield as Affected by Competition from Varying Densities of a Photoperiod Offtype Rice

Wallace, D.M., McNeely, V.M., Hamm, C.E., Sigsby, M.T., and Gann, S.P.

RiceTec hybrid rice is generally considered to be a highly competitive rice line. RiceTec hybrids are known for having a high tillering ability and an aggressive growth habit that is generally considered to result in a higher competitive ability than non-hybrid rice. RiceTec, Inc. decided to test various hybrids and rice lines against a photoperiod offtype hybrid rice to determine the competitive ability of RiceTec hybrids versus non-hybrid rice lines.

Experiments were conducted in Alvin, TX, and Harrisburg, AR, in 2007, 2008, and 2009 evaluating various rice lines. Lines used were: Clearfield XL729, Clearfield XL745, XL723, CL161, Cocodrie, and Wells. Lines were seeded at recommended seeding rates: RiceTec hybrids 1,482,000 seeds/ha (600,000 seeds/A) and non-hybrids 3,211,000 seeds/ha (1,300,000 seeds/A). A photoperiod offtype hybrid rice was used in densities of: 0, 11, 53, and 107 plants/m^2 (0, 1, 5, and 10 plants/ft^2) to compete with the various rice lines. The photoperiod offtype hybrid rice will not produce seed. The photoperiod offtype rice seed was mixed in each plot at specific seed counts to achieve emerged density levels. All plots were planted with a Hege cone planter with a plot size of 1.8 by 5.4 m (6 by 18 ft). Experiments were planted in April in Texas and May in Arkansas. Yield results were taken by a small plot combine.

RiceTec hybrids yielded statistically higher in all densities versus non hybrids. Clearfield XL729 and Clearfield XL745 maintained the highest yields in the experiment across all densities. XL723 maintained the highest yields of a non-Clearfield line across all densities. CL161 and Wells exhibited similar yields across all densities and were not statistically different. Cocodrie experienced the lowest yields of all the tested lines. In evaluating percent yield loss per rice line and density, RiceTec hybrids again showed an advantage. At the 11 plants/m^2 (1 plant/ft^2) density, all lines performed equally from a percent yield reduction regardless of hybrid or non-hybrid. Typical yield loss was 12% for CLXL745 and 13.5% for Wells. Cocodrie had the highest yield loss at 19%. As density of the photoperiod offtype hybrid rice increased, RiceTec hybrids established their superior competitive ability. Clearfield XL729 and Clearfield XL745 had significantly lower yield loss at the 53 and 107 plants/m^2 densities. Clearfield XL745 had the smallest yield loss of all the lines at 52% compared with 77% in Cocodrie. The experiment clearly shows in the presence of competition from weeds that RiceTec hybrids have a better ability to maintain higher yields than non-hybrid rice lines.

Approaches to Eliminating Arsenic Hazard in Rice

Loeppert, R.H., Pillai, T.R., Somenahally, A., Yan, W.G., Gentry, T.J., and McClung, A.M.

Arsenic (As), which is toxic to plants and animals, is especially problematic to rice since the predominant As species are more soluble and more bioavailable under the reduced conditions of flooded rice culture. Two major problems have received international attention in efforts to minimize potential As hazard in rice: (i) the occurrence of As in grain and the related issues of food quality and (ii) As toxicity to rice and its implications to crop yield, food security, and agricultural sustainability.

All soils contain As, with background concentrations generally ranging from 0.2 to 5 $\mu g\ g^{-1}$. The primary sources of soil As are the weathering of naturally occurring soil parent materials and sediments, the use of As-contaminated irrigation water, and the use of arsenical pesticides and defoliants in agricultural. In the current paper, we will discuss our experiences during the past six years in the south central United States, where the occurrence of As and its subsequent toxicity result primarily from the historical use of arsenical pesticides and defoliants.

Arsenic in soil exists in two predominant oxidation states: As^{III} and As^{V}. The primary species of interest are the inorganic (iAs) and mono- and di-methyl As forms. All forms of As are toxic to plants and animals, except for the dimethyl As^{V} species that has a relatively low toxicity. All forms of As are considerably more soluble and bioavailable under flooded than under dryland conditions. In spite of the fact that arsenicals are no longer used in production agriculture, soil As persists, which indicates the very low rates of net As loss. Though soil microbes are involved in both methylation and demethylation processes, there is a net demethylation, the rate of which is highly dependent on soil and environmental conditions. A $MMAs^{V}$ demethylation half-life of approximately 0.5 to 1.0 year might be reasonable to expect.

There is considerably genetic variability (up to 4 fold) in As uptake and grain-As concentration of rice. The predominant As species in rice grain are iAs^{III} and dimethyl As^{V}. Rice grain in the south central United States tends to be considerably higher in the proportion of dimethyl As^{V} ($DMAs^{V}$) to total grain As (TGAs) than the rice grain produced in south Asia. The reason for this difference (plant genetics vs. the occurrence of trace concentrations of methyl As in soil vs. crop management) remains a matter of intense interest.

Arsenic can result in a reduction in rice-grain yields by the increased occurrence of straighthead, reduced tillering, and reduced root health. Though there is considerable genetic variability in relative susceptibility to straighthead, recent studies have indicated that there is poor correlation between this trait and grain-As concentration and speciation, indicating that different genes are likely involved in these respective processes.

Several soil factors strongly impact As toxicity to rice, e.g., soil Fe-oxide mineralogy and content, soil silicate, phosphate and N status, and soil organic matter. The impact of organic matter is especially intriguing. Arsenic concentrations in grain are almost always increased and tolerance to As is often reduced upon the addition of fresh organic matter to soil. The reduced tolerance to As might be attributable to decreased rhizosphere redox potentials and increasing As solubility, though it could also be strongly impacted by altered microbial populations and functions, which likely impact As speciation and local As dynamics. These complex processes deserve further study.

Water management can have a profound impact on plant tolerance to As and the uptake of both iAs and methyl As species and tolerance to As toxicity. A primary impact of reduced water systems is on increased rhizosphere redox potentials and decreased As solubility; though, a second major factor is the altered microbial community population that can strongly impact As dynamics. Reduced water-use systems, e.g., intermittent flooding, can be used to greatly reduce As uptake and grain-As concentration. By means of combined plant selection and water-management strategies, the potential exists to virtually eliminate As as a concern in rice production.

Evaluation of Poultry Litter as a Phosphorus and Potassium Fertilizer Source for Rice Production

DeLong, R.E., Slaton, N.A., Norman, R.J., Golden, B.R., and Wilson, Jr., C.E.

The rising costs of inorganic phosphorus (P) and potassium (K) fertilizers have stimulated interest in the use of poultry litter as a nutrient source for rice (*Oryza sativa* L.) production in Arkansas. The benefits of poultry litter as a soil amendment to restore soil productivity on leveled soils and as a nitrogen (N) source are well documented. However, information regarding the availability of the P and K in litter is limited. Our objective was to compare rice yield and growth responses with equivalent rates of P and K applied as inorganic P and K fertilizer (FERT) and pelleted poultry litter (PPL).

Six field trials were established on silt loam soils between 2003 and 2005. Pelleted poultry litter was applied preplant at rates providing 29, 44, 59, and 74 kg P ha^{-1} (60, 90, 120, and 150 lb P_2O_5 A^{-1}) and compared with equal rates of P applied preplant as triple superphosphate (200 g P kg^{-1}). The total P and K contents of PPL were determined using standard laboratory methods and used to determine the rate of moist litter required to supply each P rate. Litter P and K contents ranged from 1.38 to 1.55% P and 2.31 to 2.57% K, depending on the PPL source. Muriate of potash fertilizer was applied with the triple superphosphate at rates that provided equivalent rates of K supplied by PPL, which were roughly equivalent to the applied P rate expressed in the oxide form (i.e., P_2O_5 and K_2O). Each experiment also included a control that received no P or K fertilizer. Nitrogen fertilizer was applied uniformly across the test area at a rate (preflood) of 146 kg N ha^{-1} for five experiments conducted on agricultural experiment station fields. The sixth site was located in a grower field and the N rate was applied according to Extension recommendations. A 0.9-m section of an inside row from each plot was cut at ground level to determine dry matter accumulation, whole-plant P and K concentrations, and P and K uptakes at the midtillering (MT), panicle differentiation (PD), and early heading (EH) stages. Grain yield was determined at maturity and expressed as a uniform moisture content of 130 g H_2O kg^{-1}. Each trial was a randomized complete block design with treatments replicated four times and arranged in a 2 (nutrient source) x 4 (nutrient rate) factorial structure compared with a unfertilized control (no P and K). Data were analyzed as a split plot treatment structure where site-year was the whole-plot factor (random) and the subplot was factorial treatment arrangement (fixed). Fishers protected LSD was used to separate means for significant effects at the 0.05 level using SAS v9.1.

Grain yield was not affected significantly by nutrient source, rate, or their interaction. However, P and K uptakes at each of the sampled growth stages were often significantly affected by nutrient source, rate, or their interaction. The main effects of nutrient source and rate both affected P and K uptakes at the MT and PD stages. Uptakes of P and K by rice receiving no P and K were always less than that of rice receiving PPL and FERT, averaged across rates. Rice fertilized with PPL had P and K uptakes that were greater by 10 to 15% for P and 9 to 19% for K than rice receiving FERT with the difference between nutrient sources declining with plant development. By the EH stage, there was no significant difference in K uptake between nutrient sources and the difference in P uptake had declined to 6%, but PPL was greater than FERT. In general, P and K uptakes at all growth stages increased as nutrient rate, averaged across nutrient sources, increased from 0 to 44 or 59 kg P ha^{-1} and plateaued. Whole-plant P and K concentrations were generally similar between PPL and FERT at all growth stages, and dry matter accumulation at each stage was affected only by nutrient source. These results suggest that P and K uptakes of rice fertilized with PPL may have been stimulated by organic N mineralization in the PPL. Overall, the results indicate that the availability of P and K in PPL is similar to that of inorganic fertilizer. Results of complementary studies (not presented) indicate that fresh litter and PPL produce similar P and K uptakes. Regardless of the poultry litter form, growers should have poultry litter analyzed for moisture and nutrient content to determine the rate of moist litter needed to maximize rice yield or to maintain soil fertility levels as recommended by routine soil test results.

Evaluation of Nitrogen Sources for Organic Rice Production

Wild, P.L., van Kessel, C., Lundberg, J., and Linquist, B.A.

Organic rice is produced on 14,000 ha in the United States. California is the largest single producer of organic rice worldwide with 6,000 ha, most of which is in the Sacramento Valley where this study was conducted. In the Northern Sacramento Valley, soils have high clay contents, and N fertility has traditionally been applied in the form of poultry litter (PL), due to the inability to grow cover crops under these soil conditions. Recently, a lack of PL availability has forced growers to search for alternative fertilizers. Other sources of organic N fertilizer are available on the market, but the efficacy of these fertilizers for rice production, where the rice is grown under flooded, anaerobic conditions, is not known. Therefore, the objective of this study was to evaluate four organic fertilizers (including PL) in regards to (1) their impact on rice yields, (2) N recovery efficiency, (3) their N mineralization rates under anaerobic conditions, and (4) the economics of their use.

To fulfill the objectives, field trials were conducted using a randomized complete block design in 2008 (one site) and 2009 (two sites). The trials were planted with a N-responsive rice variety (S-102) and fertilized with four sources of N fertilizer as treatments; 1) PL (3-5% N); 2) feather meal (12% N); 3) PL and feather meal (6% N); 4) bone and blood meal (13% N); and 5) control (no N). All N treatments received the same amount of N at 157 kg/ha (2008) and 112 kg/ha (2009). Phosphorous and potassium were applied to all plots to ensure that these nutrients were not liming. Aboveground biomass, grain yield, plant N-uptake, and soil NH_4^+-N were measured at different stages of crop growth. In addition, a 60-day anaerobic laboratory incubation with aforementioned fertilizers was conducted to quantify mineralization rates of the organic fertilizers. The incubation was designed as a factorial with 5 treatments, 6 sampling events, and 4 replications. The study was conducted by adding between .5µg and 4µg of N in the form of different fertilizers (equivalent to 180 kg N/ha) to 10 g of soil. Tubes were uniformly filled with water, O_2 removed, sealed, and placed in an incubator at 25^{o}C. At designated times, tubes were analyzed for NH_4^+ by extraction with 2 M KCl.

Among the three field sites, grain yields (14% moisture) ranged from 7055 kg/ha to 11,522 kg/ha. Grain yield in control treatment averaged 7451 kg/ha and was always significantly lower than the yields in plots fertilized with pelletized materials and usually significantly lower than yields in plots fertilized with PL. Pelletized fertilizer response varied across sites but gave on average 25% higher yields than the control plots. Yields in plots fertilized with PL were always lower than the yields of pelletized treatment plots (not always significant) and always higher (on average by 20%) than the control plots (not always significant).

Fertilizer N-recovery efficiency (NRE) was determined as the difference in N uptake between the fertilizer treatment and the control and dividing by the rate of N applied. In the 2008 field trial, PL had an average NRE of 19%, while the NRE of the pelletized materials ranged from 25 to 37% and averaged 32%. Results on NRE from 2009 are forthcoming.

In the anaerobic laboratory incubation study, N mineralization tended to maximize at 36 days, after which the rate of N mineralization plateued. Averaging the two final sampling points (36 and 60 days), 17% of the applied N mineralized in the PL, which was lower than the pelletized material which ranged from 20 to 33% N mineralized. These results are consistent with the total N uptake and NRE in the 2008 field study (2009 data not yet available).

These preliminary data indicate that PL, at the rates applied, does not provide sufficient N to meet crop demand, resulting in lower rice yields. The pelletized material mineralizes at a faster rate and thus provides higher yields at similar N rates. We are conducting a complete economic assessment in order to determine which source of material is the most cost-effective.

Trinexapac-Ethyl as a Potential Tool to Improve Harvestable Yield Potential for Hybrid Rice

Dillon, K.A., Walker, T.W., Tarpley, L., and Bond, J.A.

Hybrid rice technology is offered by private companies in the United States; however, hybrids are only planted to 20 to 25% of the USA rice area. Reasons for low adoption in the southern USA rice belt is partly due to hybrids being taller and more prone to premature lodging and grain shattering compared with inbred cultivars. Trinexapac-ethyl, a gibberellic acid (GA) biosynthesis inhibitor stops production of GA_{19} to GA_{20} in the GA pathway. The result is growth inhibition. The main objective of this study was to determine if an application of trinexapac-ethyl would reduce plant height and lodging without greatly reducing grain yield and/or milling quality.

A high-yielding, lodging-prone hybrid, 'XL723,' was planted in a 2-year study (2007 and 2008) conducted at the Delta Research and Extension Center in Stoneville, MS, on a Sharkey clay soil. Eight treatment combinations of two preflood N rates (134 and 202 kg N ha^{-1}), two topdress N timings [panicle differentiation (PD) and panicle emergence (PE)] where 52 kg N ha^{-1} was applied, and two rates of trinexapac-ethyl (0 and 85 ml ai ha^{-1}) applied at 14 days after PD were included with replication. Response variables included plant height at harvest maturity, a visual lodging score, grain yield, and milling yield. Data were subjected to tests of fixed effects using PROC MIXED in SAS. Means were separated using LSMEANS at a 95% confidence interval.

Averaged across years, preflood N rates, and topdress N timings, trinexapac-ethyl reduced plant height from 117 to 94 cm. Lodging was not observed in 2007; however, in 2008, an interaction among main effects was present for lodging. No lodging was observed where trinexapac-ethyl was applied; however, lodging ranged from 28 to 83% of the plots, depending on PF N rate and topdress N timing where no trinexapac-ethyl was applied. Grain yield or whole milled rice was not affected by trinexapac-ethyl. However, grain yields were greatest when 202 kg N ha^{-1} were applied.

These data suggest that trinexapac-ethyl has potential to allow hybrids to be fertilized for near maximum yields while minimizing the risk for lodging. The ability to employ a tool such as this could have a profound impact on the adoption of hybrid rice in the United States, which could ultimately greatly improve production per unit of land area.

RiceTec Hybrid Development Testing Program

Hamm, C.E., Wallace, D.M., Simpson, G.D., and McNeely, V.M.

The RiceTec hybrid development testing program is designed to encompass a multitude of several different experiment scenarios in order to paint a full picture of each hybrid's performance potential. The program compares current commercial and experimental hybrids along side of available commercial varieties in as many locations as logistically practical. The primary testing range includes all rice growing counties and parishes in Texas, Louisiana, Arkansas, Missouri, and Mississippi with some miscellaneous tests conducted in other locations, such as Puerto Rico and Mexico. Presently, the program includes over 30 unique experimental protocols that are strictly adhered to so as to ensure consistency and precision of all concluded data.

The experimental protocols include but are not limited to hybrid purity, weed competition, herbicide tolerance/recovery/screening, and stand establishment, as well as crop management trials such as nitrogen rate/timing and water conservation. Trial notes for emergence date, stand count, plant vigor/response, P.I. date, 50% heading, plant height, lodging score, grain retention, grain yield at 12.5% moisture, and milling yield are measured for each experiment. Ratoon data are collected where applicable. All field studies are planted and harvested with small plot equipment to maximize space usage. The average plot is 1.8 x 5.8 m (6 x 19 ft), seeded 34 kg/ha (30 lb/A) for hybrids and 67-90 kg/ha (60-80 lb/A) for varieties. Each plot is randomly replicated three to four times within a trial so that each line tested can be accurately represented within the test range.

The program continually evolves to address current and potential issues such as herbicide response and nitrogen use efficiency, as well as addressing water usage concerns. The primary utility of the hybrid development testing program is as an information gathering tool to aid in the advancement of hybrid rice technology.

The Effect of Variations in P Fertilizer Timing on the Growth of Flooded Rice in California

Lundy, M.E., van Kessel, C., Hill, J.E., and Linquist, B.A.

The prevalence of herbicide-resistant weeds in California rice (*Oryza sativa*) systems has prompted research into alternative management strategies that seek to minimize weed competition. Components of these strategies include minimum tillage, stale seedbed crop establishment, and modified nutrient management. Recent research has shown that surface applications of phosphorus (P) fertilizer increase the growth of weeds and algae, suggesting that changing the timing of P fertilizer application may reduce weed and algae growth. However, the effect of alternative P timing on the growth of flooded rice in California is unknown. Therefore, the objective of this study was to determine the effect of variations in the timing of P fertilizer application on rice growth, P uptake, and yield.

Phosphorus deficiency is rare in California rice systems because, regardless of P fertilizer application, a sufficient fraction of Fe-bound phosphate solubilizes under anaerobic conditions and becomes available to the developing roots of the rice plant. Therefore, in order to differentiate the response of rice to variations in P timing, this study was conducted on two fields deficient in available P as predicted by Olsen P values below 6 mg P/kg soil. Both fields were located in Butte County and had similar soils but varied in management. In Field A, straw from the previous crop was fall-incorporated into the soil and flooded over the winter. In Field B, straw residue was burned and no permanent flood was held over the winter.

In each field, we imposed five treatments in six randomized complete blocks. The treatments were: Fall P (FP) - applied in November 2008 prior to the onset of winter rains; Spring P (SP) - applied to the soil surface immediately prior to flooding and water seeding (the conventional P application practice); 35 DAP (35P) - applied to the flooded field 35 days after planting (the mid-tillering stage); 49 DAP (49P) - applied to the flooded field 49 days after planting (immediately prior to panicle initiation); and Zero P (ZP) - no P fertilizer was applied to the field. Phosphorus fertilizer was applied in the form of TSP at a rate of 56 kg P_2O_5/ha (50 lb P_2O_5/A) in plots at least 5 m x 2.5 m. At 35 DAP (mid-tillering), aboveground biomass and Y-leaf plant samples were taken from the FP, SP, and ZP treatments, dried at 60°C, weighed, and analyzed for total P and extractable phosphate. At physiological maturity, rice was harvested from a 1 m x 1 m area in each plot. Plants were dried at 60°C and weighed; grains were separated and weighed.

At mid-tillering (35 DAP), rice in the SP treatment had taken up more total P (89% in Field A and 37% in Field B) and extractable phosphate (126% in Field A and 49% in Field B) than the FP. Likewise, rice in the FP treatment took up 95% more total P and 110% more extractable phosphate than the Zero P (ZP) treatment in Field A and 227% more total P and 280% more extractable phosphate than the ZP treatment in Field B. The Y-leaf concentrations for total P and extractable phosphate followed the same pattern. Spring P treatments had 0.29% total P and 1020 ppm extractable phosphate in Field A and 0.34% total P and 1250 ppm extractable phosphate in Field B. Fall P treatments had 0.22% total P and 630 ppm extractable phosphate in Field A and 0.27% total P and 890 ppm extractable phosphate in Field B. Zero P treatments had 0.16% total P and 410 ppm extractable phosphate in Field A and 0.12% total P and 340 ppm extractable phosphate in Field B. Both FP and ZP treatments were below established critical levels of tissue P concentration for rice at mid-tillering. However, because the FP took up substantially more total P and extractable phosphate than the ZP treatment, fall applications of P fertilizers may still be a viable management option, but a higher rate would be necessary on fields with P deficiencies comparable with those in this study. Although not compared statistically, trends indicate that there was more fertilizer P available in Field B (burned straw) than in Field A (incorporated straw).

At harvest, there were no significant differences in aboveground biomass or grain yield between the FP, SP, 35P, and 49P treatments in Field A. In this field, all treatments with P fertilizer added had greater biomass and grain yield than the ZP treatment, but only the SP and 35P treatments were statistically significant for yield. In Field B, the SP, FP, and 35P treatments had significantly greater yield than the ZP treatment, and the SP and FP treatments also had significantly greater aboveground biomass than the ZP treatment. Fall application of P fertilizer increased yields 5% in Field A and 11% in Field B relative to the ZP treatment. Application of P fertilizer at mid-tillering (35 DAP) increased yields 13% in Field A and 11% in Field B relative to the ZP treatment. Neither the FP nor the 35P treatments were significantly different from the SP treatment in terms of yield in either field. Based on these results, we conclude that P fertilizers applied in the fall prior to cropping or at mid-tillering are viable alternatives to the preplant, surface P applications that are the conventional practice. These alternative P applications may reduce weed and algae growth without reducing rice yields.

Estimating Yield Potential by Planting Date Utilizing Observed Data from the Rice Research Verification Program

Runsick, S.K., Griffin, T.W., Mazzanti, R., Wilson, Jr., C.E., Watkins, K.B., and Hignight, J.A.

The Rice Research Verification Program (RRVP) was created in 1983 and represents a public demonstration of the implementation of research-based recommendations in actual field-scale farming environments. The goals of the RRVP are to: 1) educate producers on the benefits of utilizing University of Arkansas recommendations to improve yields and/or net returns, 2) to conduct on-farm field trials to verify research based recommendations, 3) to aid researchers in identifying areas of production that require further study, 4) to improve or refine existing recommendations which contribute to more profitable production, and 5) to incorporate data from RRVP into Extension educational programs at the county and state level. The RRVP has been conducted on 319 commercial rice fields in 33 rice-producing counties in Arkansas.

Until recently, data from the RRVP have only been subjected to analyses based upon the current year results. This study uses the entire dataset in a panel-context with cross-sectional and time-series attributes to evaluate long-term trends for use in a whole-farm decision making model. Observed data from 1983 to 2009 were analyzed to estimate the yield potential by planting date and to determine whether Arkansas farmers are planting earlier over time. The shape of the functional form was evaluated by goodness of fit metrics, and estimation results reveal the expected yield potential based on planting dates measured as 'weeks of year.'

