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Thirty-Second Rice Technical Working Group

San Diego, California: February 18 – 21, 2008

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 Cooperative State Research, Education, and Extension Service, 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
Southwest Region
Rice Research Station
Crowley, Louisiana 70526

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PROCEEDINGS ... THIRTY-SECOND 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 Cooperative State Research, Education, and Extension Service, 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. 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 2008 Meeting

The 32nd RTWG meeting was hosted by California and held at Westin San Diego in San Diego, California, from February 18 to 21, 2008. The Executive Committee, which coordinated the plans for the meeting, included Garry McCauley, Chair; Randall Mutters, Secretary; and Don Groth, Immediate Past Chair. Geographic Representatives were Rick Cartwright (Arkansas), Chris Greer (California), Steve Linscombe (Louisiana), Tim Walker (Mississippi), Gene Stevens (Missouri), and Lee Tarpley (Texas). Administrative Advisors were David Boethel (Experiment Station), Mike French (Extension Service), and Anna McClung (USDA-ARS). Publication Coordinators were Don Groth and Mike Salassi. The Industry Representative was Dave Jones. Website coordinator was Chuck Wilson. The Local Arrangements Chair was Randall Mutters.

Location and Time of the 2010 Meeting

The Location and Time of the 2010 Meeting Committee recommended that the 33rd RTWG meeting be held by the host state Mississippi. The meeting will be held from February 22 to 24, 2010, at the Beau Rivage Hotel in Biloxi, MS.

2008 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. Don Groth for his contributions to rice disease management. The team award was presented to Jeffrey J. Oster, Robert K. Webster, Laurel L. Carter, Christopher A. Greer, and Roberta L. Firoved for their contributions to the control of the foolish seedling disease in California.

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 Drs. Carl Johnson, Richard Dunand, Mike French, and Chuck Rush.

Publication of Proceedings

The LSU AgCenter published the proceedings of the 31st RTWG meeting. Professors Mike Salassi and Donald Groth of Louisiana served as the Publication Coordinators for the 2006 proceedings. They were assisted in the publication of these proceedings by Darlene Regan.

Instructions to be closely followed in preparing abstracts for publication in the 33rd RTWG (2010 meeting) proceedings are included in these proceedings.

Committees for 2010

Executive:

Chair:	Randall Mutters	California
Secretary:	Tim Walker	Mississippi

Geographical Representatives:

Karen Moldenhauer	Arkansas
Chris Greer	California
Ronald Rice	Florida
Eric Webster	Louisiana
Jason Bond	Mississippi
Gene Stevens	Missouri
Rodante Tabien	Texas

Immediate Past Chair:

Garry McCauley	Texas

Administrative Advisors:

David Boethel	Experiment Station
Mike French	Extension Service
Anna McClung	USDA-ARS

Publication Coordinator:

Mike Salassi	Louisiana

Web Page Coordinator:

Chuck Wilson	Arkansas

Industry Representative:

Frank Carey	California

2010 Local Arrangements:

Jason Bond	Mississippi

Location and Time of 2012 Meeting:

Rick Cartwright	Arkansas
Brad Watkins	Arkansas
Tim Walker	Mississippi

Nominations:

Chuck Wilson (Chair)	Arkansas
Luis Espino	California
Ronald Rice	Florida
Eric Webster	Louisiana
Nathan Buehring	Mississippi
Gene Stevens	Missouri
Lee Tarpley	Texas
Frank Carey	Industry

Rice Crop Germplasm:

Georgia Eizenga, Chair	Arkansas
Jim Correll	Arkansas
James Gibbons	Arkansas
Xueyan Sha	Louisiana
Farman Jodari	California
Dwight Kanter	Mississippi
Karen Moldenhauer	Arkansas
Jim Oard	Louisiana
Mo Way	Texas
Fangming Xie	Texas
Ex Officio:	
Harold Bockleman	USDA-ARS
Mark Bohning	USDA-ARS
David Marshall	USDA-ARS
J. Neil Rutger	USDA-ARS
Kay Simmons	USDA-ARS