Over the past 27 years, the majority of the RRVP fields were planted during weeks 16, 17, and 18 but were planted beginning in week 13 through week 25. Casual observation of the average yields per week in the RRVP would suggest optimal yields occurred when planting during week 13 with a linearly decline in yield for the following weeks. However, normalizing data across weeks and time shows a more accurate picture of the impact of planting date on yields. A base week was sought to compare yields across weeks planted within a given year. However, no given week was planted every year. Therefore, a 'base period' rather than a base week was defined for this study as the most frequent weeks planted (16, 17, and 18) each year. Yields were then normalized dividing actual yields in a given year by the average yield calculated for the base period in the given year.

Data suggest that yield potential is maximized between the 13th week and the 20th week of the year; after which yield penalties are expected, although early planting does have the risk of frost damage. This 8-week planting window without large yield penalties generally allows producers sufficient time to complete planting operations assuming that their equipment complement and rice acreage allocation are appropriately matched to the local days suitable for fieldwork. The general trend is that earlier planting, beginning with weeks 13 and 14, results in higher yields. The normalized yields indicated that week 14 had the highest yield potential. Relative yield decline by later planting (planting beyond week 20) in the RRVP was greater than research estimates in the Arkansas Rice Production Handbook. The differences can be attributed to uncontrolled observations in the RRVP. Late plantings in the RRVP were not intentional rather a factor of some actual farming condition that limited planting opportunities.

Rice Varietal Responses to Early Planting at Two Locations in Texas

Tarpley, L. and Mohammed, A.R.

Early planting of rice in the southern United States can potentially provide increased yields because the reproductive period of the main crop can avoid the hottest portion of the summer. Also, the ratoon crop has additional time to mature before the cool weather of fall limits grain maturation. On the other hand, the cool soils present at early planting dates can limit germination and are often associated with soil diseases. Knowledge of the response of promising cultivars under early-planting conditions in Texas is limited. In 2006, studies were initiated to evaluate current and promising cultivars at early and normal planting dates at two locations in Texas: Eagle Lake – representing the western growing region of Texas with relatively greater solar radiation and a generally more southerly growing area contributing to historically earlier planting dates, and Beaumont – representing the eastern growing region of Texas with historically later planting dates. These ongoing studies seek to identify rice varieties that perform well with respect to yield and milling when planted before the optimum planting date in Texas, with an emphasis on identifying cultivars that consistently perform well at the earlier planting date relative to the optimum planting date.

The targeted planting dates were very early to mid-March (early planting) at both locations compared with a mid-March to mid-April target range for optimum planting at Eagle Lake and a late-March to mid-April range for Beaumont. At Eagle Lake (silt loam), non-hybrids received 207 kg N ha^{-1} (185 lb N A^{-1}) as a 3-way split (50 preplant, 90 permanent flood, 67 panicle initiation) plus 151 kg N ha^{-1} (135 lb N A^{-1}) to the ratoon crop at preflood, while hybrids received 134 kg N ha^{-1} (120 lb N A^{-1}) preflood and 34 at boot. At Beaumont (clay), non-hybrids received 241 kg N ha^{-1} (215 lb N A^{-1}) as a 3-way split (50 preplant, 101 permanent flood, 90 panicle initiation) plus 151 kg N ha^{-1} (135 lb N A^{-1}) to the ratoon crop at preflood), while hybrids received 168 kg N ha^{-1} (150 lb N A^{-1}) preflood and 34 at boot. Fungicides were not applied. The selection and number of cultivars (24 total) evaluated differed among years and locations depending on producer/researcher interests and availability. The 2009 Beaumont results were not yet available for preparation of this abstract.

Yield differences between the early and normal planting dates varied widely among year-locations and cultivar. Early planting was sometimes quite detrimental and sometimes very beneficial. Among the six cultivars that were evaluated for at least 5 year-locations, the average range of yield differences was 3868 kg ha^{-1} (3454 lb A^{-1}). No cultivar was immune to poor rank performance with respect to yield difference. However, among the three cultivars that were analyzed for all seven available year-locations, Presidio (median = 4.3) and XL723 (median = 5) performed better ($p = 0.1250$) under early planting, based on rank performance with respect to yield difference, compared with Cocodrie (median = 8.17).

Any benefit of early planting in Texas is generally dwarfed by other factors affecting yield for particular year-location-cultivar combinations. Presidio and XL723 provide the least risk among the best-studied cultivars for planting early, if seeking to obtain a yield equal to or better than that obtained by the same cultivar planted within the “optimal” range of dates, whereas Cocodrie presents the greatest risk.

Spatial Variability of Yield, Nutrient Availability, and Salinity in Rice Soils: The Role of Flood Water Movement

Simmonds, M.B., Linquist, B.A., Pena, J.M., Plant, R.E., and van Kessel, C.

An understanding of the mechanisms causing spatial variability of yield is needed to predict and effectively manage variability within a field. Currently, rice growers lack the information needed to manage the spatial variability of yield-limiting factors, such as soil salinity and nutrient deficiencies. Instead, fields are managed uniformly. Field-leveling, water temperatures, flood water movement, and water-holding practices may be the main factors driving the spatial patterns of yield, soil nutrients, and salinity. This paper focuses on the effects of water management. As surface water moves laterally across a field, salts dissolve at the soil surface, causing increasing concentrations of solutes in surface water with increasing distance from the inlet. Following the flow of water to the outlets, we would expect the concentration gradient of salts and other solutes in the soil to increase due to increasing downward flux and evapoconcentration of solutes.

The main objectives are to quantify variability of yield, soil, and water chemical properties; determine the mechanisms and processes that cause variability; and determine the degree to which spatial and temporal patterns of soil fertility and productivity can be accurately predicted and at what scale. In this paper, we report on the importance of water management influencing spatial variability.

Studies were performed in four different fields, ranging in size from 23 to 69 hectares, during the 2008 and 2009 growing seasons. The fields are located in the Sacramento Valley and were conventionally managed by the respective growers. After land preparation but before fertilizer application and flooding, soil samples were collected at geo-referenced locations throughout the fields in order to characterize the spatial variability of soil properties within each field. These samples were analyzed for organic carbon (SOC), total nitrogen (N), nitrate, phosphorous (P), potassium (K), pH, and electrical conductivity (EC) by standard methods. To characterize the spatial distribution of flood water solute concentrations within a field, surface water samples were collected from irrigation boxes as water was flowing through the field. Water samples were analyzed for pH, EC, total N, soluble P and K, nitrate, ammonium, and dissolved organic carbon (DOC) by standard methods. The spatial variability of yield within each field was measured by commercial yield monitors, and by hand-harvesting plots to confirm commercial yield monitor results.

Ranges across fields for soil properties measured in 2008 include EC of 0.27 to 5.09 deciSiemens per meter, 0.06 to 0.23% total N, 0.61 to 2.34% SOC, 4.64 to 7.95 pH, 2.8 to 49.1 mg P/kg soil, and 76 to 503 mg K/kg soil. Grain yield measured from plots in 2008 (2009 data not yet available) at 14% moisture ranged from 9,354 kg/ha to 13,463 kg/ha across fields.

Surface water solute concentrations generally increased with increasing distance from the inlets in all fields. However, there were mixed results for observed patterns of nutrient concentrations in soils across fields. One field, in agreement with the predicted effect of water movement, displayed increasing nutrient concentrations, and soil EC toward the outlets, while the patterns of nutrient concentrations and EC in the other three fields were either all unrelated to distance from inlets or only certain soil properties were related to distance from the inlets. Clearly, other mechanisms are also responsible for spatial variability of soil nutrients and EC in rice fields.

ARIZE QM1003 Lodging and Grain Yield Response to Starter Fertilizer, Seed Rate, and Nitrogen Rate

Walker, T.W., Shao, Q., and Johnson, K.

Hybrid rice seed became commercially available in the southern United States approximately 10 years ago. Since then, area planted to hybrid rice has increased and currently accounts for approximately 25%. Because of heterosis, achievable grain yields for hybrids can be 15 to 25% greater than the inbred parents and competing commercially available inbred cultivars. Lodging often limits growers from harvesting the full hybrid potential, thus this has been one factor that has limited grower adoption. Hybrid seed costs are substantially greater than inbred cultivars, thus it is imperative to capitalize on heterosis as it increases tiller production so that fewer seed can be planted. Bayer CropScience has introduced its first commercially available hybrid, 'ARIZE QM1003,' in the southern United States. The main objective of this research was to determine an optimum balance of starter fertilizer, seed rate, and N rate that would lead to profitable grain yields while minimizing the risk of lodging.

An experiment was conducted on a Sharkey clay soil near Benoit, MS, and on a Dundee silt loam soil near Shaw, MS. A split-split plot experimental design was utilized to evaluate hybrid grain yield response and lodging to starter fertilizer application, seeding rate, and preflood N rate. Starter fertilizer application was the main plot unit, and it consisted of none and 168 kg ha^{-1} of a blend of N (20%), P_2O_5 (23%), and K_2O (30%) applied at the 2-leaf growth stage. The subplot unit was seed rate and it consisted of 11, 22, and 33 kg ha^{-1}. The sub-sub-plot unit was preflood N rate and it consisted of 0, 50, 100, and 150 kg N ha^{-1}. Treatment combinations were replicated four times. Lodging observations were made prior to harvest. Plots were harvested with a Wintersteiger Delta combine equipped with a HarvestMaster weigh system. Grain yields were adjusted to 12% moisture.

Starter fertilizer application did not affect lodging at either location. Lodging did not occur at the clay soil location. Substantial lodging did occur at the silt loam location; however, no relationship between lodging and treatment combinations existed. The silt loam location underwent several rain events after the grain reached harvest moisture, which contributed to the high variability in lodging with respect to treatments.

Grain yield was affected by the main effects of seed rate and N rate at the clay soil location. Pooled across starter and N rate, grain yield increased with increasing seed rate reaching a maximum of 13,658 kg ha^{-1}. When means were pooled across starter and seed rate, grain yield responded in a quadratic fashion with respect to N rate; however, a yield plateau was not achieved with the N rates that were applied. An interaction among seed rate and N rate affected grain yield at the silt loam location. When the seed rate was 11 kg ha^{-1}, grain yield responded linearly to N rate and reached 14,162 kg ha^{-1} when 150 kg N ha^{-1} was applied. When 22 and 33 kg seed ha^{-1} were planted, grain yield responded in a quadratic fashion to N rate and reached yield plateaus at 50 and 100 kg N ha^{-1}, respectively.

These results were inconclusive with respect to the stated objective; however, the data do suggest that the soil environment can greatly affect management of this hybrid. Multi-environment data will need to be generated in the future so that a better understanding of how to manage this hybrid, as well as potential hybrids, that have similar geno- or phenotypes so that greater yield potential is obtained at the production scale.

Accuracy of the Arkansas DD50 Rice Program in Predicting Panicle Differentiation in Northeast Arkansas

Frizzell, D.L., Duren, M.W., Wilson, Jr., C.E., Norman, R.J., Slaton, N.A., and Branson, J.D.

The Arkansas Rice Degree Day (DD50) Program was developed in 1978 to assist growers in timing midseason nitrogen applications. The program was expanded over time and now predicts the timing of 26 management decisions. Rice producers located in northeast Arkansas have suspected inaccuracies in the predicted dates produced by the Arkansas Rice DD50 Program compared with rice growth stages observed in actual field conditions. It has been suggested by producers that these differences could be attributed to threshold development being located in the southern part of Arkansas. A study was initiated in 2004 to compare DD50 thermal unit accumulations needed to reach panicle differentiation with predicted accumulation values generated by the DD50 Program at the Northeast Research and Extension Center near Keiser, Arkansas.

Seven cultivars ('Bengal,' 'CL161,' 'Cocodrie,' 'Francis,' 'Medark,' 'Wells,' and 'RiceTec XL-8') were seeded in early April, mid April, early May, and early June beginning in 2004 and continuing through 2006 at the Northeast Research and Extension Center near Keiser, Arkansas, on a Sharkey clay soil (very-fine, smectitic, thermic, Chromic Epiaquert). Specific seeding dates were dependent on weather and soil conditions. Standard cultural practices for the delayed flood management system were used throughout the growing season. Ten main stem samples were taken from each plot beginning at internode elongation and continued twice weekly until all stems sampled reached 13 mm of accumulated internode movement. Data were averaged for each cultivar within each seeding date. Data were then compared with values generated by the DD50 Program. Regression analyses were conducted with SAS.

Results showed mixed linear relationships between predicted and actual thermal unit accumulation values for each cultivar, but strong linear relationships between predicted and actual days for each cultivar. Data suggest the DD50 Program is more accurate in predicting days to panicle differentiation rather than accumulated thermal units in northeast Arkansas. But, without a standard, it is difficult to determine how much of the variation is due to differences in management and/or differences due to latitude and environments. More studies are needed to access the relationship between plant development rates in northeast Arkansas and thresholds developed at the Rice Research and Extension Center near Stuttgart, Arkansas.

Trends in Arkansas Rice Cultural Practices

Branson, J.D., Wilson, Jr., C.E., Runsick, S.K., Frizzell, D.L., Norman, R.J., Slaton, N.A., and Mazzanti, R.

Arkansas is the leading rice producing state in the United States, representing approximately 45% of the total U.S. production and 47% of the total acres planted to rice. Rice cultural practices vary across the state and across the United States. However, because of the changing political, environmental, and economic times, the practices are dynamic. This survey was initiated in 2002 to monitor how the changing times reflect the changes in the way Arkansas rice producers approach their livelihood. It also serves to provide information to researchers and Extension personnel about the ever-changing challenges facing Arkansas rice producers.

A survey was conducted annually between 2002 and 2009, by polling county Extension agents in each of the counties in Arkansas that produce rice. Acreage, yield, and crop progress information was obtained from the USDA National Agricultural Statistics Service (http://www.nass.usda.gov). Rice variety distribution was obtained from summaries generated from the University of Arkansas Rice DD50 program enrollment.

The majority of rice is still produced on silt loam soils. However, an increasingly more important factor is the amount of rice produced on clay or clay loam soils (21 and 21% of the acreage, respectively). This represents unique challenges in rice production issues, such as tillage, seeding rates, fertilizer management, and irrigation. The increase in rice acreage on clay soils has been observed in counties along the Mississippi River, where historically non-irrigated soybeans have dominated. For example, rice production in Mississippi County has more than doubled over the last 20 years increasing from approximately 6,000 hectares each in 1984 to about 15,000 in 2009 with a high of 19,800 hectares in 2005. Other areas where rice production on clay soils have increased during this time frame include Crittenden County, and the Eastern half of Poinsett, Cross, and St. Francis counties.

Approximately 58% of the rice produced in Arkansas was planted using conventional tillage methods. The most common conservation tillage system utilized by Arkansas rice farmers is stale seedbed planting following fall tillage, representing approximately 27% of the state's rice acreage. True no-till rice production is not common but is done in a few select regions of the state. Rice production in Arkansas most commonly follows soybean in rotation, accounting for almost 75% of the rice acreage. Approximately 22% of the acreage is planted following rice, and the remaining 3% make up rotation with other crops including corn, grain sorghum, cotton, wheat, oats, and fallow. The majority of the rice in Arkansas is produced in a dry-seeded, delayed flood system with only approximately 2% using a water-seeded system. Approximately three fourths of all the Arkansas rice acreage is drill seeded, with an additional 20% broadcast seeded in a delayed flood system.

Irrigation water is one of the most precious resources for rice farmers of Arkansas. Reports of diminishing supplies have prompted many producers to develop reservoir and/or tail water recovery systems to reduce the "waste" by collecting all available water and re-using. Simultaneously, producers have tried to implement other conservation techniques to preserve the resource vital to continued production. Approximately 80% of the rice acreage in Arkansas is irrigated with groundwater, with the remaining 20% irrigated with surface water obtained from reservoirs or streams and bayous. During the mid 1990s, the University of Arkansas began educating producers on the use of poly-tubing as a means irrigating rice to conserve water and labor. The adoption of multiple-inlet irrigation using poly-tubing has increased from 17% in 2002 to more than 36% in 2009. Approximately 72% of the rice is still irrigated with conventional levee and gate systems. A small percentage of rice acreage produced in more upland conditions utilizing furrow irrigation systems. An additional means of conserving water for rice irrigation is through precision leveling. Approximately 45% of the rice acreage in Arkansas has been precision leveled, with more than 10% utilizing zero-graded fields.

During the past 20 years, the state average yields in Arkansas have increased approximately 1995 kg/ha or 2 bu/acre/year. This increase can be attributed to improved varieties and improved management, including such things as better herbicides, fungicides, and insecticides, improved water management through precision leveling and multiple inlet poly-pipe irrigation, improved fertilizer efficiency, and increased understanding of other practices such as seeding dates and tillage practices. Collecting this kind of information regarding rice production practices in Arkansas is important for researchers to understand the adoption of certain practices, as well as to understand the challenges and limitations faced by producers in field situations.

Long-Term Rice-Based Cropping System Effects on Near-Surface Soil Compaction

Motschenbacher, J.M., Brye, K.R., and Anders, M.M.

Rice (*Oryza sativa* L.) production in the United States is concentrated in the Mississippi River Delta region of south-eastern Missouri, eastern Arkansas and Louisiana, and western Mississippi, and rice-based cropping systems are different from other row crops due to the flood-irrigation scheme used from about 1 month after planting to a few weeks prior to harvest. Harvesting crops, particularly rice, in wet soil conditions makes the soil prone to compaction, which can negatively affect early-season stand establishment and has the potential to negatively impact subsequent crop yield. A study was conducted in the Mississippi River Delta region of eastern Arkansas to evaluate the long-term effects of rice-based crop rotations, tillage [conventional tillage (CT) and no-tillage (NT)], soil fertility regime (optimal and sub-optimal), and soil depth (0- to 10-cm and 10- to 20-cm) after 10 years of consistent management on near-surface soil compaction, as measured by soil bulk density (BD). Soil BD was greater under NT than CT in the top 10 cm but was similar between NT and CT in the 10- to 20-cm depth interval. Soil BD differed among common rice-based cropping systems, but few consistent trends were evident. It appears that, even after 10 years of continuous CT or NT rice production on a silt-loam soil, substantially increased near-surface soil BD has not occurred yet to the point where soil compaction would be a likely culprit responsible for potential early-season stand establishment or crop yield differences among rice-based copping systems.

Across Soils and State Boundaries: Evaluation of N-ST*R, A Soil-Based Nitrogen Test for Midsouth Rice Production

Roberts, T.L., Norman, R.J., Walker, T.W., Harrell, D.L., and McCauley, G.N.

Recent economic volatility has profoundly influenced the price of fertilizer, especially nitrogen (N), due to its close relation to the price of petroleum. The costs associated with rice production continue to increase, and although current N fertilizer prices are near average, the only certainty is that prices will increase. Long-term sustainability of domestic rice production hinges on the efficient use of inputs such as N fertilizer and proactive environmental stewardship. United States rice production boasts one of the highest levels of N use efficiency of any cereal crop in the world, but there is still room for improvement. Currently, N rate recommendations for many rice producing states rely on "yield goal" approaches that suggest rates based on soil texture and previous crop. Research suggests that this approach may lead to the over-fertilization of many fields that have above average native N fertility. Problems associated with over-fertilization of rice include increased incidence of disease and lodging, as well as an increased potential for movement of N off-site, resulting in negative environmental impacts. Nitrogen fertilizer needs are directly influenced by the amount of N mineralization in the soil, a process that has been widely documented, but difficult to quickly and consistently measure. Soil testing has developed several methods to measure the soil N availability, but with little success. Most methods require rigorous treatments and long hours that poorly correlate to either crop yield or N uptake. A basic understanding of the organic N fractions that are mineralized during the growing season may shed light on the availability of the native soil N supply. Identification of a soil-based N test for rice production will allow more precise applications of N fertilizers while utilizing native soil N and lowering the potential environmental impacts due to excessive N applications.

Researchers at the University of Arkansas have developed N-ST*R: a soil-based N test for rice that has shown a demonstrated ability to correlate with rice response parameters such as total N uptake and percent relative grain yield. N-ST*R has been calibrated to predict the N fertilizer rates for silt loam soils that will achieve 90, 95, and 100% relative grain yield. Currently, there is not enough data to develop and evaluate the ability of N-ST*R to predict N fertilizer needs on clay soils. However, several data points from each state where rice was produced on silt loams soils are available for comparison.

The objective of this research was to evaluate the potential of the N-ST*R calibration curve for silt loam soils that was developed in Arkansas to predict N rates for geographic regions and silt loam soils outside the geographic area where the curve was developed. An ongoing, multistate collaboration has been implemented between the University of Arkansas, Mississippi State University, Louisiana State University, and Texas A&M University to investigate the applicability of N-ST*R for the Midsouth rice producing region of the United States. Nitrogen response trials were planted at several locations throughout the cooperating states. Field trials were randomized complete block designs with four replications and a sufficient range and number of fertilizer rates to develop a N response curve for each location. Data for percent relative grain yield and N rate to achieve 95% relative grain yield from Mississippi, Louisiana, and Texas were compared with the N-ST*R calibration curve that has been developed by the University of Arkansas. Percent relative grain yield and N rate to achieve 95% relative grain yield for each location will be determined and statistically compared with the University of Arkansas correlation and calibration curves developed for N-ST*R. A comparison of the number of sites that fall within the 95% confidence interval will be compared with the number of sites that fall outside of that confidence range. The relative number of sites that can be accurately predicted using the N-ST*R correlation and calibration curves will determine if a universal N-ST*R curve can be utilized for all silt loam soils in the Midsouth or if individual states will have to develop their own correlation and calibration curves.

Effect of Tillage and N Rate on Rice Yield, N-Uptake, and Efficiency

Harrell, D.L.

Rice is grown using various seeding and tillage practice combinations in the Gulf Coastal Plains region of the United States. A recent survey of Louisiana grown rice indicated that 61% of all rice acres grown in 2008 were drill seeded. Rice can be drill seeded in a conventional- or reduced-tillage system. Conventional tillage (CT) is currently the most common tillage system used in drill-seeded, delayed-flood Louisiana rice; however, reduced tillage systems have become more common over the last decade. Estimates from the 2008 cropping season suggest that over 57,800 ha of rice planted in Louisiana used some form of conservation tillage practice, with a fall stale seedbed (FSS) being the predominant form. Past research of nitrogen (N) fertilization in drill-seeded delayed-flood rice has almost extensively concentrated on CT systems. Given the increased popularity of drill-seeded, delayed-flood FSS rice systems, research concentrated on evaluating optimal N rate, uptake, and recovery efficiency differences between CT and FSS systems is warranted.

The objective of the current study was to evaluate the effects of tillage on grain yield, optimum N rate, total N uptake, and N recovery efficiency (RE) of a newly released long- and medium-grain cultivar. Two tillage systems (CT and FSS) and nine N rates (0, 34, 67, 101, 134, 168, 202, 235, and 269 kg ha^{-1}) were used in separate experiments to evaluate 'Neptune' and 'Catahoula' rice. Rice was grown in upland conditions until the rice reached the 4- to 5-leaf stage of development. At that time, all N treatments were surface broadcast as urea (46% N) onto a dry soil surface and the field was flooded 1 day later to an approximate depth of 15 to 20 cm. Aboveground plant samples were collected when approximately 50% of the panicles had emerged from the boot (50% heading) to evaluate total N uptake.

Emergence of Neptune and Catahoula rice was delayed in FSS compared with CT and is most likely attributable to cooler soil temperatures of the FSS during early spring. Plant height was not affected by the main effect of tillage or by the tillage by N rate interaction; however, it was altered by N rate for both Neptune and Catahoula. The tillage system did not affect grain yield in Neptune; however, grain yield in Catahoula was increased in FSS by 403 kg ha^{-1} compared with CT. A significant tillage by N rate interaction was not observed for either variety.

Optimum N rate as determined by mean separation analysis was 235 kg ha^{-1} with a corresponding yield of 11,697 kg ha^{-1} for Catahoula and 202 kg ha^{-1} with a corresponding yield of 11,344 kg ha^{-1} for Neptune. Optimal N rate determined by the linear-plateau analysis for Catahoula and Neptune was 156 and 151 kg ha^{-1}, respectively. The result from the linear plateau analysis of both cultivars fell near the mean of the Louisiana recommended N application range; however, the optimum N rates determined by the mean separation test were above published recommendations.

Total N uptake increased linearly with increasing rates of N for both varieties; although, it was not significantly different between FSS and CT. Nitrogen RE was unaltered between CT and FSS providing anecdotal evidence that applied N for drill-seeded, delayed-flood rice production is equally available between CT and FSS; however, further research is needed to verify N availability and distribution equivalence.

Results of the current study suggest that commercial rice producers should not alter current state N recommendation guidelines for Neptune and Catahoula rice varieties when grown using FSS. Past research has identified older cultivars that do respond differently between CT and FSS; therefore, similar work with future rice varietal releases is warranted.

Survey of Total Salts in Vermilion Parish Rice Fields after the Hurricane Ike Storm Surge

Gauthier, S., Landry, K.J., Saichuk, J.K., Harrell, D., Wolcott, M., and Henderson, R.E.

Rice production has historically been the largest agricultural commodity grown in Vermilion Parish, with a traditional base of over 32,000 hectares and a 2009 economic value of $41.5 million. However, within the last 5 years, two major hurricanes have dealt a major blow to the Vermilion Parish rice industry by dumping a salty storm surge on over 91,459 hectares of land in southern Vermilion Parish. Aware of the danger salt poses to rice production, the LSU AgCenter responded after Hurricane Rita in 2005 by taking soil samples in the flood zone from 177 gps mapped locations at three sampling depths. Storm samples run by the LSU AgCenter soil testing lab helped farmers make planting decisions based on soil test results. A 56% reduction in rice acreage followed Hurricane Rita in 2006, and farmers reported low yields in rice fields with high soil and/or irrigation water salt levels. After Hurricane Ike made landfall in September 2008, a planning meeting was held to design a smaller, less expensive, predictive survey of storm surge flooded rice cropland. As a result, 10 gps site locations still in rice production from the 2005 study were selected to monitor soil salt levels at a depth of 0 cm to 15 cm, seven times between October 2008 and November 2009. By the 2009 planting season, soil test results from the 10 sentinel locations indicated that most storm surge affected land still had soil salt levels above the recommended tolerance of 750 ppm total salts. Correspondingly in 2009, Vermilion Parish rice acreage declined after Ike by 33% or 8,361 hectares due to either a salty soil or lack of access to fresh irrigation water. Additionally, since Rita, Vermilion Parish farmers have personally submitted over 1,866 samples from storm flooded fields. Data also were used to monitor trends in declining soil salt levels. Multiple regression analysis performed on the data indicates that time was more highly correlated with a consistent reduction in total salts in the soil than rainfall. A 1-year hiatus from rice production seems to be necessary following a salty storm surge flood to cleanse soil and irrigation waterways of elevated salt levels. Literature indicates that this pattern was seen after Hurricanes Audrey, Rita, and now Ike.

Soil Organic Carbon Dynamics in a Long-Term Rice Cropping System

Jung, W.K., Stevens, W.E., and Dunn, D.

Rice (*Oryza sativa* L.) has long been cultivated as a staple crop and considered as cultural, social, and economic resources for half of the world population. Rice production increased since the 1960s through adoption of technological practices, including fertilizers, mechanization, crop management, and plant breeding. Crop residue management is an important component of rice cultivation, especially since soil and rice quality are influenced by nutrient cycling and chemical fertilization. Alteration in temperature and precipitation by projected climate change may also influence rice production. Rice yield and emission of greenhouse gases may either increase or decrease, depending on management practices. Therefore, this study assessed the long-term effects of different management practices in a mono-cropping (one rice crop per year) experiment on soil organic carbon (SOC) pool and rice grain yield. The experimental research site (Aquic Fluvaquentic Eutrudepts) is located in Suwon, Korea. The SOC pool and rice yield differed significantly among residue management treatments. The SOC pool (52 ± 3.4 Mg ha^{-1}) for 0- to 15-cm depth was the highest in the treatment, receiving 13 Mg ha^{-1} of residue. Rice grain yield was significantly correlated with the SOC pool ($r=0.68^{**}$). In a long-term rice cropping experiment, the highest rate of SOC sequestration of 201 kg C ha^{-1} yr^{-1} was observed for the residue application rate of 3 Mg ha^{-1} yr^{-1}.

Abstracts of Papers on Weed Control and Growth Regulation
Panel Chair: Jason A. Bond

Glyphosate Injury to Clearfield® Rice Before and After Imazethapyr Applications

Meier, J.R., Smith, K.L., and Scott, R.C.

The imazethapyr-tolerant (Clearfield®) rice system has been readily adopted by Arkansas farmers as a tool to help manage red rice infestations. The tolerance of Clearfield rice to imazethapyr, as well as the effects of sub-lethal rates of glyphosate, has been examined. However, it is unclear whether an increased response is noted when applications of imazethapyr and sub-lethal rates of glyphosate occur simultaneously or sequentially. Field and greenhouse experiments were conducted in 2007 to examine Clearfield® rice response to imazethapyr and low rates of glyphosate when applied sequentially at 0, 1, 3, 7, and 14 days.

In the field trial, the cultivar 'CL 161' was drill-seeded into a Sharkey clay soil at 101 kg/ha and arranged in a randomized complete block design with four replications. In the greenhouse, trial CL 161 was hand-seeded into pots 10.2 cm square and 12.7 cm tall. A randomized complete block design with six replications was used and the trial was duplicated. Treatment began when the plants reached the four- to five-leaf growth stage in both field and greenhouse experiments. Glyphosate was applied at 0, 45, and 90 g ai/ha at 0, 1, 3, 7, and 14 d prior to applications of imazethapyr at 0, 105, or 210 g ai/ha. Imazethapyr was also applied at the above rates 0, 1, 3, 7, and 14 days prior to receiving glyphosate to determine any predisposition of plants to either herbicide. Plant height (cm) was measured 7, 14, and 21 d after the final applications (DAFA) in the greenhouse trial, and plant height was measured 7 and 14 d and prior to harvest in the field trial, and yield was obtained with a small-plot combine. At 21 d, plants were cut at the soil surface and dry weight (g) recorded.

In the field experiment, plant height was reduced by glyphosate at all application timings; however, the reduction in height was not influenced by imazethapyr at any rate or timing. Plant height was reduced 7 and 14 DAFA from glyphosate at 90 g/ha at all application timings. At harvest, there was no difference in plant height between 0, 45, and 90 g/ha of glyphosate when applied 14 days after imazethapyr, but plant height was reduced at all other application timings by glyphosate 90 g/ha. Reductions in rice yield were observed from both imazethapyr and glyphosate, but there was no interaction between the two herbicides or application timing. Rice yield was reduced by imazethapyr at 210 g/ha compared to 0 g/ha, but rice yield from applications of 105 g/ha was not different from either 0 or 210 g/ha, and rice yield was reduced as the rate of glyphosate increased.

In the greenhouse experiment, plant height was reduced by glyphosate at 45 and 90 g/ha at all application timings 7, 14, and 21 DAFA. Imazethapyr had no effect on dry weight of rice regardless of application rate or timing, but dry weight was reduced as the rate of glyphosate increased. From these trials there is no evidence that imazethapyr applications will predispose CL 161 to greater injury from glyphosate or that glyphosate will predispose CL 161 to injury from imazethapyr.

Response of Rice to Low Rates of Glyphosate and Glufosinate

Davis, B.M., Scott, R.C., and Dickson, J.W.

Off-target movement of herbicides has been detrimental to crop yields. When new technology is released, it is necessary to understand the potential impact it may have on off-target crops. Field studies were conducted in 2007 and 2008 to evaluate and compare the effects of low rates of glufosinate and glyphosate on rice.

Rice canopy height and flag leaf length reductions, prolonged maturity, and yield losses were caused by both herbicides when applied at various timings [three- to four-leaf, 0.635-cm panicle initiation (PI), and boot]. Although both herbicides caused significant response in the parameters measured, visual symptoms varied greatly between the two herbicides. Glufosinate injury to rice was more rapid and visually intense than with glyphosate. Glufosinate symptoms, which consisted of rapid necrosis, were visible in 1 to 2 days, while glyphosate symptoms, stunting and chlorosis, became visible after 7 to 10 days or not at all depending on time of application. For example, glyphosate 3 weeks after treatment (WAT) at the 1/2x rate applied at the boot stage caused less than 10% injury but resulted in 80% yield loss. Conversely, glufosinate at this timing caused 80% injury which resulted in similar yield losses of 80%. Glyphosate symptoms from PI and boot timings were typically only visible at heading and included malformed seedheads and shortened flag leaves. Harvested grain seed weights were reduced as much as 14% by both herbicides applied at the PI and boot stages. Germination of harvested grain was not affected by any treatment.

Effect of Glyphosate/Command Tank-Mixtures on Barnyardgrass Control

Norsworthy, J.K., Scott, R.C., and Smith, K.L.

Clomazone (Command 3ME) is tank-mixed with glyphosate and applied to most rice acreage prior to or immediately following planting to provide residual grass control. Occasional failures from this combination on barnyardgrass are reported to Extension weed scientists each year, but overall the combination has proven effective in controlling emerged weeds as well as providing residual grass control. Experiments were conducted at Lonoke, Rohwer, Stuttgart, and Keiser, Arkansas, in the spring of 2009 to determine the cause of failure from glyphosate plus clomazone combinations.

The experimental design was a randomized complete block with a factorial arrangement of clomazone and glyphosate rates. Glyphosate rates at Lonoke and Rohwer differed from rates evaluated at Stuttgart and Keiser. At Stuttgart and Keiser, clomazone was applied 0, 0.34, and 0.67 kg ai/ha in all possible combinations with glyphosate at 0, 0.43, and 0.87 kg ae/ha. Glyphosate rates evaluated at Lonoke and Rohwer were 0, 0.87, and 1.26 kg/ha. Broadleaf signalgrass (*Urochloa platyphylla*) was the only grass weed present at application at Lonoke, and in addition to barnyardgrass (*Echinochloa crus-galli*), it was present at Keiser. Barnyardgrass and broadleaf signalgrass were 10 to 15 cm tall and most had not yet begun to tiller prior to application at Rohwer, Stuttgart, and Lonoke. At Keiser, most of the barnyardgrass and broadleaf signalgrass was 25 to 38 cm tall and had profusely tillered prior to application. Weed control at all sites was rated for 3 to 4 weeks following application.

Barnyardgrass and broadleaf signalgrass were effectively controlled with glyphosate alone, regardless of rate. Clomazone alone was not effective in controlling barnyardgrass or broadleaf signalgrass at any location. There was no apparent antagonism from glyphosate plus clomazone tank mixtures at Stuttgart, Rohwer, and Lonoke. However, at Keiser, barnyardgrass and broadleaf signalgrass control were reduced when the highest rate of clomazone was applied with the lowest rate of glyphosate. No antagonism occurred when the full labeled rate of glyphosate (0.87 kg/ha) was applied with either clomazone rate. The large barnyardgrass and broadleaf signalgrass may have contributed to the reduced control and apparent antagonism at Keiser.

Further research is needed to determine the exact cause of the reduced control observed at Keiser and the occasional failure of clomazone plus glyphosate in production fields. Based on the data from these four sites, it is recommended that a full rate of glyphosate be used when tank-mixing with clomazone to ensure a high degree of grass control.

Do Starter Fertilizer Applications Reduce Clomazone Injury?

Bond, J.A. and Walker, T.W.

Clomazone (Command) has been used in southern dry-seeded rice since 1999, and today many rice weed control programs are designed around clomazone applications. Although rice tolerance to clomazone is acceptable in most cases, rice injury can occur under certain conditions. Rice injury is a concern following clomazone applications, especially when rice is seeded early in the season (prior to April 1 in Mississippi). Inbred rice cultivars can respond differently to clomazone applications; furthermore, practitioners report that clomazone injury is more severe on hybrid than inbred rice cultivars. Agronomic research conducted in Mississippi demonstrated a positive rice response to early-season (starter) nitrogen (N) fertilizer applications. Following clomazone with a starter N fertilizer application may reduce the injury often observed from clomazone. Research was conducted in 2008 and 2009 at the Mississippi State University Delta Research and Extension Center in Stoneville to 1) compare the response of hybrid and inbred rice cultivars to applications of clomazone and 2) determine if starter N applications reduce clomazone injury on rice seeded early in the growing season.

Treatments were arranged as a three-factor factorial within a randomized complete block design with four replications. Factor 1 was two rice cultivars, 'XL723' (hybrid) and 'Cocodrie' (inbred). Factor 2 included three rates of clomazone (0, 420, and 672 g ai/ha). Factor 3 was starter N applied as ammonium sulfate (AMS; 21:0:0) at 0 or 24 kg N/ha. Rice was seeded on March 24 and emerged April 14 both years. All clomazone treatments were applied immediately after seeding, and AMS was applied approximately 2 weeks after emergence (WAE) when rice reached the two-leaf growth stage. Visual estimates of rice injury were recorded 1, 2, 3, and 4 WAE; rice seedling density was determined at 3 WAE; and rice yields were converted to 12% moisture content at season's end. All data were subjected to ANOVA, and means were separated using Fisher's protected LSD at $p \leq 0.05$.

Clomazone at 420 and 672 g/ha injured XL723 more than Cocodrie 1 WAE. Starter N applications did not influence rice injury. For both cultivars, injury was greatest following clomazone at 672 g/ha before and after AMS application. Differences in early-season rainfall may have caused differences in rice injury between 2008 and 2009. XL723 seedling density was not impacted by clomazone or AMS applications. Seedling density of Cocodrie was higher in one of two years in plots where no clomazone was applied but AMS was applied at the one- to two-rice stage. Heat unit accumulation was 12% greater in 2008 compared with 2009. Cocodrie yield was not impacted by clomazone application in either year. XL723 yield was reduced in one of two years in following clomazone at 420 and 672 g/ha. Pooled across year and cultivar, yield was lower following both clomazone rates in plots receiving no AMS. However, when AMS was applied, yield was not negatively impacted by clomazone application.

Clomazone injured the hybrid cultivar XL723 more than the inbred cultivar Cocodrie. No positive early-season response to AMS was detected where clomazone was applied. Rice yield can be reduced by clomazone. However, the yield loss can be overcome with starter fertilizer.

Can Command Use Rates in Rice be Increased?

Wilson, M.J., Norsworthy, J.K., Griffith, G.M., DeVore, J.D., Still, J.A., and Bangarwa, S.K.

Clomazone (Command) is one of the most widely used herbicides in rice production. It is known for exceptional grass control [barnyardgrass (*Echinochloa crus-galli*), broadleaf signalgrass (*Urochloa platyphylla*), crabgrass (*Digitaria* spp.), fall panicum (*Panicum dichotomiflorum*), and sprangletop (*Leptochloa* spp.)] when applied preemergence (PRE), delayed preemergence (DPRE), or early postemergence (EPOST). With the trend toward more residual weed control during the growing season, will a rate increase injure the rice crop and extend grass control? A field study was conducted in Stuttgart, AR, in 2009 on a silt loam soil to evaluate higher than labeled rates of clomazone.

The experiment was a randomized complete block with four replications. Clomazone was applied at rates of 0.336 and 0.448 kg ai/ha at timings of PRE and EPOST. Treatments were clomazone alone, clomazone followed by clomazone, and clomazone followed by clomazone in combination with thiobencarb (Bolero) at 3.36 kg ai/ha. All

EPOST applications contained 1% crop oil concentrate. Rice injury and weed control ratings were taken weekly. Weeds in this study included barnyardgrass, broadleaf signalgrass, hemp sesbania (*Sesbania herbacea*), and pitted morningglory (*Ipomoea lacunosa*).

Results showed that an increase in the rate of clomazone to 0.448 kg/ha caused 44% injury to rice at 21 days after application (DAA) compared with 26% injury from clomazone at 0.336 kg/ha. Sequential applications of clomazone at 0.448 kg/ha injured rice as much as 61%. Barnyardgrass was effectively controlled (≥98%) through 29 DAA at both rates of clomazone applied as a single application. Multiple clomazone applications at the labeled and higher-than-labeled rate provided comparable barnyardgrass control through 36 DAA. Pitted morningglory control was improved from 38% at 22 DAA when clomazone was applied at 0.336 kg/ha to 59% when applied at 0.448 kg/ha. However, even the highest rate was not effective in providing acceptable control. Similarly, sequential applications controlled pitted morningglory only 70% at either rate. Overall, it can be concluded that the increased rate results in greater injury to rice with minimal or no increase in weed control. Therefore, there appears to be no value to increasing the rate of clomazone on a silt loam soil.

Fall Programs for Managing Glyphosate-Resistant Italian Ryegrass

Bond, R.C., Nandula, V.K., Martin, S., and Bond, J.A.

Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) is an erect, winter annual with a biennial-like growth habit. It grows vigorously in winter and early spring and is highly competitive. Several populations of Italian ryegrass from Mississippi crop production fields have been confirmed resistant to glyphosate. In Mississippi, a majority of rice is grown on heavier-textured soils in rotation with soybean. Most tillage is performed in the fall following soybean harvest and fields remain undisturbed throughout the winter. Emerged weeds are controlled with burndown herbicide applications prior to rice planting. Large populations of glyphosate-resistant (GR) Italian ryegrass could be problematic for producers utilizing these practices. The presence of GR Italian ryegrass can jeopardize preplant burndown programs, and fields containing GR Italian ryegrass not controlled at burndown will have significant residue at planting. Residue will impede planting practices, contribute to competition between rice and established GR Italian ryegrass, and hinder herbicide programs due to inadequate coverage. Therefore, it is important to identify alternative herbicides that will adequately control GR Italian ryegrass to prevent competition and yield reductions. Recent research has identified fall-applied residual herbicide applications as the best option for managing GR Italian ryegrass in Mississippi. Research was conducted at an on-farm site near Tribbett, MS, from 2007 to 2008 to (1) determine the most efficacious rate of fall-applied residual herbicides targeting GR Italian ryegrass and (2) evaluate GR Italian ryegrass control with residual herbicides applied in combination with fall tillage.

A two-year study to evaluate application rates of fall-applied residual herbicides was designed as a randomized complete block with four replications. Treatments included soil incorporated applications of trifluralin (Treflan; 1.12 and 1.68 kg ai/ha) and surface applications of S-metolachlor (Dual Magnum; 1.07, 1.42, and 1.78 kg ai/ha), clomazone (Command; 0.56, 0.84, and 1.12 kg ai/ha), and pyroxasulfone (KIH-485; 0.035, 0.049, and 0.165 kg ai/ha). Herbicides were applied in the fall prior to emergence of GR Italian ryegrass. Visual estimates of GR Italian ryegrass control were recorded 100, 140, and 180 days after application (DAT). At 100 and 140 DAT, only the two lowest rates of pyroxasulfone controlled GR Italian ryegrass less than 85%. Although both rates of trifluralin and S-metolachlor at 1.07 kg/ha controlled GR Italian ryegrass through 140 DAT, control was not complete and these treatments would most likely require an additional herbicide application prior to planting. No rate response was observed for clomazone or S-metolachlor at 100 or 140 DAT. The highest rates of S-metolachlor, clomazone, and pyroxasulfone provided >90% control 180 days after fall application. This level of residual control will result in a seed bed relatively void of GR Italian ryegrass at planting, as most Italian ryegrass emerges in the fall.

A second study utilized fall tillage in combination with treatments identified as effective against GR Italian ryegrass from the first study. Treatments were arranged as a factorial of herbicide treatment and tillage within a randomized complete block design with four replications. The study was also replicated in time. Trifluariln (1.68 kg/ha), S-metolachor (1.42 kg/ha), and clomazone (0.84 kg/ha) were surface applied or incorporated with fall tillage. Visual estimates of GR Italian ryegrass control were recorded 21 and 140 DAT. Glyphosate-resistant Italian ryegrass control 21 DAT was equivalent and at least 86% for all herbicide and tillage combinations. Fall tillage with no herbicide application controlled GR Italian ryegrass 83%, which was lower than that from a surface application of clomazone. An interaction of fall tillage and herbicide was detected 140 DAT. S-metolachlor or clomazone applied prior to fall tillage and a surface application of clomazone controlled GR Italian ryegrass at least 74%. At the same evaluation, control from all other fall tillage and herbicide combinations was <54%.

Fall tillage can be used as a tool for GR Italian ryegrass control where it fits into a producer's production practices. However, the risk of subsequent flushes following tillage operations in the fall jeopardizes the utility of this practice as a useful management option. Although fall applications of S-metolachlor, clomazone, and pyroxasulfone provided residual control for up to six months following application, the rice tolerance to fall applications of S-metolachlor and pyroxasulfone has not been studied. Consequently, fields containing GR Italian ryegrass that will be planted to rice the following spring should be treated with clomazone at 0.84 kg/ha in the fall. Subsequent research will focus on defining the rice tolerance to fall applications of S-metolachlor, pyroxasulfone, and trifluralin.

Weed Control Programs using Aminopyralid and Aminocyclopyrachlor in Arkansas Rice

Johnson, D.B., Norsworthy, J.K., Still, J.A., and Wilson, M.J.

Aminopyralid is an auxin-type herbicide that is currently labeled by Dow AgroSciences for postemergence (POST) broadleaf weed control in pastures under the trade name Milestone. Aminocyclopyrachlor, another auxin-type herbicide, is being developed by DuPont Crop Protection for use in range and pasture. The objective of this research was to compare the effectiveness of aminopyralid and aminocylopyrachlor on broadleaf weed species commonly found in Arkansas rice, and to evaluate rice tolerance to these herbicides in tank mixtures with three other commonly used rice herbicides. These herbicides included: clomazone (Command), quinclorac (Facet), and imazethapyr (Newpath).

A field study was conducted as a RCB design with four replications, at Stuttgart, Arkansas, in 2009. The entire test area was over-seeded with hemp sesbania (*Sesbania herbacea)* and pitted morningglory *(Ipomoea lacunosa)* and contained a natural infestation of broadleaf signalgrass *(Urochloa platyphylla)* and barnyardgrass *(Echinochloa crus-galli)*. CL 171 rice was drill-seeded at 90 lb/A. Weed control and rice injury were visually assessed throughout the growing season. Aminopyralid was applied preemergence (PRE) at 0.023 lb ae/A (0.026 kg ae/ha) and aminocyclopyrachlor was applied PRE at 0.0625 lb ai/A (0.070 kg ai/ha). All treatments were applied at 15 GPA in a tank mixture with one of the following herbicides or combination of herbicides: clomazone (Command) at 0.06 lb ai/A (0.673 kg ai/ha), quinclorac (Facet) at 0.5 lb ai/A (0.561 kg ai/ha), imazethapyr (Newpath) at 0.094 lb ai/A (0.105 kg ai/ha) and 0.0625 lb ai/A (0.070 kg ai/ha), or clomazone and quinclorac at the same rates as used in the previous treatments. The entire plot area was over-sprayed with fenoxaprop (Ricestar HT) at 0.11 lb ai/A (0.123 kg ai/ha) for control of annual grasses three weeks after planting.