Rice Variety Acreage:

Johnny Saichuk, Chair	Louisiana
Chuck Wilson	Arkansas
Kent McKenzie	California
Curtis Rainbolt	Florida
Tim Walker	Mississippi
Bruce Beck	Missouri
Ted Wilson	Texas

2010 RTWG Panel Chairs:

Breeding, Genetics, and Cytogenetics:	
Dwight Kanter	Mississippi
Economics and Marketing:	
Steve Martin	Mississippi
Plant Protection:	
Tom Allen	Mississippi
Processing and Storage:	
Elaine Champagne	Louisiana
Rice Culture:	
Dustin Harrell	Louisiana
Rice Weed Control and Growth Regulation:	
Jason Bond	Mississippi

RESOLUTIONS
32nd RTWG – 2008

The 32nd meeting of the RTWG held at San Diego, California, February 18 to 21, 2008, 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 resolutions committee, on behalf of the RTWG, expresses its appreciation to the following individuals and organizations that contributed to the success of the 32nd meeting.

1. Garry McCauley, RTWG Chair, and all other members of the Executive committee who organized and conducted this very successful meeting. We recognize Randall "Cass" Mutters 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 Westin, San Diego for their assistance in arranging lodging, services, and hospitality before and during the RTWG meeting.

3. The local Arrangements committee chaired by Randall "Cass" Mutters for the site selection and overseeing arrangements. To Larry Godfrey and Chris Greer for their time and assistance in locating and securing arrangements with the hotel. To Janice Corner for conducting all aspects of registration, publicity, printing of the program, and for handling many other details of planning the meeting. To Lauri Brandeberry and Janice Corner for design and operation of the 32nd RTWG website and management of online registration. Angela Oates, Chelo Abrenilla, and Ria Tenorio, support staff, for all aspects of on-site registration and set up. We appreciate all the aforementioned efforts to make sure everything was in place so the meeting ran smoothly.

4. To all other University of California, Davis staff who contributed time and effort to make sure this meeting was a success. Special recognition is extended to the Ray Wennig and Steve Bickely, research technicians, who assisted with A/V in all concurrent sessions and numerous other vital tasks.

5. The Panel Chairs Kent McKenzie, Daniel Summer, Larry Godfrey, Jim Thompson, Richard Plant, and Albert Fischer and moderators for planning, arranging, and supervising the technical sessions. Special recognition is due for the efforts of the chairs, Mike Salassi, and Don Groth 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. The Weed Science Society of America generously provided the poster easels and presentation boards.

7. The Mini-Symposium and General Session speakers for sharing their knowledge and wisdom. We appreciate the contributions of Tim Johnson, George Soares, Reece Langley, John Sheehy, Mark Rosegrant, Scott Rozelle, and William Horwath.