Rice injury of 13 to 45% was observed at 2 weeks after treatment (WAT) with the greatest injury from treatments that contained clomazone (41 to 45% injury). Injury from aminopyralid and aminocyclopyrachlor was in the form of reduced stand whereas clomazone caused bleaching. Both compounds were effective in controlling hemp sesbania when tank mixed with quinclorac, providing 99 to 100% control 5 WAT. Aminopyralid and aminocyclopyralchlor provided 93 to 97% hemp sesbania control when tank mixed with imazethapyr at 0.094 lb/A (0.105 kg/ha) 5 WAT. Pitted morningglory control was similar to that of hemp sesbania in that quinclorac was the most effective tank-mix partner with aminopyralid and aminocyclopyrachlor, with the combinations providing 96 to 100% 5 WAT.

Herbicide Programs for Controlling ALS-Resistant Barnyardgrass in Clearfield Rice

Wilson, M.J., Norsworthy, J.K., Johnson, D.B., McCallister, E.K., DeVore, J.D., Griffith, G.M., and Bangarwa, S.K.

Barnyardgrass (*Echinchloa crus-galli*) is the most problematic weed in Arkansas rice production, causing yield reduction, lodging, and poor grain quality. It infests most of the Arkansas rice acreage and has biotypes resistant to propanil (Stam), quinclorac (Facet), and clomazone (Command). Clearfield rice has led to extensive use of the imazethapyr (Newpath) herbicide in rice and, with the use of other acetolactate synthase (ALS)-inhibiting herbicides such as penoxsulam (Grasp) and bispyribac (Regiment), the evolution of resistant barnyardgrass was inevitable. In early 2009, an ALS-resistant barnyardgrass biotype was documented. Thus, an effective herbicide program is needed for control of the ALS-resistant biotype.

A field study was conducted at Lonoke, AR, on a Stuttgart silt loam to determine herbicide programs that would provide effective control of the susceptible and resistant biotypes. The experiment was organized as a factorial arrangement of treatments in a randomized complete block design with four replications. Imazethapyr at 0.071 kg ai/ha was applied alone and in combination with clomazone at 0.34 kg ai/ha, quinclorac at 0.56 kg ai/ha, pendimethalin (Prowl H2O) at 1.12 kg ai/ha, thiobencarb (Bolero) at 4.48 kg ai/ha, and fenoxaprop (Ricestar HT) at 0.122 kg ai/ha at multiple timings [preemergence (PRE), delayed preemergence (DPRE), early postemergence (EPOST), and preflood (PREFLD)].

Multiple applications of imazethapyr alone were ineffective in controlling the resistant biotype but did control the susceptible biotype. Programs that contained clomazone, quinclorac, pendimethalin, and thiobencarb PRE or DPRE followed by split applications of imazethapyr EPOST and PREFLD alone or tank mixed with fenoxaprop controlled at least 90% of both biotypes. Therefore, alternative herbicide programs were effective in controlling the ALS-resistant barnyardgrass biotype.

Program Approaches for Hemp Sesbania (*Sesbania exaltata*) Control in Drill-Seeded Rice

Meier, J.R., Smith, K.L., Bullington, J.A., and Doherty, R.C.

Hemp sesbania (*Sesbania herbacea*) is one of the most common broadleaf weeds found in Arkansas rice fields. There are many herbicides labeled for use in rice that are effective for control of hemp sesbania depending upon weed size and application timing. Six trials were conducted in 2009 at Rohwer, AR, on a sharkey clay soil to evaluate hemp sesbania control with imazethapyr, imazamox, imazethapyr plus quinclorac, quinclorac, halosulfuron, orthosulfamuron, penoxsulam, triclopyr, carfentrazone, pyraflufen, and saflufenacil at various timings in drill-seeded rice.

The addition of orthosulfamuron to imazethapyr applied preflood (PREFLD) (81%) improved control over imazethapyr applied early-post (EPOST) followed by imazethapyr applied PREFLD (30%) 22 days after application (DAA). Imazethapyr plus orthosulfamuron (81%) and imazamox plus orthosulfamuron (84%) applied PREFLD was more effective following imazethapyr plus quinclorac (100%) applied EPOST than when applied alone. Control with carfentrazone (89%) was greater when applied mid-post (MPOST) compared to EPOST (40%), whereas control with quinclorac (93%) applied EPOST was greater than MPOST (74%) 28 DAA. There was no difference in control with carfentrazone plus quinclorac applied EPOST or MPOST. Penoxsulam applied PREFLD alone or in combination with triclopyr or halosulfuron controlled hemp sesbania 100%, and this level of control was greater than that with triclopyr (76%) 21 DAA. Control 91 DAA with saflufenacil applied EPOST (93%) was greater than carfentrazone applied EPOST (68%) but was not different when both herbicides were applied MPOST (96% and 84% respectively). Saflufenacil plus quinclorac and carfentrazone plus quinclorac 91 DAA were similar in control when applied EPOST and MPOST. Carfentrazone at 17 g ai/ha (1 oz/A) provided 91% control of hemp sesbania compared to pyraflufen at 2 g ai/ha (1 oz/A) and 4 g ai/ha (2 oz/A), which provided 88% and 90% control, respectively, 21 DAA. There are several options for control of hemp sesbania in drill-seeded rice depending upon herbicide combinations and application timings.

Beyond Tank-Mixtures with Broadleaf Herbicides for Red Rice Control

Johnson, D.B., Norsworthy, J.K., McCallister, E.K., and Devore, J.D.

Red rice is the second most troublesome weed of rice in Arkansas. Imazethapyr (Newpath) is an acetolactate synthase (ALS)-inhibiting herbicide that is effective in controlling red rice in Clearfield rice. However, the use of imazethapyr prevents the production of conventional rice in the subsequent year due to potential injury from carryover. Imazamox (Beyond), a late-season herbicide, controls a similar spectrum of weeds to imazethapyr but has less risks of carryover to the following rice crop. Therefore, the use of imazamox in place of imazethapyr would allow producers to rotate from Clearfield to conventional rice production systems while still providing effective weed control.

In 2009, a study was conducted at the Pine Tree Branch Station near Colt, AR, to determine the effectiveness of imazamox in combination with several broadleaf herbicides in controlling red rice and other weed species commonly found in Arkansas rice culture. The test area was over-seeded with red rice *(Oryza sativa)* and hemp sesbania *(Sesbania herbacea)* and then drill-seeded with CL161 rice. The site also contained a natural population of Amazon sprangletop *(Leptochloa panicoides)*. Weed control and rice injury were visually assessed throughout the growing season. Imazamox was applied at 0.039 lb ai/A (0.044 kg ai/ha) POST at 15 GPA to two-leaf rice, and a subsequent application was applied when rice reached the five-leaf stage. Additionally, one of six herbicides was applied with either the first or second application of imazamox. These herbicide included: halosulfuron (Permit) at 0.0234 lb ai/A (0.0262 kg ai/ha), orthosulfamuron (Strada) at 0.0656 lb ai/A (0.0736 kg ai/ha), carfentrazone at 0.0156 lb ai/A (0.0175 kg ai/ha), triclopyr (Grandstand) at 0.25 lb ai/A (0.280 kg ai/ha), bentazon (Basagran) at 0.75 lb ai/A (0.841 kg ai/ha), and bispyribac (Regiment) at 0.025 lb ai/A (0.0280 kg ai/ha). All herbicides were applied with 1 % v/v crop oil concentrate.

There was no visible injury to the rice at 2 and 4 weeks after final treatment (WAFT). Sequential applications of imazamox provided 83 to 86% red rice control from 2 to 8 WAFT. There was apparent antagonism with the added herbicides when applied with the first imazamox application; however, halosulfuron and orthosulfamuron did reduce red rice control when applied in the second application. Amazon sprangletop control with all herbicide combinations was comparable to the sequential application of imazamox alone. Sequential imazamox applications provided at least 95% Amazon sprangletop control at 8 WAFT. Imazamox alone was ineffective in controlling hemp sesbania. Combinations of imazamox plus halosulfuron or bispyribac, regardless of the application timing, controlled hemp sesbania >90% at 8 WAFT.

BAS 800 (Kixor) for Northern Jointvetch and Hemp Sesbania Control in Rice

Dickson, J.W., Scott, R.C., Smith, K.L., Norsworthy, J.K., and Davis, B.M.

The objective of this research was to evaluate the performance of BAS 800, a new herbicide from BASF, on hemp sesbania (*Sesbania exaltata*) and northern jointvetch (*Aeschynomene virginica*) in rice (*Oryza sativa*). The experiment was conducted at the Rice Research and Extension Center at Stuttgart, AR, and at the University of Arkansas at Pine Bluff farm at Lonoke, AR. The experimental design was a randomized complete block with four replications. The Clearfield rice variety CL 171 was used at the Stuttgart location, and the conventional variety Wells was used at the Lonoke location. Conventional cultivation and planting methods were used in planting the rice, and the entire study was over-seeded with hemp sesbania and northern jointvetch. A preemergence (PRE) application of imazethapyr was applied to the entire study at a rate of 105 g ai/ha (6 oz/A) on the Clearfield variety, and cyhalofop at 313 g ai/ha (15 oz/A) with a crop oil concentrate at 2.5% v/v was applied to the entire study at the Lonoke location when grass weeds were at the one- to two-leaf stage in order to eliminate grass weeds. BAS 800 at 25, 50, and 100 g ai/ha (1, 2, and 4 oz/A) was applied PRE or to rice in the two- or four-leaf stage. Carfentrazone at the rate of 56 g ai/ha (3.2 oz/A) was also applied at the same rice growth stages for comparison. A non-ionic surfactant at 1% v/v was included in all postemergence treatments.

Neither herbicide displayed any significant amount of residual activity at the rates evaluated. BAS 800 controlled hemp sesbania from 90 to 100% by 35 and 85 days after application following both postemergence application timings at both locations, while carfentrazone controlled hemp sesbania 100% following both postemergence timings at both locations. BAS 800 controlled northern jointvetch from 90 to 100% by 85 days after both postemergence application timings at both locations. At 85 days after application, carfentrazone, applied to two-leaf rice, controlled northern jointvetch 48% at the Stuttgart location and 58% at the Lonoke location. At the four-leaf timing, however, carfentrazone controlled northern jointvetch 100% at the Stuttgart location, and 90% at Lonoke. Visual rice injury was never greater than 10 % and no significant yield response was observed.

Enhanced Control of Red Rice Using RiceBeaux with Newpath in Clearfield Rice Programs

Sandoski, C.A. and Leeper, J.R.

Resistance management is essential for preserving the ability to control red rice (*Oryza sativa*) with imazethapyr (Newpath) in the Clearfield rice production system. Tank-mixing labeled rates of imazethapyr with herbicides possessing alternate modes of action represents an effective resistance management tool for preserving the Clearfield technology. Studies were conducted in 2009 to determine if thiobencarb plus propanil (RiceBeaux) enhanced control of red rice with imazethapyr in the Clearfield rice production system.

The imazethapyr-tolerant long grain line, CL131, was drill-seeded on 36-cm row spacings with the conventional variety Cheniere inter-seeded on 36-cm row spacings as a mimic of red rice such that rows alternated between the two varieties. Plot size was 1.8 (9 rows) by 6 m. Seeding rate was 50 kg/ha for each cultivar. Imazethapyr was applied alone at various rates and tank-mixed with propanil (SuperWHAM! or RiceShot), thiobencarb (Bolero) or the thiobencarb plus propanil premix at full and half rates with recommended surfactant systems. Both propanil formulations, thiobencarb, and the thiobencarb plus propanil premix were applied alone at full and half rates with the same surfactant systems for comparison. All treatments were applied early-postemergence (EPOST), late-postemergence (LPOST), as well as sequential applications of EPOST and LPOST. Control of Cheniere rice was evaluated as an indicator of red rice control using the various combinations.

In the first of two field studies, single applications of imazethapyr at 17.5 and 35 g/ha with propanil plus thiobencarb exhibited significantly improved control of Cheniere rice compared with imazethapyr alone at 19, 36 and 51 days after treatment (DAT). Sequential applications of imazethapyr at 17.5 and 35 g/ha with propanil plus thiobencarb exhibited improved control of Cheniere rice compared with imazethapyr alone at 13 and 28 DAT. Control of Cheniere rice with labeled rates of imazethapyr was not improved with the addition of other herbicides. Control of Cheniere rice was not improved when imazethapyr was combined with propanil (SuperWHAM!).

In the second field study, single applications of imazethapyr at 17.5 g/ha with propanil (RiceShot) and thiobencarb (Bolero) exhibited improved control of Cheniere rice from early (three-leaf) application compared with imazethapyr applied alone. Single applications of imazethapyr at 35 g/ha with propanil (RiceShot), thiobencarb, and thiobencarb plus propanil (RiceBeaux) exhibited improved control of Cheniere rice from late (five-leaf) applications compared with imazethapyr alone. Control of Cheniere rice with labeled rates or sequential applications of imazethapyr was not improved by the addition of other herbicides.

Tank mixes of imazethapyr with thiobencarb plus propanil (RiceBeaux) improved control of red rice in the Clearfield rice production system and in conjunction with labeled rates of imazethapyr, can serve as a resistance management tool to help preserve the Clearfield technology. Tank-mixing imazethapyr with thiobencarb plus propanil also provides improved control of *Leptochloa* spp., *Echinochloa* spp., *Commelina* spp., *Sesbania* spp., and *Aeschynomene* spp.

F7275: Broadhead™, a New Herbicide for Delayed Preemergence and Postemergence Weed Control in Rice

Mitchell, H.R., Wilson, J.S., and Reed, J.P.

Broadhead™ (F7275) is a new herbicide in development by FMC Corporation for weed control in both conventional and Clearfield rice production systems. It is a premix of carfentrazone and quinclorac (1:16.7 ratio) and can be applied preemergence or early-postemergence for control of difficult to manage grass and broadleaf weeds in rice. Broadhead will be formulated as a 70% dry flowable (DF) and can be used in either a dry-seeded or water-seeded rice production system. In a dry-seeded production system, Broadhead may be applied preemergence, delayed-preemergence (prior to crop emergence) or postemergence when rice has at least two true leaves. In a water-seeded system, Broadhead may be applied only as a postemergence treatment when rice has at least two true leaves. Registered rates of Broadhead will range from 0.196 to 0.594 kg ai/ha with specific use rates based on soil texture and, in the case of postemergence applications, targeted weed size. Where applications are made postemergence targeting existing grass and broadleaf weeds, a non-ionic surfactant at 0.25% v/v or crop oil concentrate at 0.5 to 1.0 % v/v is required.

Broadhead has been evaluated in private and university rice weed management research programs during the past three years for its potential fit as a grass and broadleaf weed control herbicide in rice. Results presented herein are a compilation of experiments conducted in 2009 by private and university personnel with Broadhead applied early-postemergence (EPOST) at a rates ranging from 0.302 to 0.594 kg/ha for crop tolerance, weed efficacy and subsequent effects on yield.

Excellent rice tolerance was observed with Broadhead. Rice injury in the form of stand reduction or stunting was not observed. At 7 days after treatment (DAT), Broadhead-treated rice resulted in less than 5% discoloration/ necrosis and recovered from the initial discoloration by 30 DAT.

Broadhead provided excellent control (> 85% at 14-21 DAT) of entireleaf and ivyleaf (*Ipomoea* spp.), palmleaf (*Ipomoea wrightii*) and pitted (*Ipomoea lacunosa*) morningglory, hemp sesbania (*Sesbania herbacea*), Pennsylvania smartweed (*Polygonum pensylvanicum*), and spreading dayflower (*Commeline diffusa*) at a rate of 0.196 to 0.594 kg/ha. Excellent grass control was also observed against branyardgrass (*Echinochloa crus-galli*) and broadleaf signalgrass (*Urochloa platyphylla*).

These data support acceptable rice tolerance to Broadhead when applied at rates of 0.196 to 0.594 kg/ha. At these rates, Broadhead should prove to be a valuable new weed control tool in rice through its multiple modes of action, rapid activity, and excellent broadleaf and grass weed efficacy. In a Clearfield production system, Broadhead provides control of key weed species that escape Newpath with its two unique non-ALS modes of action. Broadhead provides both contact and residual grass control with excellent control of hemp sesbania, morningglories, jointvetch (*Aeschynomene* spp.) species, smartweed and other broadleaf weeds. In a conventional production system, Broadhead provides an economical base herbicide program with proven active ingredients providing effective control of a wide variety of grass and broadleaf weeds. FMC anticipates registration of Broadhead in time for the 2010 use season.

Rice Weed Management in Louisiana and Mississippi

Webster, E.P., Bond, J.A., Hensley, J.B., Bottoms, S.L., Carlson, T.P., and Fish, J.C.

It is common for producers to add spray additives to mixtures to aid in herbicide uptake through the use of surfactants and/or water conditions in the form of ammonium sulfate (AMS) or AMS substitutes. Studies were established at the Louisiana State University Agricultural Center Rice Research Station and at the Mississippi State University Delta Research and Extension Center to evaluate several AMS substitutes compared with dry sprayable AMS. Preliminary data indicates the addition of AMS to fenoxaprop increases activity of the herbicide on target species and aids activity under adverse conditions.

A study was established to evaluate two liquid AMS substitutes, Choice and Quest, and a dry sprayable formulation of AMS. Preliminary pH values were obtained for all spray solutions. The tap water used in both studies had a base pH of approximately 8.2. The addition of dry AMS reduced the pH to 7.0. The two liquid formulations, Choice and Quest, reduced pH to 5.5 and 3.5, respectively. Choice and Quest were applied at 0, 0.292, 0.584, 0.876, 1.17, and 2.34 mL/ha mixed with Ricestar at 86 g ai/ha. A comparison treatment of 2.24 kg/ha of AMS plus fenoxaprop at 86 g/ha was also evaluated. At 14 days after treatment (DAT), barnyardgrass (*Echinochloa crus-galli*) control was 76 to 86% with no differences observed regardless of additive. At 28 DAT, control of barnyardgrass in Mississippi was 70 to 88%. All fenoxaprop plus Quest mixtures controlled barnyardgrass below 80%. The addition of Choice, AMS, or no AMS provided 83 to 88% control of barnyardgrass. The later rating in Louisiana resulted in reduced control compared with Mississippi; however, trends were similar. Data indicate that the addition of dry AMS preformed slightly better than the other AMS formulations.

Another study was established to evaluate AMS, nonionic surfactant, crop oil concentrate, methylated seed oil, and 32% urea ammonium nitrate (UAN) as spray additives with fenoxaprop applied at 122 g/ha. At both locations, the addition of UAN appeared to be consistent across rating dates. Cyhalofop plus a crop oil concentrate was added for comparison and in nearly every case resulted in lower barnyardgrass control than any fenoxaprop treatment regardless of additive in Louisiana. In Mississippi, little difference was observed with cyhalofop compared with fenoxaprop.

These studies indicate that the addition of AMS to fenoxaprop is not consistent across treatments or locations. The added costs of a spray additive to fenoxaprop may not be justified.

Efficacy of Fenoxaprop Tank-Mixed with Other Herbicides

Bond, J.A., Webster, E.P., Blouin, D.C., and Hensley, J.B.

Herbicides inhibiting the acetyl CoA carboxylase (ACCase) enzyme have increased the options available to rice producers for managing grass species. Members of this class of herbicide chemistry are known collectively as graminicides and only control grass species. Fenoxaprop (Ricestar HT) is an ACCase-inhibiting herbicide that is widely used in rice for control of barnyardgrass (*Echinochloa crus-galli*), broadleaf signalgrass (*Urochloa platyphylla*), and *Leptochloa* spp. Combining a broadleaf herbicide with a graminicide could potentially broaden the weed control spectrum and lessen application costs. The success of such an approach is contingent upon each herbicide working as well in the tank-mixture as it does when applied alone. Unfortunately, reduced efficacy of graminicides applied in tank-mixtures with broadleaf herbicides is well documented. Therefore, tank-mixtures of graminicides with other herbicides are discouraged in most cases. Research was conducted in 2009 at the Mississippi State University Delta Research and Extension Center in Stoneville, MS, and at the south unit of the Louisiana State University AgCenter's Rice Research Station near Crowley, LA, to (1) evaluate the efficacy of fenoxaprop applied in tank-mixtures with broadleaf herbicides and (2) determine if control of annual grasses could be improved by increasing the rate of fenoxaprop applied in tank-mixtures with broadleaf herbicides.

Treatments were arranged as a two-factor factorial within a randomized complete block design with four replications. Factors included three application rates of fenoxaprop (0, 86, and 122 g ai/ha) and seven broadleaf herbicides applied in tank-mixtures with fenoxaprop. Broadleaf herbicides included bensulfuron (Londax; 42 g ai/ha), bispyribac (Regiment; 28 g ai/ha), halosulfuron (Permit; 53 g ai/ha), imazethapyr (Newpath; 70 g ai/ha), penoxsulam (Grasp; 35 g ai/ha), carfentrazone (Aim; 17 g ai/ha), and quinclorac (Facet; 750 g ai/ha). Treatments were applied to rice in the three- to four-leaf stage and weeds in the four- to five-leaf stage. Control was visually estimated at 14, 28, and 42 days after treatment (DAT). Control of barnyardgrass, browntop millet (*Urochloa ramosa*), and hemp sesbania (*Sesbania herbacea*) was determined at Stoneville. Barnyardgrass, broadleaf signalgrass, Amazon sprangletop, and alligatorweed (*Alternanthera philoxeroides*) were evaluated at Crowley. All data were subjected to ANOVA and means were separated using Duncan's multiple range test.

Control of hemp sesbania and alligatorweed was not influenced by tank-mixtures of broadleaf herbicides with fenoxaprop. Browntop millet control 28 DAT was reduced when either rate of fenoxaprop was combined with penoxsulam, and a tank-mixture of quinclorac with fenoxaprop at 86 g/ha resulted in lower browntop millet control compared with fenoxaprop alone at 86 g/ha. Broadleaf signalgrass control was lower when either rate of fenoxaprop was combined with bispyribac, imazethapyr, or penoxsulam at 28 DAT. Adding bispyribac or imazethapyr to either rate of fenoxaprop resulted in reduced efficacy on Amazon sprangletop. Barnyardgrass control 28 DAT was greater following fenoxaprop alone at 122 g/ha compared with fenoxaprop alone at 86 g/ha. Only tank-mixtures of quinclorac plus fenoxaprop at both rates controlled barnyardgrass as well as fenoxaprop alone. Lower control of barnyardgrass was observed when either rate of fenoxaprop was applied in tank-mixtures with bensulfuron, bispyribac, halosulfuron, imazethapyr, penoxsulam, or carfentrazone.

The performance of fenoxaprop applied in tank-mixtures with broadleaf herbicides was inconsistent across a variety of weed species. Therefore, these tank-mixtures should be avoided. In fields where the target species are annual grasses, producers should rely on fenoxaprop alone at 122 g/ha. A sequential application of a broadleaf herbicide should be utilized to control broadleaf weeds. In situations where a tank-mixture is necessary, the full rate of fenoxaprop plus quinclorac should be employed to avoid reduced efficacy on annual grasses.

Impact of Flush Timing on Fenoxaprop and Quinclorac Efficacy

Bond, J.A.

Weed control programs in rice are often designed around management of barnyardgrass. Quinclorac (Facet) and fenoxaprop (Ricestar HT) are widely utilized in midsouthern USA rice fields for barnyardgrass control. The two are often applied in combination for postemergence and residual control. Recently, questions have arisen about the efficacy of sequential applications of quinclorac and fenoxaprop. Research was conducted in 2009 at the Mississippi State University Delta Research and Extension Center in Stoneville, MS, to evaluate annual grass control with different sequential applications of quinclorac and fenoxaprop applied before and after surface irrigation.

The study was designed as a randomized complete block with four replications. Quinclorac (420 g ai/ha) and fenoxaprop (122 g ai/ha) were applied as tank-mixtures or in sequential applications 1 or 5 days prior to surface irrigation followed by application 1 or 5 days after surface irrigation. A sequential treatment of clomazone (Command; 560 g ai/ha) applied preemergence followed by propanil (SuperWham; 4,480 g ai/ha) plus pendimethalin (Prowl H2O; 1,120 g ai/ha) and a nontreated control were included for comparison. Visual estimates of rice injury and barnyardgrass (*Echinochloa crus-galli*) and browntop millet (*Urochloa ramosa*) control were recorded 14, 28, and 49 days after the final application (DAT). At maturity, plots were harvested and rice grain yields were adjusted to 12% moisture content. All data were subjected to ANOVA and means were separated using Duncan's multiple range test.

No rice injury was observed at the three evaluations. Differences in control of barnyardgrass and browntop millet were detected with the tank-mixture application timings and the different sequential applications. Barnyardgrasss was controlled 66 to 80% 49 DAT with all quinclorac plus fenoxaprop tank-mixtures. Control of both species was lower when quinclorac plus fenoxaprop was applied prior to surface irrigation compared with applications following surface irrigation. Herbicide sequence impacted barnyardgrass and browntop millet control more than the interval between applications. Regardless of the interval between sequential treatments, barnyardgrass and browntop millet were controlled better 14 and 49 DAT when fenoxaprop was applied before quinclorac. All fenoxaprop followed by quinclorac sequential applications controlled barnyardgrass better than tank-mixtures applied 1 or 5 d following surface irrigation.

Soil moisture may not have been low enough to limit the effectiveness of fenoxaprop applied 1 or 5 d prior to surface irrigation. Futhermore, quinclorac injury may have reduced uptake of fenoxaprop and caused lower control when quinclorac preceded fenoxaprop. Although tank-mixtures of quinclorac and fenoxaprop are recommended in many rice-growing areas, results of the current research indicate that control of barnyardgrass and browntop millet may be improved with sequential treatments of fenoxaprop followed by quinclorac. In situations requiring sequential applications of quinclorac and fenoxaprop, our results suggest that best annual grass control will be achieved with fenoxaprop followed by quinclorac.

Weed Control and Yield Potential for a Promising Rice Line, STG06L-35-061, Selected from Crosses between Weed-Suppressive Indicas and Commercial Long-Grain Rice

Gealy, D.R., Moldenhauer, K.A.K, and Mattice, J.D.

Sustainable weed control is an ongoing challenge in rice production. Indica rice lines such as PI 312777 that can suppress *Echinochloa crus-galli* and other troublesome C_4 grass weeds have been evaluated extensively in Arkansas for more than a decade. In an ongoing breeding/selection program, we are combining desirable quality and yield characteristics of southern long-grain cultivars with highly weed-suppressive rice lines. In previous findings, both competition and allelopathic components have been implicated in the weed suppressive activity of PI 312777 and other Indica lines. The selection RU0701087 (pedigree containing PI 338046, PI 312777, and Katy) produced adequate yield and quality, but provided only marginal weed suppression. STG06L-35-061 (pedigree containing PI 338046, PI 312777, Katy, and Drew) was initially identified in preliminary field trials in 2008 as a highly weed-suppressive selection. It was visually distinctive among many other selections and standard cultivars as having relatively few weeds in the midst of a large screening area that was mostly overrun by weeds. Its suppressive activity was subsequently confirmed in several field tests in 2009.

STG06L-35-061 and other rice lines of interest were evaluated in both weed-free and weed-infested ('weedy') drill-seeded plots that were flooded five to six weeks after planting. Weed-free plots were treated with propanil at 4.4 kg ai/ha to obtain complete control of grass weeds. Weedy plots of the same cultivar were treated with 1.1 kg/ha propanil (¼ of standard use rate) to achieve minimal stunting of weeds. Generally, weed suppression activity of STG06L-35-061 approached that of PI 312777 and other suppressive lines, and was superior to that of Lemont and a number of other commercial tropical japonica cultivars. In weed-free plots in one test, the time from emergence to 50% heading was 87 days and mature plant height was 109 cm. By comparison, these respective values were 87 days and 111 cm for Drew and 88 days and 97 cm for PI 312777. In other weed-free plots, STG06L-35-061 produced yields similar to those of LaGrue, averaging 8520 kg/ha (169 bu/A), and was not damaged by lodging, which has been a significant problem in its parent, PI 312777. In a bioassay conducted in soil in small cups in a growth chamber, apparent allelopathic activity of STG06L-35-061 roots, as determined by their inhibition of barnyardgrass seedlings, was intermediate between that of known allelopathic cultivars such as PI 312777 and non-allelopathic cultivars such as Katy.

STG06L-35-061 appears to be the most promising weed-suppressive selection from our efforts to date. It produces commercially acceptable rough rice yields and its weed control activity, apparently involving an allelopathic component, can be nearly as great as that of its most suppressive parental lines. Natural variation in weed infestation levels and weed suppression activities across experiments and years suggests that STG06L-35-061 would benefit from supplemental weed control inputs in most situations.

Does Soil pH Influence Rice Varietal Tolerance to Halosulfuron?

McCallister, E.K., Norsworthy, J.K., Devore, J.D., Wilson, M.J., Bangarwa, S.K., and Griffith, G.M.

Halosulfuron is labeled in rice for broadleaf and sedge weed control under the trade name Permit. The highest labeled rate of this herbicide to be applied to rice in a single growing season is 62 g ai/ha. Two separate field experiments were conducted in the summer of 2009 at the Rice Research Center near Stuttgart, AR, and the Research Station at Pine Tree, AR, to determine the cultivar response to halosulfuron on soils of different pH.

Soil pH was 5.5 at Stuttgart and 8.0 at Pine Tree. Ten common rice cultivars were drill-seeded in each experiment to determine any cultivar response to preemergence (PRE) and postemergence (POST) applications of halosulfuron. The cultivars/hybrids were: Wells, Cybonnet, CL 171, Francis, CL XL745, Neptune, Catahoula, Taggart, Jupiter, and Templeton. Treatments included a nontreated control for each cultivar/hybrid along with halosulfuron applied at 124 g/ha (2X) rate PRE and POST at the two- to three-leaf stage of rice. The POST applications included 0.25% v/v nonionic surfactant. Rice stand counts were taken in nontreated plots and those treated with halosulfuron PRE, and all plots were rated for injury through 4 weeks after treatment. Rice grain was harvested at maturity and corrected to 13% moisture. There were no stand reductions from the halosulfuron applied PRE at either location and injury at both sites from the PRE and POST treatments was minimal. All cultivars/hybrids responded similar to halosulfuron.

Imazosulfuron Interaction with Other Rice Herbicides

Norsworthy, J.K., Wilson, M.J., McCallister, E.K., Johnson, D.J., and Bangarwa, S.K.

Imazosulfuron is an acetolactate synthase-inhibiting herbicide that is being developed by Valent USA for use in rice. Combinations of herbicides can result in reduced weed control (antagonism) compared with the individual herbicides applied alone. Therefore, research was conducted to determine the efficacy of commonly applied rice herbicides alone and in mixture with imazosulfuron on hemp sesbania (*Sesbania herbacea*) and barnyardgrass (*Echinochloa crus-galli*), two common weeds of Arkansas rice.

The experiment was conducted in 2009 at the Rice Research and Extension Center near Stuttgart, AR. The test site contained a natural infestation of both weeds. Imazosulfuron was applied alone at 0.224 kg ai/ha to three- to five-leaf hemp sesbania (20- to 40-cm tall) and two- to four-leaf barnyardgrass (4- to 15-cm tall). Herbicides evaluated alone and in combination with imazosulfuron were propanil at 4.48 kg ai/ha, quinclorac at 0.56 kg ai/ha, bispyribac at 0.0224 kg ai/ha , penoxsulam at 0.0347 kg ai/ha, fenoxaprop at 0.0896 kg ai/ha, cyhalofop at 0.314 kg ai/ha, halosulfuron at 0.0526 kg ai/ha, thiobencarb at 3.36 kg ai/ha, 2,4-D amine at 1.12 kg ai/ha, triclopyr at 0.28 kg ai/ha, carfentrazone at 0.0179 kg ai/ha, acifluorfen at 0.0224 kg ai/ha, bentazon at 0.84 kg ai/ha, and imazethapyr at 0.071 kg ai/ha. All herbicide treatments contained Dyne-A-Pak at 2.5% v/v and were applied at 15 GPA.

Imazosulfuron alone provided 60, 80, and 99% control of hemp sesbania at 2, 4, and 7 weeks after treatment (WAT), respectively. Propanil, quinclorac, 2,4-D, triclopyr, acifluorfen, carfentrazone, and halosulfuron alone and in combination with imazosulfuron provided ≥90% hemp sesbania control 2 to 7 WAT, indicating no antagonism from these combinations. Hemp sesbania was not controlled with bentazon, fenoxaprop, cyhalofop, or imazethapyr alone. However, hemp sesbania control from imazosulfuron in combination with fenoxaprop or cyhalofop was comparable to imazosulfuron alone 2 to 7 WAT. Bentazon and imazethapyr antagonized hemp sesbania control when mixed with imazosulfuron.

Imazosulfuron provided no barnyardgrass control at any of the three evaluations. Of the herbicides having activity on barnyardgrass, only cyhalofop and fenoxaprop when used in combination with imazosulfuron had lower barnyardgrass control than the graminicides alone. Hence, it is unlikely that either of these herbicides can be used in combination with imazosulfuron.

Abstracts of Posters on Weed Control and Growth Regulation
Panel Chair: Jason A. Bond

New RebelEX® Herbicide - Filling the Gaps in Rice Weed Control

Ellis, A.T., Haygood, R.A., Lassiter, R.B., Mann, R.K., Richburg, J.S., and Walton, L.C.

Rebel EX is a pre-mixture of cyhalofop (Clincher®) plus penoxsulam (Grasp®) and will be released in 2010 for use in Southern U.S. rice for control of broadleaf, aquatic, and grass weeds. Rebel EX will bring two modes of action in one container which will help prevent herbicide resistance in selected grass species such as barnyardgrass.

In 2009, Rebel EX trials were conducted in Arkansas, Louisiana, Mississippi, and Texas using small plot research methods. Results from this study provided information on the crop safety, efficacy of weed control, and target application rates of Rebel EX. Control of barnyardgrass (*Echinochloa crus-galli*) was excellent with all Rebel EX rates; 92% with 284 g ai/ha (16 oz/A), 91% with 320 g/ha, 92% with 356 g/ha, and 93% with 716 g/ha (40 oz/A). Barnyardgrass control was similar (90 to 92%) with the tank mixture of Clincher plus Grasp at equivalent active ingredient rates. Clincher alone applied at rates of 251, 282, and 313 g ai/ha controlled barnyardgrass at 82, 82, and 88%, respectively. Rebel EX at 284, 320, 356, and 716 g/ha controlled sprangletop (*Leptochloa* spp.) 69 to 84%. The Clincher plus Grasp tank-mixture controlled sprangletop 71 to 83% and control with Clincher alone was 77 to 84%. Amazon sprangletop control was less than expected with all treatments due to heavy infestation pressure at research locations. Hemp sesbania (*Sesbania herbacea*) was the only broadleaf weed observed in the studies and all premix and tank-mixture treatments controlled hemp sesbania > 93%. Crop safety was excellent with all treatments. Overall, the efficacy of Rebel EX was slightly better than the Clincher plus Grasp tank-mixture.

Symptoms of Rice Herbicide Drift on English Walnut (*Juglans regia)* in California

DeWitt, T.C. and Ksander, T.E.

Bispyribac-sodium (Regiment CA) is a postemergence herbicide that has excellent efficacy against certain grasses, sedges, and broadleaf weeds with selectivity for rice. Bispyribac-sodium inhibits the plant enzyme acetolactate synthase (ALS), which blocks branched-chain amino acid biosynthesis. Bispyribac-sodium controls sensitive species resulting in a cessation of growth followed by chlorosis, necrosis, and plant death. Onset of symptoms usually occurs in 3 to 4 days. Similar symptoms can often be observed on crops grown next to rice. In California, rice is not grown exclusively in one area. Often, rice fields can be grown next to other crops including perennial crops. The bispyribac-sodium label has buffer zones which are necessary to reduce drift on to non-registered crops. Occasionally, the County Agricultural Commissions receive reports of yellow spotting on crops other than rice. English walnut (*juglans regia*) is very susceptible to herbicide spotting. Currently there are five ALS and one photosystem II (PS II) herbicides registered by air which can produce phytotoxic symptoms on young walnuts. These herbicides include bispyribac-sodium, bensulfuron-methyl, orthosulfanuron, halosulfuron-methyl, penoxsulam, propanil.

The object of this trial was to determine differences in phytotoxic response between the six rice herbicides in English walnut. Rates were established for each of the six herbicides including adjuvant. Each herbicide was diluted to simulate direct application (1X and 0.1X) and aerial drift (0.01X and 0.001X). Treatments were applied with a hand-held atomizer to simulate aerial application. The trial was set up as a randomized complete block design. Single, tree replications were used with the treatments applied around each tree at four- to six-feet level. Individual leaves were tagged for evaluation to differentiate between environmental damage from outside sources. Phytotoxicity data was taken at 5 and 12 days after application (DAT). Ratings were made on a scale of 0 to 10. In addition to phytotoxicity data, slides were taken at 5 and 12 DAT. Application rates of 1X and 0.1X are considered to be equal to a direct over spray by an aircraft. Lower concentrations of 0.01X and 0.001X are considered drift rates which would be from driftable fines from inversions or direct drift.

All of the ALS herbicides had similar symptom profiles, regardless of concentrations. Direct 1X over-sprays of ALS and PS II herbicides often show up as necrotic spots or total leaf burn and death. On the other hand, phytotoxicity from the drift rates of ALS or PS II herbicides typically show up as yellow spots. All of the ALS herbicides had similar drift profiles regardless of concentrations. The direct over-spray rate resulted in necrosis and leaf burn while the drift rates results in yellow spots. Propanil at the 1X rate exhibited leaf burn. The remaining concentrations had yellow spots similar to ALS symptomology. At 5 DAT, the phytotoxicity had just started to exhibit symptoms. However, at 12 DAT, the phytotoxicity had fully expressed its symptoms. By 30 DAT, most of the yellow spotting had disappeared. From this data, at driftable rates (0.01X and 0.001X), it is impossible to identify the different herbicides from the symptoms expressed on English walnut.

Response of Barnyardgrass and Junglerice (*Echinochloa* spp.) Accessions from the Mississippi Delta to Selected Herbicides

Nandula, V.K., Bond, R.C., and Bond, J.A.

Recently, less than acceptable control of barnyardgrass (*Echnochloa crus-galli*)/junglerice (*Echinochloa colona*) with currently labeled herbicides in rice has been reported by growers in the Mississippi Delta. Similar observations were recorded by weed scientists at Mississippi State University. In an effort to gain a better perspective on occurrence and distribution of herbicide resistance, seed from several populations suspected to be resistant to one or more herbicides was collected from rice-growing regions across the Mississippi Delta in 2009.

Greenhouse studies were initiated in fall 2009 to screen for resistance/susceptibility to selected rice-labeled herbicides applied postemergence (POST) and/or preemergence (PRE) in the greenhouse. All POST treatments were applied on two- to three-leaf plants. Percent control of *Echinochloa* plants 3 weeks after treatment (WAT) ranged from 30 to 85 with imazamox (Beyond, 0.044 kg ae/ha), 50 to 95 with cyhalofop (Clincher, 0.31 kg ai/ha), 30 to 75 with quinclorac (Facet, 0.56 kg ai/ha), 20 to 80 with penoxsulam (Grasp, 0.04 kg ai/ha), 40 to 95 with imazethapyr (Newpath, 0.11 kg ae/ha), 70 to 95 with bispyribac-sodium (Regiment, 0.04 kg ai/ha), 100 with glyphosate (Roundup WeatherMAX, 0.84 kg ae/ha), and 10 to 80 with propanil (Stam, 4.5 kg ai/ha), all applied POST. Evaluation of PRE treatments, clomazone (Command, 0.72 kg ai/ha), quinclorac (0.56 kg/ha), and imazethapyr (0.11 kg/ha), indicated complete susceptibility of barnyardgrass/junglerice populations to clomazone with a few accessions surviving the quinclorac and imazethapyr treatments at both 1 and 4 WAT. A portion of both the POST and PRE treatments from the above research will be repeated in follow-up studies.

Hybrid Rice Tolerance to Clomazone as Affected by Planting Date and Soil Characteristics

McKnight, B.M., Senseman, S.A., Camargo, E.R., Turner, A., McCauley, G.N., and Samford, J.

Field studies were conducted to evaluate hybrid rice tolerance to clomazone herbicide on two different soils in March and April plantings. Hybrid rice was seeded at three densities in Morey silty clay loam near Beaumont, TX, and Nada fine sandy loam near Eagle Lake, TX. Seeding rates were 25, 35, and 45 lb/A. Clomazone was applied at seven different rates PRE and EPOST. Each herbicide treatment was applied to the three seeding rates to assess the impact of injury on that particular seeding density. Visual ratings were recorded on weekly intervals and yield data was collected at the end of the study.

The March planting on the fine-textured soil in Beaumont showed minimal injury (<10%) while the April planting showed no clomazone injury. The March planting on the course textured soil in Eagle Lake showed significant injury as high as 90% in some plots. The April planting in Eagle Lake showed minimal injury (<10%). Over time, injury symptoms dissipated and were visually undetectable in the most severely injured plots 50 days after the last clomazone application. No significant difference was observed in mean yield in any of the treatments. There was also no interaction between herbicide treatment and seeding rate.

Competitiveness of Rice Hybrids in Rice

Fish, J.C., Webster, E.P., Bottoms, S.L., Hensley, J.B., and Carlson, T.P.

Clearfield rice, developed at the Louisiana State University Agricultural Center Rice Research Station near Crowley, Louisiana, is a non-genetically modified rice that allows the use of herbicides in the imidazolinone family to be applied over the crop to control red rice and other difficult to control weeds. Clearfield rice is now available in conventional cultivars and hybrids. Hybrid Clearfield rice has some seed shattering and dormancy characteristics and can become a non-conventional weed problem the following growing season if not properly managed. A study was established at the Rice Research Station to determine the competitiveness of rice hybrids with a Clearfield cultivar.

Arize, CLXL 745, CLXL 729, and XL 723 were evaluated for their competitiveness with CL 131. The hybrids were planted at 0, 1, 2, and 4 plants/m^2. CL 131 was planted at 70 kg/ha. The area was kept weed-free throughout the season to allow for evaluating competition between the rice and hybrids without other weed competition.

CL 131 was planted April 14, 2009, and immediately received a surface irrigation. At 24 hours after surface irrigation pregerminated hybrid seed were planted at the appropriate densities. At 4 weeks after emergence, stand counts were obtained to ensure proper hybrid densities. Immediately prior to harvest four hybrid plants were removed from each plot to determine the number of stems and panicles produced. All panicles were removed from remaining hybrids to prevent seed from contributing to overall yield.

Immediately prior to harvest, a 45 cm section of CL 131 was removed from the center row of each plot to evaluate the impact of the hybrid on CL 131 agronomic characteristics. CL 131 stem counts were reduced with XL 723 and CLXL 745 planted at 2 and 4 plants/m^2. Stem counts from CL 131 were similar to the nontreated when CLXL 729 and Arize were planted at all densities evaluated.

CL 131 panicle counts were obtained at harvest. These data indicated that XL 723 and CLXL 745 at 2 and 4 plants/m^2 reduced panicle numbers of CL 131 compared with CLXL 729 and Arize. All of the XL hybrids evaluated reduced yield regardless of density compared with Arize. These data indicate that at 4 plants/m^2 Arize reduced the overall yield by 23%, while the XL hybrids reduced the yield from 31 to 37%, and XL 723 and CLXL 745 appear to be more competitive with the CL 131.

This study did not evaluate the impact of F_2 seed harvested from the F_1 hybrids. With these data and observations from actual fields with a hybrid infestation the following year, it is hypothesized that yield reductions will be greater under F_2 and later generations of hybrids. Producers should take all precautions and employ management practices to prevent hybrids from shattering and becoming weed problems the following growing season.

Economic Evaluations of Imazethapyr Rates and Timings

Carlson, T.P., Salassi, M.E., Webster, E.P., Bottoms, S.L., Hensley, J.B., and Bond, J.A.

Imidazolinone-resistant (IR) rice, was developed in 1993, allows for the control of red rice with no effect on the crop. The target herbicide for use in IR rice is imazethapyr which is in the imidazolinone herbicide family. Several studies have evaluated the efficacy of imazethapyr on red rice resulting in 93% red rice control with a single postemergence (POST) application and up to 99% control with sequential applications. However, due to costs and total weed control concerns surrounding the most effective imazethapyr timing, the objective of this research is to evaluate the weed control, crop response, cost, yield and economical return of imazethapyr at various application rates and timings throughout the growing season.

This study was conducted in 2009 at the LSU AgCenter Rice Research Station and the Mississippi State University Delta Research and Extension Center using Clearfield 'CL 131' rice drilled-seeded at 75 lb/A. This study was arranged in a randomized complete block design on a Crowley silt loam soil. Plot size was 5 by 20 feet and each treatment was replicated four times. The initial application of imazethapyr was applied at emergence, 1 week after emergence (WAE), 2 WAE, 3 WAE, or 4 WAE followed by a sequential application of imazethapyr 14 days after the initial application on a given treatment. A nontreated was added for comparison purposes. Imazethapyr was applied at 71 g ai/ha for both applications, 105 g/ha for both applications or a combination of the two. A crop oil concentrate (COC) was added in each application at 1% v/v. Economic applications were based on average prices for 2009. Base rice price was $13.00/cwt with price deductions based on rice grade. Newpath was priced at $525/gallon and crop oil at $15/gallon.

A timing interaction occurred for red rice control and yields; therefore, data were averaged over rate. Imazethapyr applied at emergence controlled red rice 89%; however, delaying the initial application to 1 WAE or later resulted in 48 to 59% red rice control. Since all herbicide rates were averaged over timing yields and quality will play the biggest role in maximizing profit. When imazethapyr was applied at emergence rice yield was 4280 lb/A and a rice grade of 3, resulting in a gross market revenue of $546/A. However, when the initial application was delayed to 1, 2, or 3 WAE, yields and gross market revenue were reduced approximately 30% to 40%. When delaying the initial application of imazethapyr to 4 WAE, yields and gross market revenue were reduced approximately 50% compared with treatments that received a Newpath application at emergence. Furthermore, milling and rice grade were also reduced when delaying the initial treatment to 1 WAE or later.