8. Don Groth, Mike Salassi, and the LSU AgCenter staff for editing and publishing the RTWG proceedings.

9. Chuck Wilson for creating a permanent website for the RTWG and agreeing to continue to maintain this website.

10. Thanks to Kathy Yeater and Sara Duke for conducting the RTWG Statistics Workshop.

11. We gratefully recognize our many sponsors that made the 32nd Rice Technical Working Group meeting possible.

RTWG Conference Sponsorship

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In Memory of

Henry M. "Hank" Beachell

From 1931-1963, Henry M. "Hank" Beachell was Texas' first rice breeder at the Rice Pasture Experiment Station near Beaumont, TX, in a joint appointment with USDA/ARS and Texas A&M University. The nine varieties introduced by Hank during this period accounted for greater than 90% of U.S. long-grain production. While at the Beaumont Center, Hank became one of the founders of the RTWG. In 1963, Hank became a rice breeder at the International Rice Research Institute (IRRI) in the Philippines, where he was a major player in the release of IR8 in 1966. The IR8 variety, the first "modern rice," doubled previous yields, leading to the "Green Revolution" in rice. Hank received the Japan Prize from the Emperor of Japan in 1987 in recognition of the impact IR8 had upon rice production throughout Asia. Hank was also awarded the World Food Prize along with Gurdev Singh Khush in 1996 for their work conducted at IRRI. In 1981, Henry M. "Hank" Beachell returned to Texas where he remained active in hybrid rice development with RiceTec, a research-based hybrid rice company based in Alvin, Texas, until his death at age 100 in 2006.

In Memory of

Ray J. Wu

Dr. Ray J. Wu, faculty member of Cornell University, Ithaca, NY, since 1966, passed away on February 10, 2008, at the age of 79. He was the Liberty Hyde Bailey Professor of Molecular Biology and Genetics, International Professor of Molecular Biology and Genetics, and the Department Chair of Biochemistry, Molecular and Cell Biology (1976-1978) at Cornell. Born in China and educated in the United States, Wu was a scientific adviser to the governments of both China and Taiwan. Ray Wu was a pioneer in genetic engineering. He developed the first method for sequencing DNA, as well as some of the fundamental tools for DNA cloning. He developed the location-specific primer-extension method for DNA sequencing in 1970 that, although it has been modified by other scientists to speed up the process, is the same method still being used some four decades later. This method has been used to determine the DNA sequence of the entire genomes of rice, human, and other organisms. In 1988, he led one of the first groups to succeed in producing transgenic rice plants. Without any doubt, Ray Wu was an outstanding and highly accomplished researcher who successfully mentored a large number of productive graduate students and postdoctoral associates who are currently very active in academia institutions and industrial companies globally, as well as in the U.S. His research accomplishments fostered the development of Cornell University as one of the top 10 in molecular biology and plant biotechnology programs in the world. His outstanding achievements were well complemented by his kind demeanor. He will be missed by colleagues and hundreds of graduate students that he has mentored.

In Memory of

T.H. “Ted” Johnston

Dr. T. H. (Ted) Johnston was born in Antelope County, Nebraska, on May 3, 1917. He received his B.S. and M.S. degrees in 1940 and 1942 from the University of Nebraska, Lincoln - then served in the Army as Captain during World War II. In 1946, he became Assistant Agronomist at the Oklahoma State University, where he took periodic leave to complete the Ph.D. in crop breeding at the Iowa State University in 1953. Dr. Johnston then moved to Stuttgart, Arkansas, where he led the USDA/ARS State/Federal rice improvement project for 30 years. He released 12 rice varieties, including Starbonnet, Newbonnet, Mars, and Nortai. Starbonnet was first grown in 1967 and became the most widely grown variety in the U.S., accounting for 25 percent of all U.S. rice production in 1972. Dr. Johnston was very active in the Rice Technical Working Group (RTWG), serving as Secretary/Program Chair, Chair, and on many committees. He received the Distinguished Service Award in 1976, the Distinguished Rice Research and Education Team Award in 1988, and was honored by Louisiana and Arkansas rice festivals and the rice industry. He was a Fellow of ASA, CSSA, and AAAS and received the Superior Service Award, USDA. After retiring, he worked to rejuvenate the USDA World Rice Collection and edited the Arkansas Rice Research Series for many years. Dr. Johnston passed away May 20, 2006, and at that time was survived by Marian Swanson Johnston, his wife of 63 years, two sons and daughter-in-laws, and three grandchildren.

Distinguished Rice Research and/or Education Award

Don Groth

Don Groth has been an active rice researcher for 24 years. He has been responsible for rice disease control studies in the areas of disease resistance, cultural management, chemical control, epidemiology, scouting methods, disease prediction methods, and yield loss estimates. As principle investigator, Dr. Groth has received over $1,532,720 grants in the last 24 years and has been a cooperator or co-principle investigator on grants totaling over 7 million dollars. He also has extensively published his work as both senior and coauthor in over 225 publications, of which 45 are refereed.