The data evaluated in this study suggest that delaying the initial herbicide application can be detrimental to rice production. To maximize profit initial applications should be applied within the first week of rice emergence. Delaying this initial application could result in reduced profit due to yield, milling, and grade reductions.

Influence of Halosulfuron Rate and Timing on Weed Control in Rice

McCallister, E.K., Norsworthy, J.K., Devore, J.D., Wilson, M.J., Bangarwa, S.K., Johnson, D.B., and Still, J.A.

Halosulfuron is labeled in rice for broadleaf and sedge weed control under the trade name Permit. A field experiment was conducted in the summer of 2009 at the Rice Research Center near Stuttgart, AR, to study the influence of halosulfuron rate and timing on weed control.

'Wells' rice was drill-seeded at 24 seed/ft in plots 6 ft by 20 ft with four replications. Halosulfuron was applied at rates of 0.035 and 0.069 kg ai/ha. Applications were made preemergence (PRE) and postemergence (POST) at 2 and 4 weeks after crop emergence (WAE). A non-treated control was included. Visual rice injury ratings were taken 2 and 3 weeks after treatment which resulted in no injury. Rice grain was harvested at maturity and corrected to 13% moisture. Visual weed control ratings were taken 2, 3, 5, and 8 weeks after the PRE application timing. Weeds evaluated for control included: barnyardgrass (*Echinochloa crus-galli*), broadleaf signalgrass (*Urochloa platyphylla*), large crabgrass (*Digitaria sanguinalis*), pitted morningglory (*Ipomoea lacunosa*), hemp sesbania (*Sesbania herbacea*), and yellow nutsedge (*Cyperus esculentus*).

Herbicide applications across all timings had minimal activity on grasses, with the highest control resulting from PRE applications. POST-applied halosulfuron provided no control of barnyardgrass, broadleaf signalgrass, or large crabgrass. Pitted morningglory control was no more than 65% following PRE-applied halosulfuron and POST-applied halosulfuron supplied less than 15% control. PRE-applied halosulfuron controlled yellow nutsedge 100% at 2 weeks after treatment (WAT). Regardless of application timing and rate, halosulfuron controlled hemp sesbania >90% at 2 WAT.

Rice Tolerance to Saflufenacil in a Clomazone Weed Control Program

Camargo, E.R., Senseman, S.A., McCauley, G., and Guice, J.B.

Saflufenacil is a new herbicide being globally developed by BASF for residual preemergence (PRE) broadleaf weed control in corn and other crops. Experimental formulations of saflufenacil were tested in rice to control dicotyledon weeds and to assess crop tolerance. However, use of saflufenacil needs to be further investigated before this herbicide can be effectively used in rice. Clomazone is a widely used herbicide because of low cost and effective annual grass control, although broadleaf control from clomazone in rice is limited. Therefore, saflufenacil might have a niche by providing broadleaf control when used in combination with clomazone in a comprehensive weed control program. The objective of this study was to evaluate rice tolerance to saflufenacil applied PRE and postemergence (POST) on a sandy soil.

Two separate experiments to evaluate 1) PRE and 2) POST treatments of saflufenacil were conducted during 2009 at the Texas A&M AgriLife Research and Extension Center located at Eagle Lake. Soil was a Nada fine sandy loam with 61.4% of sand, 31.2% of silt, 7.4% of clay, 0.7% of organic carbon, and pH of 6.1. The experimental design was a randomized complete block with a factorial arrangement. The treatments included combinations of three rates of clomazone (0, 392, and 505 g ai/ha) and five rates of saflufenacil. In the experiment with PRE applications of saflufenacil, rates were 0, 25, 50, 100, and 200 g ai/ha. Rates for POST applications of saflufenacil were 0, 12.5, 18.75, 25, and 50 g/ha. Treatments were replicated four times. Experiments were seeded on April 15 using cultivar 'Cocodrie'. Crop management practices were followed according to the 2008 Texas Rice Production Guidelines. Rice injury was estimated visually using a scale of 0 to 100% where 0= no rice injury and 100= rice death. Rice grain was harvested with a mechanical plot harvester when grain moisture was approximately 20%. Final grain yield was adjusted to 12% moisture. Visual injury was subjected to arcsine transformation prior to analysis to normalize the data. Analysis of variance was performed to test all possible interactions. Means for significant effects were separated using Tukey's test at α=0.05.

Injury from PRE applications of saflufenacil was not observed in assessments collected from 10 to 38 days after emergence. Interaction between rates of saflufenacil and clomazone were observed when saflufenacil was applied POST. Higher rice injury (68%) was observed with combinations of the highest rate of clomazone (505 g/ha) and saflufenacil (50 g/ha) in evaluations conducted 3 days after POST application (DAA). However, in assessments performed 18 DAA, rice injury was lower than 15% in all treatments. Rice yield was not affected for saflufenacil PRE and POST applications. Although injury as high as 68% occurred early in the season from POST applications of saflufenacil, yield was not adversely affected. It is important to emphasize that environmental conditions were favorable for crop recovery during the rice season.

Hybrid Rice Tolerance to Imazethapyr

Turner, A., Senseman, S., McCauley, G., Camargo, E., McKnight, B., and Samford, J.

Clearfield rice has helped farmers battle red rice (*Oryza sativa*) problems for a several years. Recently, breeders introduced hybrid Clearfield lines with hopes to maintain the desired herbicide resistant traits while having the added benefits of a hybrid. Soon after the hybrid line released, farmers started noticing herbicide injury to these new varieties while following the label recommendations. Texas AgriLife Research was able to plant the hybrids in Beaumont and Eagle Lake, TX, at two different time periods, an early March planting and a later April planting at each location. The purpose of the studies was to evaluate the percent injury caused at different herbicide application rates compared to planting date and seeding rate. Each study had an early postemergence and a late postemergence application in increasing rates. We chose four different rates for the early application, 35, 71, 105, and 142 g ai/ha, and three rates for the late application, 71, 105, and 142 g/ha; while we planted at 25, 35, and 45 pounds of seed per acre. The plots were evaluated for percent injury three different times after the second application.

We found that the hybrid plants had injury symptoms early in the trial after the second application in the plots with increased herbicide rates, but the injury recorded was not significant. Once fertilizer was applied and a flood was established, the plants were able to recover fully. The data did not show a higher percent injury in respect to different planting rates. There were no significant differences in the yields of the plots.

Herbicide-Resistant *Echinochloa phyllopogon* Biotypes are Smaller but More Competitive than Susceptible Biotypes

Boddy, L.G., Streibig, J.C., and Fischer, A.J.

Echinochloa phyllopogon (Late Watergrass) is one of the most economically important weeds in California rice production, and the number of populations that evince non target-site resistance to most available grass herbicides continues to grow. This severely limits control options and warrants a deeper investigation into the ecological and physiological effects of resistance in this weed.

To explore the possibility of fitness costs for resistance, a full-season outdoor competition experiment was conducted between rice and four *E. phyllopogon* biotypes, two of which are resistant to thiobencarb and two susceptible. Hyperbolic regressions were fixed to the data and derived the ED-50 parameter to compare the effects of *E. phyllopogon* biotype competition on rice biomass and yield. Across all planting densities, resistant biotypes were smaller in both stature and above ground biomass than susceptible biotypes and also tended to be less fecund. However, this apparent disadvantage for light capture did not translate into significant differences in competitiveness against rice, as rice biomass reductions were similar for resistant and susceptible biotypes at any given *E. phyllopogon* planting density. Further, when the effects of competition were gauged against weed biomass, resistant biotypes produced greater biomass reductions in rice for any given *E. phyllopogon* biomass. This indicates that resistant biotypes have a greater reliance on other mechanisms of interference with rice besides competition for light.

Are Non-Target-Site Herbicide Resistance and Environmental Stress Tolerance Related?

Fischer, A.J., Pavlovic, D., Yasuor, H., Merotto, A., Vrbnicanin, S., and Bozic, D.

Echinochloa phyllopogon represents one of the worst herbicide resistance cases among major crop weeds and poses a serious threat to rice production in California. There are possible commonalities between this situation and the recently documented low-level resistance to atrazine in *Chenopodium album* L. in Serbia. We examine: a) non target-site (NTS) mechanisms of herbicide resistance in *E. phyllopogon* from CA rice fields, b) resistance to ROS (reactive oxygen species)-related herbicides in *E. phyllopogon* and *C. album*, and c) a hypothesis regarding stress tolerance and NTS resistance with new implications for herbicide resistance management.

Experimental procedures involved plant growth analysis, C-herbicide uptake, whole-plant dose-response, target-site enzyme (ALS, ACCase) activity, herbicide metabolism using cytochrome-P450 (P450) inhibitors, P450 contents and activity assays, metabolic profiles and metabolomics. AFLP markers were used to study the spread of resistant *E. phyllopogon* in CA, while resistance to photooxidant-generating herbicides was assessed through leaf pigment and chlorophyll fluorescence (Fv/Fm) measurements. Resistance in *E. phyllopogon* occurs simultaneously for several thiocarbamate, ACCase and ALS inhibitors. These R biotypes exhibit enhanced submergence tolerance, low-level clomazone resistance, and low paraquat sensitivity, while moisture stress tolerance and low atrazine sensitivity were documented in a *C. album* biotype surviving in Serbian atrazine-treated corn fields. Submergence and moisture stresses can cause photooxidation damage to plants. These multifactorial NTS herbicide resistances result from enhanced detoxification and possibly other mechanisms. Chloroplast photoprotective systems and stress-inducible detoxifying enzymes can confer cross-protection to both environmental and xenobiotic photooxidative stresses. If such complex NTS resistances result from a general up-regulation of stress tolerance responses in biotypes previously adapted to various environmental stresses, weed management in stressful environments should focus on strategies that delay NTS resistance evolution. Conversely, selection for certain NTS resistance mechanisms could result in plants with increased stress tolerance and fitness levels.

Predicting Germination of *Echinochloa phyllopogon* Biotypes across Environmental Gradients Using Population-Based Threshold Models

Boddy, L.G., Bradford, K.J., and Fischer, A.J.

Echinochloa phyllopogon (Late Watergrass) has evolved resistance to almost all available grass herbicides in California. Postemergence chemical control options have thus become increasingly limited and there is a pressing need to identify and refine alternative control methods. One such method is the stale seedbed approach, which entails recruiting weeds prior to planting and treating them with broad-spectrum herbicides to which they have not developed, nor are likely to develop, resistance. Accurate predictions of weed seed germination can help optimize field level implementation of the stale seedbed technique by fine-tuning the timing of water application, water removal and herbicide application.

Dry-stored and stratified seeds of two herbicide-resistant and two -susceptible biotypes of *E. phyllopogon* were subjected to eight temperature, four moisture and six oxygen levels in a controlled laboratory setting. Interactive effects of moisture and oxygen levels were also examined. Germination was counted daily and simple population-based threshold models were used to derive germination rates, thresholds and patterns in terms of accrued heat, moisture and oxygen. Stratification reduced minimum oxygen requirements and hydrothermal time to germination, and allowed for germination under drier conditions. Among dry-stored seed, resistant biotypes tended to germinate under lower temperatures, in drier conditions and at lower oxygen levels than susceptible biotypes, but stratification reduced these differences.

Use of the Fungus *Colletotrichum gloeosporoides* to Control Northern Jointvetch

Roberts, M., Cartwright, A., Kelly, B., and Kowalski, M.J.

The fungus *Colletotrichum gleosporoides* f. sp. aeschynomene (Lockdown™) has been used on a commercial basis to control northern jointvetch (*Aeschynomene virginica*) in rice for over 20 years. Benefits with using this biological include its efficacy, safety to humans, crops, wildlife, and the environment, absence of drift issues, and zero day pre-harvest interval. Natural Industries, Inc. purchased the licensing right for this organism last year and successfully brought a commercial product to market this year. Production, quality control, and application methods have been optimized. It is important to determine the compatibility of biologicals with various pesticides commonly used in field applications to not only enhance the effectiveness or target range of the applications but also as a cost and time saving solution for growers and applicators.

This study was conducted to determine the compatibility of *C. gleosporoides* spores with three herbicides, acifluorfen (Ultra Blazer), penoxsulam (Grasp), and imazethapyr plus quinclorac (Clearpath). *C. gloeosporiodes* spores, 3.65 x 10^6 spores/ml were mixed into 100 ml of acifluorfen, penoxsulam, and imazethapyr plus quinclorac solutions at concentrations simulating the recommended herbicide application rates, 140 g ai/ha, 35 g ai/ha, and 420 g ai/ha, respectively. One ml of the spore/herbicide mixture was removed at time zero, 15 minutes, 30 minutes, one hour, and three hour time intervals. The mixture was serially diluted, plated on 10% potato dextrose agar, incubated overnight (28^{o}C), and scored for percent spore germination vs. the rehydration solution (30% sucrose) control.

A similar method was employed to determine the efficacy of these simulated tank mixtures *in vivo*. Northern jointvetch seeds were surface disinfested, rinsed in sterile water, dried, and planted in general potting medium. Seeds were incubated at 29/25^{o}C, 14/10 day/night cycle and transplanted, one seedling/pot, at one true leaf stage. Seedlings were reincubated and herbicide, *C. gloeosporiodes*, or combinations applied to run-off at the one- to two-true leaf stage. *C. gloeosporoides* spores were mixed with herbicides for 1 hr before application at concentrations previously described. Disease ratings were determined at day 3 and 7 according to the scale: 0=no effect or disease, 1=minimal effect but disease present, 2=cotyledons heavily infected and/or dying, 3=cotyledons and true leaves heavily affected and/or dying, 4=all leaves affected, stem heavily affected, 5=entire plant heavily affected, dead or dying.

No *C. gloeosporoides* spore germination differences were observed over a 3 hour time period in any of the herbicide/spore combinations and the rehydration control, ANOVA means separation, $p = 0.05$. Disease severity on northern jointvetch increased dramatically with the penoxsulam/ *C. gleosporoides* and acifluorfen/*C. gleosporoides* combination in comparison to the herbicide treatments alone (91.9 and 29.8% increase, respectively) at the three day observation period. The *C. gleosporoides* treatment alone elicited a disease rating of 2 at the 3 day observation period which increased to a 4 by day 7. No distinctive disease differences were observed with the imazethapyr plus quinclorac/ *C. gleosporoides* treatment combination relative to imazethapyr plus quinclorac alone. All plants in all treatments were highly infected by day 7, 4 to 5 disease rating, except for the water control, which remained healthy.

Results of this research indicate that *C. gleosporoides* can be tank-mixed with imazethapyr plus quinclorac, penoxsulam, or acifluorfen, as percent spore germination remained on par with the rehydration control germination levels. Furthermore, the results are highly suggestive that the *C. gleosporoides*/penoxsulam and *C. gleosporoides* /acifluorfen tank mixes may act in a synergistic manner. The combination treatments elicited a dramatic increase in disease severity at the early observation period in comparison to the herbicide or *C. gleosporoides* treatments alone.

C. gleosporoides has been shown to be highly effective in controlling northern jointvetch, not only in this study, but in approximately 30 years of research. Field studies have shown up to 97 % control in rice trials conducted over a 13-year period, averaging 91% control overall.

Index of Abstract Authors

INSTRUCTIONS FOR PREPARATION OF ABSTRACTS FOR THE 2012 MEETING

Beginning with the Proceedings for the 24th Rice Technical Working Group meetings, Desktop Publishing software was chosen as a means for expediting the post-meeting publication process. To accomplish this move, Microsoft Word (Windows) has been identified as the preferred word processing software to be used. If individuals do not have access to MS Word, submission of materials in ASCII format (DOS compatibility is essential) is acceptable. **Each electronic file should include: 1) title of materials, 2) corresponding RTWG panel, 3) corresponding author's name, daytime telephone number, e-mail address, and 4) computer format** (i.e., MS Word and version number). These criteria apply uniformly to 1) presented paper abstracts, 2) poster abstracts, 3) symposia abstracts, 4) panel recommendations, and 5) list of panel participants. More details with respect to each of these items follow below.

As soon as a web page is established by the host state, a link will be provided to the Rice Research Station web page where current submission instructions will be maintained.

Presented Paper, Poster, and Symposia Abstracts

To be published in the printed proceedings, presented paper, poster, and symposia abstracts for the 34rd RTWG meeting must be prepared as follows. Please follow these instructions -- doing so will expedite the publishing of the proceedings.

1. Both a paper copy and an electronic file are required. Hard copy and electronic file are to be submitted to the respective panel chairs 2 ½ months prior to the 34th RTWG meeting in 2012, or earlier as stated in the Call for Papers issued by the 34th RTWG meeting chair and/or panel chairs.

   The respective panel chairs for the 2012 RTWG meeting and their email and mailing addresses are presented following this section. In case of other questions or in the absence of being able to access the Call for Papers, contact:

   Dr. Michael Salassi
   Agricultural Economics and Agribusiness
   LSU AgCenter
   101 Ag. Administration Building
   Baton Rouge, LA 70803
   Phone: 225/578-2713
   Fax: 225/578-2716
   Email: msalassi@agcenter.lsu.edu

2. Margins: Set 1-inch for side margins; 1-inch top margin; and 1-inch bottom margin. Use a ragged right margin (do not full justify) and do not use hard carriage returns except at the end of paragraphs.

3. Type: Do not use any word processing format codes to indicate boldface, etc. **Use 10 point Times New Roman font**.

4. Heading:
   a. Title: Center and type in caps and lower case.
   b. Authors: Center name(s) and type in caps and lower case with last name first, then first and middle initials, with no space between the initials (e.g., Groth, D.E.).
   c. Affiliation and location: DO NOT GIVE AFFILIATION OR LOCATION. Attendance list will provide each author's affiliation and address.

5. Body: Single space, using a ragged right margin. Do not indent paragraphs. Leave a single blank line between paragraphs.

6. Content is limited to one page.
    a. Include a statement of rationale for the study.
    b. Briefly outline methods used.
    c. Summarize results.

7. **Tables and figures are not allowed**.

8. **Literature citations are not allowed**.

9. **Use the metric system of units**. English units may be shown in parentheses.

10. **When scientific names are used, *italicize* them -- do not underline.**

Special Instructions to Panel Chairs

Each panel chair is responsible for collecting all of his/her panel abstracts prior to the 34th RTWG meeting. The appropriate due date will be identified in the Call for Papers for the 34th RTWG meeting. **Each panel chair is responsible for assembling his/her panel abstracts into one common MS Word file that is consistent with the above guidelines, with the abstracts appearing in the order presented. Paper abstracts will be presented first and poster abstracts second. A Table of Contents should be included with each panel section. Panel chairs are responsible for editing all abstracts for their panel.** A common file should be developed prior to the beginning of the 34th RTWG meeting and submitted to Michael E. Salassi, RTWG Publication Coordinator, to accommodate preliminary preparation of the proceedings prior to the meeting. These materials will be merged in the final proceedings in the format submitted. Final editing will be done by the Publication Coordinator, Rice Research Station secretarial staff, and the incoming Chair.

In addition, panel chairs are to prepare and submit both a paper copy and MS Word computer file version of the (1) final Panel Recommendations and (2) a list of panel participants by the conclusion of the meeting. A copy of the previous recommendations and panel participants will be provided to each panel chair prior to the meetings.

ADDRESSES FOR 2012 PANEL CHAIRS

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GUIDELINES FOR RTWG AWARDS

1.0 The RTWG Chair shall solicit nominations, and when appropriate, award on a biennial basis the following types of awards, namely:

1.1 The Distinguished Rice Research and/or Education Award

1.1a Individual category – An award may be made to one individual at each RTWG meeting in recognition of recent achievement and distinction in one or more of the following: (1) significant and original basic and/or applied research, (2) creative reasoning and skill in obtaining significant advances in education programs, public relations, or administrative skills - which advance the science, motivate progress and promise technical advances in the rice industry.

1.1b. Team category – Same as the individual category, except that one team may be recognized at each RTWG meeting. All members of the team will be listed on each certificate.

1.2 The Distinguished Service Award - Awards to be made to designated individuals who have given distinguished long-term service to the rice industry in areas of research, education, international agriculture, administration, and industrial rice technology. Although the award is intended to recognize contributions of a long duration, usually upon retirement from active service, significant contributions over a period of several years shall be considered as a basis of recognition.

2.0 The Awards Committee shall consist of the Executive Committee.

3.0 The duties of the Awards Committee are as follows:

3.1 To solicit nominations for the awards in advance of the biennial meeting of the RTWG. Awards Committee Members cannot nominate or write letters of support for an individual or team for the RTWG awards.

3.2 To review all nominations and select worthy recipients for the appropriate awards. Selection on awardees will be determined by a simple majority vote. The Awards Committee Chair (same as the Executive Committee Chair) can only vote in case of a tie. The names of recipients shall be kept confidential, but recipients shall be invited to be present to receive the award.

3.3 The Awards Committee shall arrange for a suitable presentation at the Biennial RTWG Meeting.

3.4 The Awards Committee shall select appropriate certificates for presentation to the recipients of the Awards.

4.0 Those making nominations for the awards shall be responsible for supplying evidence to support the nomination, including three (3) recommendation letters. Fifteen (15) complete copies of each nomination must be submitted. A one-page summary of accomplishments should also be included with each nomination. This summary will be published in the RTWG Proceedings for each award participant.

4.1 Nominees for awards should be staff personnel of Universities or State Agricultural Experiment Stations, State Cooperative Extension personnel, cooperating agencies of the United States Department of Agriculture, or participating rice industry groups.

4.2 A member of an organization, described in 4.1, may nominate or co-nominate two persons.

4.3 Nominations are to be sent to the Awards Committee for appropriate committee consideration.

4.4 The deadline for receipt of nominations shall be three months preceding the biennial meeting.

4.5 Awards need not be made if in the opinion of the Awards Committee no outstanding candidates have been nominated.

Past RTWG Award Recipients

Year Location	Distinguished Service Award Recipients		Distinguished Rice Research and/or Education Award Recipients
1972	D.F. Houston	L.B. Ellis	None
Davis, CA	R.D. Lewis	H.M. Beachell	
	N.E. Jodon	C.R. Adair	
	E.M. Cralley	W.C. Dachtler	
1974	J.G. Atkins	R.A. Bieber	None
Fayetteville, AR	N.S. Evatt	J.T. Hogan	
	M.D. Miller	B.F. Oliver	
	T. Wassermand		
1976	D.H. Bowman	T.H. Johnston	None
Lake Charles, LA	R.F. Chandler	M.C. Kik	
	J.N. Efferson	X. McNeal	
	J.P. Gaines		
1978	J.W. Sorenson, Jr.	D.T. Mullins	R.K. Webster
College Station, TX	R. Stelly		
1980	M.L. Peterson	W.R. Morrison	B.D. Webb
Davis, CA	L.E. Crane	F.T. Wratten	

Continued.

Past RTWG Award Recipients (continued)

Year Location	Distinguished Service Award Recipients		Distinguished Rice Research and/or Education Award Recipients	
			Arkansas 'Get the Red Out' Team	
1982 Hot Springs, AR	C.C. Bowling J.P. Craigmiles	L. Drew	R.J. Smith, Jr. F.L. Baldwin	B.A. Huey
1984 Lafayette, LA	M.D. Morse L.C. Hill	E.A. Sonnier D.L. Calderwood	California Rice Varietal Improvement Team	
			H.L. Carnahan	J.N. Rutger
			C.W. Johnson	S.T. Tseng
			J.E. Hill	J.F. Williams
			C.M. Wick	S.C. Scardaci
			D. M. Brandon	
1986 Houston, TX	D.S. Mikkelsen	J.B. Baker	Texas Rice Breeding and Production Team	
			C.N. Bollich	B.D. Webb
			M.A. Marchetti	G.N. McCauley
			J.E. Scott	J.W. Stansel
			F.T. Turner	A.D. Klosterboer
			E.F. Eastin	M.O. Way
			N.G. Whitney	M.E. Rister

Continued.

Past RTWG Award Recipients (continued)

Year Location	Distinguished Service Award Recipients		Distinguished Rice Research and/or Education Award Recipients	
1988	M.D. Androus	H.L. Carnahan	Arkansas DD-50 Team	
Davis, CA	S.H. Holder	B.A. Huey	N.R. Boston	G.L. Davis
	M.D. Faulkner	W.R. Grant	F.N. Lee	N.P. Tugwell
	C.H. Hu	F.J. Williams	D.A. Downey	G.L. Greaser
			T.H. Johnson	G. Rench
			B.R. Wells	M.S. Flynn
			B.A. Huey	T.C. Keisling
			R.J. Smith	F.J. Williams
			D. Johnson	
1990	H.R. Caffey	B.R. Jackson	None	
Biloxi, MS	O.R. Kunze			
1992	C.N. Bollich	A.A. Grigarick	J.W. Stansel	
Little Rock, AR	B.D. Webb	C.M. Wick		
1994	S.H. Crawford	K. Grubenman	M.C. Rush	
New Orleans, LA	J.V. Halick	R.N. Sharp		
	R.J. Smith			

Continued.

Past RTWG Award Recipients (continued)

Year Location	Distinguished Service Award Recipients		Distinguished Rice Research and/or Education Award Recipients	
1996 San Antonio, TX	P. Seilhan	K. Tipton	D.M. Brandon	
1998 Reno, NV	G. Templeton S.-T. Tseng	B. Wells	S.D. Linscombe	
			Advances in Rice Nutrition Team	
2000 Biloxi, MS	D.M. Brandon J.W. Stansel	R.K. Webster	P.K. Bollich R.J. Norman	C.E. Wilson
			Bacterial Panicle Blight Discovery Team	
2002 Little Rock, AR	F.L. Baldwin R.H. Dilday	M.A. Marchetti J.F. Robinson	M.C. Rush	D.E. Groth A.K.M. Shahjahan
			Individual	
			K.A.K. Moldenhauer	
			Discovery Characterization and utilization of Novel Blast Resistance Genes Team	
2004 New Orleans, LA	P.K. Bollich A.D. Klosterboer F.N. Lee W.H. Brown	J.A. Musick J.E. Street J.F. Williams S.L. Wright	F.N. Lee A.K. Moldenhauer	M.A. Marchetti
			Individual	
			R.D. Cartwright	

Continued.

Past RTWG Award Recipients
(continued)

Year Location	Distinguished Service Award Recipients		Distinguished Rice Research and/or Education Award Recipients	
			LSU Rice Variety Development Team	
			S. Linscombe	X. Sha
2006	T.P. Croughan	J.N. Rutger	P. Bollich	R. Dunand
The Woodlands, TX	R. Talbert	F. Turner	L. White	D. Groth
			Individual	
			R. Norman	
2010	T. Miller	J. Thompson	Individual	
Biloxi, MS	J. Kendall		E. Webster	

RICE TECHNICAL WORKING GROUP HISTORY

Meeting	Year	Location	Chair	Secretary	Publication Coordinator(s)
1st	1950	New Orleans, Louisiana	A.M. Altschul		
2nd	1951	Stuttgart, Arkansas	A.M. Altschul		
3rd	1951	Crowley, Louisiana	A.M. Altschul		
4th	1953	Beaumont, Texas	W.C. Davis		
5th	No meeting was held.				
6th	1954	New Orleans, Louisiana	W.V. Hukill		
7th*	1956	Albany, California	H.T. Barr	W.C. Dachtler	--
8th	1958	Stuttgart, Arkansas	W.C. Dachtler	--	--
9th	1960	Lafayette, Louisiana	D.C. Finfrock	H.M. Beachell	--
10th	1962	Houston, Texas	H.M. Beachell	F.J. Williams	--
10th	1964	Davis, California	F.J. Williams	J.T. Hogan	--
11th	1966	Little Rock, Arkansas	J.T. Hogan	D.S. Mikkelsen	--
12th	1968	New Orleans, Louisiana	M.D. Miller	T.H. Johnston	--
13th	1970	Beaumont, Texas	T.H. Johnston	C.C. Bowling	--
14th	1972	Davis, California	C.C. Bowling	M.D. Miller	J.W. Sorenson*
15th	1974	Fayetteville, Arkansas	M.D. Miller	T. Mullins	J.W. Sorenson
16th	1976	Lake Charles, Louisiana	T. Mullins	M.D. Faulkner	J.W. Sorenson
17th	1978	College Station, Texas	M.D. Faulkner	C.N. Bollich	O.R. Kunze
18th	1980	Davis, California	C.N. Bollich	J.N. Rutger	O.R. Kunze
19th	1982	Hot Springs, Arkansas	J.N. Rutger	B.R. Wells	O.R. Kunze
20th	1984	Lafayette, Louisiana	B.R. Wells	D.M. Brandon	O.R. Kunze
21st	1986	Houston, Texas	D.M. Brandon	B.D. Webb	O.R. Kunze
22nd	1988	Davis, California	B.D. Webb	A.A. Grigarick	O.R. Kunze
23rd	1990	Biloxi, Mississippi	A.A. Grigarick	J.E. Street	O.R. Kunze
24th	1992	Little Rock, Arkansas	J.E. Street	J.F. Robinson	M.E. Rister
25th	1994	New Orleans, Louisiana	J.F. Robinson	P.K. Bollich	M.E. Rister
26th	1996	San Antonio, Texas	P.K. Bollich	M.O. Way	M.E. Rister M.L. Waller

Continued.

RICE TECHNICAL WORKING GROUP HISTORY
(Continued)

Meeting	Year	Location	Chair	Secretary	Publication Coordinator(s)
27th	1998	Reno, Nevada	M.O. Way	J.E. Hill	M.E. Rister M.L. Waller
28th	2000	Biloxi, Mississippi	J.E. Hill	M.E. Kurtz	P.K. Bollich D.E. Groth
29th	2002	Little Rock, Arkansas	M.E. Kurtz	R.J. Norman	P.K. Bollich D.E. Groth
30th	2004	New Orleans, Louisiana	R.J. Norman	D.E. Groth	P.K. Bollich D.E. Groth
31st	2006	The Woodlands, Texas	D.E. Groth	G. McCauley	D.E. Groth M.E. Salassi
32nd	2008	San Diego, California	G. McCauley	C. Mutters	D.E. Groth M.E. Salassi
33rd	2010	Biloxi, Mississippi	C. Mutters	T.W. Walker	M.E. Salassi

*1972 was the first year that an official Publication Coordinator position existed within the RTWG. Prior to that, the Secretary assembled and coordinated the publication of the meeting proceedings.

Rice Technical Working Group

Manual of Operating Procedures

2010

RICE TECHNICAL WORKING GROUP

MANUAL OF OPERATING PROCEDURES

2010

Page

I. Purpose and Organization

The Rice Technical Working Group (RTWG) functions according to an informal memorandum of agreement among the State Agricultural Experiment Stations and the Agricultural Extension Services of Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas, and the Agricultural Research Service (ARS), the Economic Research Service (ERS), the National Institute of Food and Agriculture (NIFA), and other agencies of the United States Department of Agriculture (USDA). Membership is composed of personnel in these and other cooperating public agencies and participating industry groups who are actively engaged in rice research and extension. Since 1960, research scientists and administrators from the U.S. rice industry and from international agencies have participated in the biennial meetings.

The RTWG meets at least biennially to provide for continuous exchange of information, cooperative planning, and periodic review of all phases of rice research and extension being carried on by the States, Federal Government, and other members. The current disciplines or Panels represented are: i) Breeding, Genetics, and Cytogenetics; ii) Economics and Marketing; iii) Plant Protection; iv) Postharvest Quality, Utilization & Nutrition; v) Rice Culture; and vi) Rice Weed Control and Growth Regulation. Each Panel has a Chair who, along with the Secretary/Program Chair, solicits and receives titles, interpretive summaries, and abstracts of papers to be presented at the biennial meeting. The papers are presented orally in concurrent technical sessions or via poster. Each Panel over the course of the meeting develops proposals for future work, which are suggested to the participating members for implementation.

Pursuant to the memorandum of agreement, the Association of Agricultural Experiment Station Directors appoints an administrative advisor who represents them on the Executive Committee and in other matters. The administrator of the USDA-ARS designates a representative to serve in a similar capacity. The Directors of Extension Service of the rice growing states designate an Extension Service Administrative Advisor.

Other members of the Executive Committee are elected biennially by the membership of the RTWG; they include the Chair who has served the previous term as Secretary/Program Chair, a Geographical Representative from each of the seven major rice-growing states (Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas), the Immediate Past Chair, and an Industry Representative. The rice industry participants elect an Executive Committee member from one of following areas: i) chemical, ii) seed, iii) milling, iv) brewing industries, v) producers, or vi) consultants. The Publication Coordinator also is on the Executive Committee. The Coordinator of the RTWG website is an ex-officio member of the Executive Committee.

Standing committees include: i) Nominations, ii) Rice Crop Germplasm, iii) Rice Variety Acreage, iv) Awards, and v) Location and Time.

II. Revised Memorandum of Agreement

The previous Memorandum of Agreement is published in the 32nd RTWG Proceedings in 2008. The following is a revised Memorandum of Agreement accepted by the 33rd RTWG membership in 2010.

REVISED MEMORANDUM OF AGREEMENT

FEBRUARY 2010

INFORMAL UNDERSTANDING

among

THE STATE AGRICULTURAL EXPERIMENT STATIONS

and

THE STATE AGRICULTURAL EXTENSION SERVICES

of

ARKANSAS, CALIFORNIA, FLORIDA, LOUISIANA, MISSISSIPPI, MISSOURI, AND TEXAS

and

THE AGRICULTURAL RESEARCH SERVICE,
THE ECONOMIC RESEARCH SERVICE,
THE NATIONAL INSTITUTE OF FOOD AND AGRICULTURE

and

OTHER PARTICIPATING AGENCIES

of the

UNITED STATES DEPARTMENT OF AGRICULTURE

and

COOPERATING RICE INDUSTRY AGENCIES

Subject: Research and extension pertaining to the production, utilization, and marketing of rice and authorization of a Rice Technical Working Group.

It is the purpose of this memorandum of agreement to provide a continuing means for the exchange of information, cooperative planning, and periodic review of all phases of rice research and extension being carried on by State Agricultural Experiment Stations, State Agricultural Extension Services, the United States Department of Agriculture, and participating rice industry groups. It is believed this purpose can best be achieved through a conference held at least biennially at the worker level of those currently engaged in rice research and extension. Details of the cooperation in the seven states are provided in formal Memoranda of Understanding and/or appropriate Supplements executed for the respective state.

The agencies represented in this memorandum mutually agree that overall suggestions of cooperative review and planning of rice research and extension in the several rice producing states and the United States Department of Agriculture shall be developed by a Rice Technical Working Group (henceforth designated RTWG), composed of all personnel actively engaged in rice investigations and extension in each of the agencies, as well as participating rice industry groups.

It is further agreed that there shall be a minimum of three Administrative Advisors to the RTWG to represent the major agencies involved, including:

1) A director of an Agricultural Experiment Station from a major rice-growing state elected by the Station Directors of the rice-growing states,

2) A director of a State Cooperative Extension Service from a major rice-growing state elected by the Extension Directors of the rice-growing states, and

3) A USDA Administrative Advisor from ARS named by the Administrator of Agricultural Research Service.

The RTWG shall convene at least biennially to review results and to develop proposals and suggested plans for future work. It is understood that the actual activities in research and extension will be determined by the respective administrative authorities and subject to legal and fund authorizations of the respective agencies.

Interim affairs of the RTWG, including preparation and distribution of the reports of meetings, plans, and agenda for future meetings, functional assignments of committees, and notification of State, Federal and industry workers will be transacted by the officers (chair and secretary), subject to consultation with the remainder of the Executive Committee.

The Executive Committee shall consist of 15 members:

Officers (2):

Chair -- presides at meetings of the RTWG and of the Executive Committee and otherwise provides leadership.

Secretary/Program Chair -- (normally moves up to Chair).

Geographic Representatives (7):

One active rice worker in state or federal agencies from each of the major rice states -- Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas.

These Geographic Representatives will be responsible for keeping all governmental rice workers and administrators in their respective geographic areas informed of the activities of the RTWG.

Immediate Past Chair -- provides guidance to incoming chair to facilitate a smooth transition between biennial meetings.

Administrative Advisor (one from each category) (3):

State Agricultural Experiment Station
State Agricultural Extension Service
USDA - Agricultural Research Service

Publication Coordinator -- serves to handle matters related to the publication of the RTWG Proceedings.

Industry Representative -- to be elected by industry personnel participating in the biennial meeting of the RTWG; represents all aspects of the U.S. rice industry and serves as liaison with other rice industry personnel; and is responsible for keeping all interested rice industry personnel informed of the activities of the RTWG.

The Officers, Geographic Representatives, and the Publication Coordinator of the Executive Committee shall be elected on the first day of each biennial meeting to serve through the close of the next regular biennial meeting.

A Panel Chair or Panel Chair and Co-Chair, at least one of whom will be an active rice worker in state or federal agencies, shall be elected by each of the active subject matter panels. Such election shall take place by the end of each biennial meeting and Panel Chairs will serve as members of the Program Committee for the next biennial meeting. Each Panel Chair will be responsible for developing the panel program in close cooperation with the Secretary-Program Chair and for seeing that the Panel Recommendations are updated at each biennial meeting and approved by the participants in the respective panel sessions.

Participation in the panel discussions, including presentation of rice research findings by rice industry representatives and by representatives from National or International Institutes, is encouraged.

At the end of each biennial meeting, after all financial obligations are met, remaining funds collected to support the programs or activities of the RTWG meeting will be transferred by the Secretary/Program Chair to the RTWG Contingency Fund, entitled 'Rice Tech Working Group Contingency Fund,' established at the University of Arkansas in the Agriculture Development Council Foundation. In instances where USDA or industry personnel are elected to serve as RTWG Secretary, either the Local Arrangements Chair or the Geographical Representative in the state where the next meeting is to be held will be designated by the RTWG Secretary to receive and deposit funds in station or foundation accounts.

This type of memorandum among the interested state and federal agencies provides for voluntary cooperation of the seven interested states and agencies.

III. Description of Committees, Positions, Duties, and Operating Procedures

A. Executive Committee

The Executive Committee conducts the business of the RTWG, appoints standing committees, organizes and conducts the biennial meetings and presents the awards. Interim affairs of the RTWG, including preparation and distribution of the reports of meetings, plans, and agenda for future meetings, functional assignments of committees, and notification of State, Federal and industry workers will be transacted by the officers (Chair and Secretary), subject to consultation with the remainder of the Executive Committee. A quorum (i.e., eight members are present, excluding the Chair) of the Executive Committee must be present for the Executive Committee to do business. A simple majority vote is needed to pass any motion and the Chair only votes in the case of a tie. The Executive Committee is composed of the following fifteen members: i) three officers—Chair, Secretary/Program Chair, and Immediate Past Chair; ii) seven Geographical Representatives from each major rice producing state; iii) three administrative advisors from the major agencies of Agriculture Experiment Stations, State Agricultural Extension Services, and the USDA; iv) a Publication Coordinator; and v) a Rice Industry Representative. The Officers, Geographical Representatives, and the Publication Coordinator shall be elected to the Executive Committee at the Opening Business meeting of each biennial meeting to serve through the close of the next regular biennial meeting. Industry personnel participating in the biennial meeting elect the Industry Representative.

1. **Chair**
   The Chair provides leadership to the RTWG by organizing the agenda and presiding over the Business and Executive Committee meetings, presiding over the Awards process, appointing temporary or ad hoc committees to explore and address RTWG interests, and being the official spokesperson for the RTWG during his/her period of office. If the nomination process for selecting geographical representatives and members of the Nominations committee fails to produce a candidate, then it the responsibility of the Chair to work with the state delegation in selecting a candidate from that state. The Secretary/Program Chair is usually nominated by the Nomination Committee to be Chair at the next biennial meeting. If the Chair nominated cannot serve or complete the full term of office, it is the responsibility of the Executive Committee to appoint a new Chair.

2. **Secretary/Program Chair**
   The Secretary/Program Chair serves a two-year term and is responsible for organizing, conducting and financing the program of the biennial meetings in concert with the Chair, Panel Chairs, and Chair of Local Arrangements. The Secretary/Program Chair appoints a Local Arrangements Committee and Chair from their home state to help with organizing and conducting the biennial meeting. The Secretary/Program Chair is responsible for the minutes of all Business and Executive Committee meetings, the publishing of the minutes of these and other committees (i.e., Rice Crop Germplasm, Rice Variety Acreage, and Nominations) at the RTWG in the Proceedings and ensuring the Panel Chairs correctly publish their minutes and abstracts in the Proceedings. The Secretary/Program Chair is responsible setting up the RTWG website. The Secretary/Program Chair is responsible for the resolutions pertaining to the biennial meeting and for the Necrology Report when appropriate. The Secretary/Program Chair authors the Resolutions section of the RTWG Proceedings that expresses appreciation to individuals and organizations that contributed to making the biennial RTWG meeting a success. The Secretary/Program Chair is a member of the Executive Committee and usually resides in the state the biennial meeting is conducted. The Secretary is usually chosen by active rice workers from the meeting host state and the candidate identified to the Nominations Committee for election. If the Secretary/Program Chair nominated cannot serve or complete the full term of office, it is the responsibility of the member on the Nominations Committee of the hosting state to appoint a new Secretary/Program Chair.

3. **Immediate Past Chair**
   Provides guidance to the incoming Chair to facilitate a smooth transition and lend continuity between biennial meetings. The Immediate Past Chair assists the Publication Coordinator in editing the nontechnical sections of the proceedings and revises the MOP as required. The Chair is nominated by the Nominations Committee to be the Immediate Past Chair at the next biennial meeting. The Immediate Past Chair will incorporate the changes approved by the Executive Committee in the MOP.

4. **Geographical Representatives**
   There are currently seven geographical representatives representing each of the major rice producing states, Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas, on the Executive Committee. Each state nominates via the Nominations Committee one active rice worker from either a state or federal agency to serve a two-year term on the Executive Committee. If the Geographical Representative nominated cannot serve or complete the full term of office, it is the responsibility of the delegate on the Nominations Committee from that state to appoint a new Geographical Representative.

5. **Administrative Advisors**
   The Administrative Advisors provide advice and lend continuity to the Executive Committee. A minimum of three Administrative Advisors will be appointed to the RTWG to represent the major agencies involved. They shall consist of: i) a Director of an Agriculture Experiment Station from a rice-growing state elected by the Station Directors of the rice-growing states; ii) a Director of a State Cooperative Extension Service from a rice-growing state elected by the Extension Directors of the rice-growing states; and a USDA Administrative Advisor from the ARS named by the Administrator of the Agricultural Research Service. No term limit is established.

6. **Publication Coordinator(s)**
The Publication Coordinator is responsible for assembling, editing, and publishing of the RTWG Proceedings from the biennial meeting. The Coordinator is assisted in the editing the nontechnical session portions of the proceedings by the Immediate Past Chair. The Coordinator serves on the Executive Committee to handle all matters related to the publication of the RTWG Proceedings. Currently, one co-publication coordinator serves this position. This is a voluntary position requiring the approval of the RTWG Executive Committee to serve. No term limit is established.

7. **Industry Representative**
The Industry Representative represents all aspects of the U.S. rice industry to the Executive Committee and serves as liaison with other rice industry personnel. Responsibilities include keeping all interested rice industry personnel informed of the activities of the RTWG. Industry personnel participating in the biennial meeting elect the Industry Representative. If the Industry Representative nominated cannot serve or complete the full term of office, it is the responsibility of the Industry members of the RTWG to appoint a replacement.

B. Standing Committees
The Executive Committee has appointed the following Standing Committees.

1. **Nominations Committee**
The purpose of the Nominations Committee is to nominate the Secretary/Program Chair, Chair, Immediate Past Chair, and Geographical Representatives to the Executive Committee, and the members or delegates to the Nominations Committee. The Nominations Committee is composed of eight members. Seven of the members represent each of the seven major rice-producing states and one delegate is from the U.S. Rice Industry. As with the Executive Committee, each state nominates via the Nominations Committee one active rice worker from either a state or federal agency to be their delegate on the Nominations Committee and the Rice Industry is responsible for designating who their delegate is on the committee. The Chair of the Nominations Committee is from the next state to hold the RTWG biennial meeting. If a delegate on the Nominations Committee cannot serve or complete the term of office, it is the responsibility of the Geographical Representative from that state to appoint a replacement. Each delegate is responsible for polling the active rice workers in their state or industry to determine who their Geographical Representative is on the Executive Committee and who their delegate is on the Nominations Committee. The Chair of the Nominations Committee is responsible for obtaining the results from each delegate on the Nominations Committee, compiling the results, and reporting the results to the RTWG at the Opening Business meeting for a vote. When a state is next in line to host a biennial meeting, it is the responsibility of the delegate from that state to nominate the Secretary/Program Chair. Since the Secretary/Program Chair moves up to RTWG Chair and the RTWG Chair to Past Chair, it is the responsibility of the Chair of the Nominations Committee to nominate them to the RTWG members.

2. **Rice Crop Germplasm Committee**
The Rice Crop Germplasm Committee functions not only as an RTWG committee but also as the Rice Crop Germplasm Committee for the National Plant Germplasm System. In this capacity, it is part of a specific national working group of specialists providing analysis, data and recommendations on genetic resources for rice and often-related crops of present or future economic importance. This committee represents the user community, and membership consists of representation from federal, state, and private sectors; representation from various scientific disciplines; and geographical representation for rice. There are also ex-officio members on the committee from the National Plant Germplasm System. The Rice Crop Germplasm Committee, along with the other Crop Germplasm Committees, is concerned with critical issues facing the NPGS including: i) identifying gaps in U.S. collections and developing proposals to fill these gaps through exchange and collaborative collecting trips; ii) assisting the crop curators in identifying duplications in the collections, and in evaluating the potential benefits and problems associated with the development and use of core subsets; iii) prioritizing traits for evaluation and developing proposals to implement these evaluations; iv) assisting crop curators and GRIN personnel in correcting passport data and ensuring that standardized, accurate, and useful information is entered into the GRIN database; v) assisting in germplasm regeneration and

in identifying closed out programs and other germplasm collections in danger of being lost and developing plans to rescue the important material in these programs; vi) working with quarantine officials to identify and ensure new techniques for pathogen identification that will assist in the expeditious release of plant germplasm; and vii) maintaining reports on the status of rice for Congress, ARS National Program Staff and Administrators, State administrators, and other key individuals involved with the NPGS. The Committee members serve six-year terms. They rotate off of the Committee in two-year intervals. The Rice Crop Germplasm Committee Chair appoints a committee who nominates a slate of members. This committee maintains the diversity of the membership. Nominations also are requested from the floor and elections take place among the voting members to fill the six-year terms of office. A Chair is then elected from the voting membership for a two-year term. The Chair can only be elected to two consecutive terms of office unless completing the term of a previous Chair.

3. Rice Variety Acreage Committee

The purpose of the Rice Variety Acreage Committee is to collect and summarize data on varieties by acreage for each state and publish the summary in the RTWG Proceedings. The Committee consists of the rice specialists from each of the seven major rice-producing states and one other representative, usually a breeder or a director of an experiment station. No more than two members can represent any one state. The Chair of the Rice Variety Acreage Committee solicits information from each of the states then compiles it for the Committee report published in the RTWG Proceedings. Members of the Rice Variety Acreage Committee solicit their own members, first based on state and then on knowledge and interest expressed by active members of the RTWG to be part of the Rice Variety Acreage Committee. The Chair of the Rice Variety Acreage Committee is elected by the members of the Committee and may serve more than one term. No term limits have been established for members of the Rice Variety Acreage Committee.

4. Awards Committee

The Awards Committee is composed of the Executive Committee. See section IV. C., 'Guidelines for RTWG Awards' for details regarding responsibilities and duties of the Awards Committee.

5. Location and Time Committee

The Location and Time Committee is made up of three individuals, two from the state next to hold the biennial meeting and one from the state following the next host state. This Committee explores when and where the next biennial RTWG meeting will be held. The incoming Chair appoints the Location and Time Committee members.

C. Website Coordinator

The website coordinator is responsible for maintaining a permanent website for RTWG. Information included on the website should be updated as necessary and include links to websites maintained by meeting host states. The permanent website can be utilized as the meeting site should the host state be unable to maintain a local site.

D. Revisions to the Manual of Operating Procedures

The Executive Committee with a majority vote has approved this 'Manual of Operating Procedures' for use by the Rice Technical Working Group. This 'Manual of Operating Procedures' is a working document that should be amended or modified to meet the needs of the Rice Technical Working Group. Amendments or modification to this 'Manual of Operating Procedures' can only be made by a quorum of the Executive Committee with the approval of the majority of the Executive Committee. The RTWG Chair can only vote in the case of a tie. The Immediate Past Chair will incorporate the approved changes in the MOP.

IV. Biennial Meeting Protocols

A. Biennial Meetings

The biennial meetings are hosted by the participating states in the following rotation: Arkansas, Louisiana, Texas, California, Missouri, and Mississippi. A state is allowed to host a biennial meeting if the state is deemed by the Executive Committee to have a sufficient number of rice scientists to properly conduct a biennial meeting. The Secretary/Program Chair is responsible for organizing, conducting, and financing the program of the biennial meetings in concert with the Chair, Panel Chairs, and Chair of Local Arrangements. The Secretary/Program Chair is responsible for setting up the RTWG website. The Chair organizes the agenda and presides over the Business and Executive Committee meetings and the Awards process. Panel Chairs coordinate the oral and poster presentations in their discipline with the Secretary/Program Chair, editing of abstracts with the Publication Coordinator, updating of panel recommendations, and choosing their successor. Detailed information on the business meetings; detailed responsibilities of the Publication Coordinator, Panel Chairs, and the Local Arrangements Committee; timeline of preparation for the biennial meeting; instructions for preparation of abstracts; and guidelines for the RTWG awards are listed in this section.

1. Executive Committee Meetings

The agenda for the Executive Committee meetings varies, but there is a standard protocol and a few items that are always discussed. Robert's Rules of Order govern all Executive Committee meetings. Following is a typical agenda.

a. Opening Executive Committee Meeting (held on day prior to start of meeting)

<u>Old Business</u>

i) The Chair opens the meeting
ii) The Chair gives the Financial Report of the previous RTWG meeting. The Chair then entertains a motion to accept the Financial Report.
iii) The Secretary reads the minutes of the previous RTWG Executive Committee Meetings and entertains a motion to accept the minutes.
iv) The Chair leads a discussion of any old business from the previous RTWG Closing Executive Committee Meeting.

<u>New Business</u>

The Necrology Report read by Chair.
The Chair announces RTWG award recipients and asks the Executive Committee to keep this information secret until after the Awards Banquet.
The Chair leads a discussion of any New Business that has developed since the last RTWG meeting. Several months prior to the RTWG meeting the Chair should solicit any New Business items from the Executive Committee.

b. Closing Executive Committee Meeting (held on last day of meeting)

<u>Old Business</u>

i) The Chair opens meeting
ii) The Chair leads a discussion of any topics that were not adequately addressed at the Opening Executive Committee Meeting.
iii) Executive Committee members discuss and address any business items that have become a topic of interest during the RTWG meeting.

2. Opening General Session and Business Meetings

The agenda for the Opening General Session and Business meetings varies, but there is a standard protocol and a few items that are always discussed. Robert's Rules of Order govern all Business meetings. Following is a typical agenda.

a. Opening General Session and Opening Business Meeting (begins the RWTG meeting)
   i) The Chair opens the meeting and thanks the host state delegation for preparing the program.
   ii) The Secretary welcomes the RTWG membership to their state.
   iii) The Chair opens the Business Meeting by asking the Secretary to read the minutes of the Closing Business meeting from the previous RTWG meeting and the Chair then entertains a motion for acceptance of the minutes.
   iv) The Chair opens the Business Meeting and informs the RTWG membership of business discussed at the Opening Executive Committee Meeting.
   v) The Chair reads the Necrology Report and asks for a few moments of silence.
   vi) The Nominations Committee Chair reads the nominations for the Executive Committee and Nominations Committee to the RTWG membership. The RTWG Chair then entertains a motion to accept the nominations.
   vii) The Chair calls on the Chair of the Location and Time Committee of the next biennial meeting to report when and where the next RTWG meeting will be held.
   viii) The Secretary informs the membership of last minute alterations in the program and any additional information on the meeting, hotel, etc.
   ix) The Chair asks for a motion to adjourn the Opening Business Meeting.
   x) The General Session usually ends with invited speaker(s).

b. Closing Business Meeting (ends the RTWG meeting)
   i) The Chair opens the meeting and calls for Committee reports from Rice Crop Germplasm, Rice Variety Acreage, Rice Industry, and the Publication Coordinator.
   ii) The Chair thanks the Publication Coordinator(s) for their efforts in coordinating, editing, and publishing the RTWG Proceedings.
   iii) The Chair thanks the host state delegation for hosting the RTWG Meeting.
   iv) The Chair then passes the Chair position to the Secretary/Program Chair. The incoming Chair thanks the Past Chair for service to the RTWG and presents the Past Chair with a plaque acknowledging their dedicated and valuable service to the RTWG as the Chair.
   v) The incoming Secretary/Program Chair informs the membership of the time and place for the next RTWG meeting.
   vi) The incoming Chair invites every one to attend the next RTWG meeting and asks for a motion to adjourn the RTWG meeting.

3. Publication Coordinator(s)

The Publication Coordinator(s) are responsible for providing instructions for manuscript preparation, collecting abstracts from the Panel Chairs, assembling all pertinent information for inclusion in the Proceedings, final review, and publication of the Proceedings upon the conclusion of each RTWG meeting. The Publication Coordinator(s) solicit input from the Executive Committee, Panel Chairs, and the general membership for changes and/or adjustments to the RTWG Proceedings content, style, format, and timetable. It is, however, the Publication Coordinator(s) responsibility to make the final decision on changes appropriate to insure the Proceedings is a quality product and reflective of the goals and objectives of the organization. This flexibility is needed to insure that publication of this information through their respective institution is done in accordance with university or other agency requirements. The Publication Coordinator(s) are responsible for updating the guidelines for submitting abstracts as needed and including this information in the published Proceedings and also on the RTWG host website once the call for abstracts is made. The Publication Coordinator(s) are responsible for mailing proceedings in CD and hardcopy format to the general membership and also placing the Proceedings on the internet.

4. **Panel Chairs**

A Panel Chair or Panel Chair and Co-Chair, at least one of whom will be an active rice worker in state or federal agencies, shall be elected by each of the six disciplines or Panels. The current Panels are: i) Breeding, Genetics, and Cytogenetics; ii) Economics and Marketing; iii) Plant Protection; iv) Postharvest Quality, Utilization, and Nutrition; v) Rice Culture; and vi) Rice Weed Control and Growth Regulation. Such elections shall take place by the end of each biennial meeting and Panel Chairs will serve as members of the Program Committee for the next biennial meeting. Each Panel Chair will be responsible for developing the Panel program in close cooperation with the Secretary-Program Chair. Program development involves scheduling of oral and poster presentations, securing moderators to preside at each panel session, editing of abstracts, seeing that the Panel Recommendations are updated at each biennial meeting and approved by the participants in the respective Panel sessions, and election of a successor. Since the Secretary is from the RTWG host state, the Panel Chairs elected should also be from the host state if possible to facilitate close cooperation with the Secretary and other Panel Chairs. If an elected Panel Chair cannot serve or fulfill the duties, then it is the Secretary's responsibility to replace the Panel Chair with someone preferably from the same discipline.

Each Panel Chair is responsible for collecting all of the Panel abstracts prior to the RTWG biennial meetings. The appropriate due date will be identified in the Call for Papers for the RTWG meeting. Each Panel Chair is responsible for assembling the Panel abstracts into one common MS Word file that is consistent with the above guidelines, with the abstracts appearing in the order presented. Paper abstracts will be presented first and poster abstracts second. A Table of Contents should be included with each panel section. Panel Chairs are responsible for editing all abstracts for their panel. A common file should be developed prior to the beginning of the RTWG meeting and submitted to the Publication Coordinator(s) to accommodate preliminary preparation of the Proceedings prior to the meeting. The Panel Chairs are strongly encouraged to edit the abstracts for content clarity and RTWG format to expedite publication of the Proceedings. These materials will be merged in the final Proceedings in the format submitted. Final editing will be performed by the Publication Coordinator(s), Rice Research Station secretarial staff, and the incoming Chair.

In addition, Panel Chairs are to prepare and submit both a paper copy and MS Word computer file version of the (1) final Panel Recommendations and (2) a list of panel participants by the conclusion of the meeting. A copy of the previous recommendations and panel participants will be provided to each Panel Chair prior to the meeting.

Panel Chairs are to organize the oral presentations in the concurrent Technical Sessions and the posters for the Poster Sessions with the Secretary/Program Chair.

5. **Local Arrangements**

The Local Arrangements Committee and the Chair of this Committee are typically appointed by the Secretary/Program Chair to help with meeting site selection and organizing and conducting the biennial meeting. Thus, they usually reside in the state the biennial meeting is conducted due to logistics. Typical responsibilities include: a survey of possible meeting sites and establishments; working with the hotels for rooms, meeting space, and food functions; securing visual aids; helping with spouse activities; solicitation of donations; and providing speakers and entertainment.

6. **Financing Biennial Meeting, Start-up Money, and the Contingency Fund**

   a. The biennial RTWG meetings are financed through registration fees and donations from industry and interested parties. The Executive Committee established a base amount of $6,000 that is to be transferred from one host state to the next as start-up money to begin preparations for the RTWG meeting prior to when donations or registration fees can be collected.

   b. At the end of each biennial meeting, after all financial obligations are met, remaining funds collected to support the programs or activities of the RTWG meeting will be transferred by the Secretary/Program Chair to the RTWG Contingency Fund, entitled 'Rice Tech Working Group Contingency Fund', established at the University of Arkansas in the Agriculture Development Council Foundation. In instances where USDA or industry personnel are elected to serve as

RTWG Secretary, either the Local Arrangements Chair or the Geographical Representative in the state where the next meeting is to be held will be designated by the RTWG Secretary to receive and deposit funds in station or foundation accounts.

c. The Contingency Fund was established as a safety net for states hosting the biennial meetings. It is to be used by the host state when the startup money transferred from the previous state to host the biennial meetings is insufficient or when a state goes into debt hosting the biennial meetings.

i. If the previous host state is unable to provide any or all of the $6,000 in start-up money for the next host state to initiate meeting preparations, the current Chair should be informed of this situation as soon as possible (as the Chair will normally have served as Secretary of the previous meeting, he/she will probably be aware of this situation). The Chair should then communicate to the EC how much money will be needed from the Contingency Fund to provide the next host state the full $6,000 in start-up funds. The Chair will then ask for approval from the EC to make arrangements to have the appropriate funds transferred from the Agriculture Development Council Foundation at the University of Arkansas to the appropriate account in the next host state. Providing the next host state adequate ($6,000) start-up funds will be the highest priority for the use of contingency funds.

ii. If a host state has gone into debt as a result of hosting the annual meeting and will request the use of contingency funds to cover all or part of that debt (over and above the inability to provide the $6,000 in start-up funds to the next host state), it must submit a detailed request for approval of the use of these funds to the Chair, who will than make this request available to the EC. The request should include a detailed accounting of all financial aspects of the hosted meeting, including all funds received and sources thereof, as well as a detailed accounting of all expenses incurred as a result of hosting the meeting. The Chair will have discretion on how to proceed with polling the EC (e.g., email or conference call) on approval of the use of contingency funds to cover all or part of the incurred debt. The EC will then decide through parliamentary procedure whether to use contingency funds to cover all or part of the incurred debt. The Chair will then make arrangements to have the amount of any funds approved by the EC for this purpose transferred from the Agriculture Development Council Foundation at the University of Arkansas to the appropriate account in the host state. No repayment of these funds will be required.

7. Complementary Rooms, Travel Reimbursements, and Registration Fee Waivers

Complementary rooms (Suite) are provided during the meeting for the Chairman and Secretary. Typically, the hotel will provide rooms free of charge in association with a certain number of booked nights. Invited speakers may be provided travel funds, free room, or registration, depending on meeting finances. The Local Arrangement Committee usually does not provide any travel assistance for attendees. Registration can be waived or refunds given on the discretion of the Local Arrangement Committee based on their financial situation. Possibly, a certain amount should be specified non-refundable before registration is begun. Distinguished Service Award recipients usually have their registration fee waived for the day of the Award Banquet if they are not already registered.

8. Biennial Meeting Preparation Timeline

May 1, 08	Secure Hotel
May 1, 09	Pre-RTWG planning meeting
June 15, 09	Announcement of when and where the RTWG meeting will be held. (E-mail only)
July 1, 09	Invite guest speakers and begin soliciting for donations. Upon receipt of donations, send out acknowledgment letters.
Aug.1, 09	First call for papers and a call for award nominations
Sept. 15, 09	Second call for papers (Reminder; e-mail only)
Oct. 15, 09	Titles and interpretive summaries due
Dec. 1, 09	Abstracts due
Dec. 1, 09	Award nominations due to Chair
Dec. 1, 09	Registration and housing packet sent
Jan. 3, 10	Reminder for registration and hotel (e-mail only)
Jan. 29, 10	Last day for hotel reservations
Jan. 30, 10	Abstracts due to Publication Coordinator(s) from Panel Chairs
Jan. 30, 10	Registration due without late fee
Feb. 28, 10	RTWG Meeting

9. Program Itinerary

The biennial meetings begin on Sunday afternoon with committee meetings followed by a social mixer in the evening. The meetings end on Wednesday morning with the Closing Business meeting. The Awards presentations are made at dinner Monday or Tuesday evening or at a luncheon on Tuesday. See programs from previous RTWG meetings for more details.

Sunday: Registration usually begins Sunday afternoon and standing committees and ad hoc committees meet Sunday afternoon. A Sunday evening social mixer is hosted by the RTWG.

Monday: Registration continues Monday morning and posters are usually setup prior to the Opening General Session. The Opening General Session starts the biennial meeting with opening remarks from the Chair, a welcome from the Secretary/Program Chair, the opening business meeting, and ends with invited speakers. The concurrent technical sessions (i.e., oral presentations) of the six Panels begins after the Opening General Session on Monday. Posters are on display throughout the meeting or removed Monday evening and new ones placed on display Tuesday morning and removed Tuesday evening, depending on the number of posters and poster sessions.

Tuesday: The concurrent technical sessions continue on Tuesday and extend through Tuesday afternoon, depending on the number of papers. Each concurrent technical session ends with the review of the panel recommendations. If there are a sufficient number of posters, a second poster session is held on Tuesday.

Wednesday: The biennial meeting usually ends on Wednesday with the Closing Executive meeting and then the Closing Business meeting.

10. Symposia

Symposia are welcomed in conjunction with the RTWG biennial meetings. Symposia must not interfere with the RTWG biennial meetings and are to be held prior to the committee meetings on the first day (i.e., Sunday) of registration or after the Closing Business meeting.

11. Functions by Industry and Other Groups

Functions held in conjunction with the RTWG biennial meetings are welcomed as long as they do not interfere with the RTWG biennial meetings. Thus, these functions must be held prior to the committee meetings on the first day (i.e., Sunday) of registration or after the Closing Business meeting. Exceptions are informal, brief functions held at the meal breaks of breakfast, lunch, or dinner.

B. Instructions for Preparation of Abstracts for Biennial Meetings

Beginning with the Proceedings for the 24th Rice Technical Working Group meeting, Desktop Publishing software was chosen for expediting the post-meeting publication process using Microsoft Word (Windows). If individuals do not have access to MS Word, submission of materials in ASCII format (DOS compatibility is essential) is acceptable. Each electronic file should include: i) title of materials, ii) corresponding RTWG Panel, iii) corresponding author's name, daytime telephone number, e-mail address, and iv) computer format (i.e., MS Word and version number). These criteria apply uniformly to i) presented paper abstracts, ii) poster abstracts, iii) symposia abstracts, iv) panel recommendations, and v) list of panel participants. More details with respect to each of these items follow below.

As soon as a web page is established by the host state, a link will be provided to the RTWG web page where current submission instructions will be maintained.

1. Presented Paper, Poster, and Symposia Abstracts

To be published in the printed Proceedings, presented paper, poster, and symposia abstracts for the RTWG meetings must be prepared as follows. Please follow these instructions -- doing so will expedite the publishing of the Proceedings.

a. Both a paper copy and an electronic file are required. Hard copy and electronic file are to be submitted to the respective Panel Chairs 2 ½ months prior to the RTWG meeting, or earlier as stated in the Call for Papers issued by the RTWG meeting Chair and/or Panel Chairs. Please e-mail the abstract to the Panel Chair by the deadline and mail the hard copy thereafter. If e-mail is not available, mail the electronic file to the panel chair on a IBM compatible CD or floppy disk.

The respective Panel Chairs for each RTWG meeting and their e-mail and mailing addresses are presented in the ‘Instructions for Preparation of Abstracts” in each Proceedings. In case of other questions or if unable to access the Call for Papers, contact:

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b. Margins: Set 1-inch for side margins; 1-inch top margin; and 1-inch bottom margin. Use a ragged right margin (do not full justify) and do not use hard carriage returns except at the end of paragraphs.

c. Type: Do not use any word processing format codes to indicate boldface, etc. Use 10 point Times New Roman font.

d. Heading:
   i) Title: Center and type in caps and lower case.
   ii) Authors: Center name(s) and type in caps and lower case with last name first, then first and middle initials, with no space between the initials (e.g., Groth, D.E.).
   iii) Affiliation and location: DO NOT GIVE AFFILIATION OR LOCATION. Attendance list will provide each author's affiliation and address.

e. Body: Single space, using a ragged right margin. Do not indent paragraphs. Leave a single blank line between paragraphs.

f. Content is limited to one page.
   i) Include a statement of rationale for the study.
   ii) Briefly outline methods used.
   iii) Summarize results.

g. Tables and figures are not allowed

h. Literature citations are not allowed.

i. Use the metric system of units. English units may be shown in parentheses.

j. When scientific names are used, *italicize* them -- do not underline.

C. Guidelines for RTWG Awards

1. The RTWG Chair shall solicit nominations, and when appropriate, award on a biennial basis the following types of awards, namely:

a. <u>The Distinguished Rice Research and/or Education Award</u>

   i) <u>Individual category</u> – An award may be made to one individual at each RTWG meeting in recognition of recent achievement and distinction in one or more of the following: (1) significant and original basic and/or applied research and (2) creative reasoning and skill in obtaining significant advances in education programs, public relations, or administrative skills - which advance the science, motivate progress, and promise technical advances in the rice industry.

   ii) <u>Team category</u> – Same as the individual category, one team may be recognized at each RTWG meeting. All members of the team will be listed on each certificate.

b. <u>The Distinguished Service Award</u> - Awards to be made to designate individuals who have given distinguished long-term service to the rice industry in areas of research, education, international agriculture, administration, or industrial rice technology. Although the award is intended to recognize contributions of a long duration, usually upon retirement from active service, significant contributions over a period of several years shall be considered as a basis of recognition.

2. The Awards Committee shall consist of the Executive Committee.

3. Responsibilities and duties of the Awards Committee are as follows:

a. To solicit nominations for the awards in advance of the biennial meeting of the RTWG. Awards Committee members cannot nominate or write letters of support for an individual or team for the RTWG awards. If a member of the Awards Committee is nominated for an award in a given category, it is common courtesy to abstain from voting in that category.

b. To review all nominations and select worthy recipients for the appropriate awards. Selection on awardees will be determined by a simple majority vote once a quorum is mustered. A quorum for the Awards Committee is when at least eight members vote, excluding the Chair. The Awards Committee Chair (RTWG Chair) can only vote in the case of a tie. The names of recipients shall be kept confidential, but recipients shall be invited to be present to receive the award.

c. The Awards Committee shall arrange for a suitable presentation at the biennial RTWG meeting. The Chair of the RTWG shall present the awards by speaking briefly about the accomplishments of the award recipient(s) and after presenting the award allow the recipient(s) an opportunity to express their appreciation.

d. The Awards Committee shall select appropriate certificates for presentation to the recipients of the awards.

4. Those making nominations for the awards shall be responsible for supplying evidence to support the nomination, including three recommendation letters, pertinent biographies of each nominee, and a concise but complete explanation of the accomplishments. Fifteen complete copies of each nomination must be submitted. A one-page summary of accomplishments should also be included with each nomination. This summary will be published in the RTWG Proceedings if the award is granted.

a. Nominees for awards should be staff personnel of Universities or State Agricultural Experiment Stations, State Cooperative Extension personnel, cooperating agencies of the United States Department of Agriculture, or participating rice industry groups.

b. A member of an organization, described in 4.a, may nominate or co-nominate two persons.

c. Nominations are to be sent to the Awards Committee for appropriate consideration.

d. The deadline for receipt of nominations shall be three months preceding the biennial meeting.

e. Awards need not be made if in the opinion of the Awards Committee no outstanding candidates have been nominated.

D. Off-Year Executive Committee Business Meeting

The Executive Committee of the 2004 RTWG Meeting voted to have an Off-Year Executive Committee Business Meeting to add continuity, indoctrinate new Executive Committee members, and discuss pertinent topics more timely. The time and place of the Off-Year meeting is flexible and the possibility of conducting the meeting through distance education is a viable alternative to meeting at a designated location. The best time for the meeting is from February to August in the off-year, and it can be held in conjunction with such meetings as the Breeders' Conference or the organizational meeting for the next RTWG. The meeting can also be held independently at a central location or at the next RTWG meeting site to allow the Executive Committee to become familiar with the hotel and available facilities. A quorum (i.e., eight members are present, excluding the Chair) of the Executive Committee must be present for the Executive Committee to do business. It is the responsibility of the RTWG Chair and the Secretary/Program Chair to call this meeting and set the agenda in concert with the other members of the Executive Committee.

Drafted by Richard J. Norman and approved by the 31st RTWG Executive Committee on March 1, 2006; revised by Garry McCauley and approved by the 32nd RTWG Executive Committee on February 21, 2008; revised by Cass Mutters and approved by the 33rd RTWG Executive Committee on February 25, 2010.

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