Dr. Groth is an integral part of the varietal development team in the evaluation of breeding lines for multiple disease resistance to sheath blight, blast, bacterial panicle blight, brown spot, narrow brown leaf spot, leaf smut, and other diseases. He has helped to maintain and improve disease resistance levels in the varieties released and provides critical information to the rice industry on varietal reactions to disease. This team has released 15 major varieties in the last 10 years that have been grown on a majority of the acreage in Louisiana and the southern United States. Including enhanced disease resistance, the improved varieties have helped raise Louisiana's rice yield 15% in the last five years from 5080 lb/A in 1999 to almost 6105 lb/A in 2007. This represents an increase of 3.5 million hundred weights of rice each year worth a conservative 25 million dollars ($7.25/cwt) per year to the Louisiana rice farmers. These accomplishments would not be possible except for the cooperative efforts of the varietal development team with Dr. Groth. In addition to varietal releases, several disease-resistant germplasm lines have been released through the years for use by breeding programs.

Dr. Groth has made several major research accomplishments during his tenure at the Rice Research Station. Through mutation breeding, a new novel source of resistance to multiple diseases, including sheath blight and bacterial panicle blight, two of the most important rice diseases in Louisiana, was developed from the adapted variety Lemont. In a team effort with Dr. Milton Rush and Dr. A. K. M. Shahjahan, the cause of panicle blight was discovered to be bacterial. Dr. Groth evaluated chemical control methods and epidemiology of the disease and showed that seed and foliar treatments could limit development. A major accomplishment has been to facilitate the development of new, more effective and environmentally friendly fungicides for rice disease control. Evaluations of the effectiveness against multiple diseases, rates, and timing results have allowed farmers to effectively use these new fungicides. In timing experiments, it was discovered that 50 to 70% heading-growth stage was critical for sheath blight and blast control with fungicides. Most farmers applied their fungicides at a later stage, leading to poor control, lower yield, and reduced milling. The slight shift in application timing has increased yields by hundreds of pounds and milling by several percentages that significantly increased the return farmers received from fungicide applications. He has also shown the importance of disease control in the first crop to the success of the second crop, a key economic consideration for rice production in the Gulf region. Through Dr. Groth's research, a complete package of information is provided to the rice grower on how to control disease. These recommendations emphasize improved yield, quality, and milling through disease resistance, cultural management, and economical fungicide use. This includes the varietal disease reactions, nitrogen and planting rate effects, scouting methods, disease treatment thresholds, recommended application timing, rates for multiple diseases, and improved application methods. Dr. Groth has established many cooperative efforts to develop superior disease control options for Louisiana and the southern U.S. production area. Companies actively seek Dr. Groth's assistance to develop rice fungicides, bactericides, and seed treatments. All of the recently labeled rice fungicide rates and timings are partially based on research conducted by Dr. Groth. Beside cooperative ties with pesticide programs, Dr. Groth also interacts with field scouts, consultants, extension personnel, and farmers to ensure that diseases are identified correctly and control practices are applied properly and in a timely manner.

Distinguished Rice Research and/or Education Team Award

Jeffrey J. Oster, Robert K. Webster, Laurel L. Carter, Christopher A. Greer, and Roberta L. Firoved

The fungal disease known as Bakanae or "the foolish seedling disease," caused by *Gibberella fujikuroi (Fusarium fujikuroi),* was first identified by pathologist from samples collected in California's Butte and Colusa Counties in 1999. Its characteristic symptoms include elongated, narrow, and lighter colored leaves that arch above their healthy counterparts in the field approximately 30 days after planting. Most infected plants die before maturity, and at very low levels, there was no discernable impact on yield. However, planting infected seed produced dramatic increases in the disease with significant yield losses. This was a new exotic fungal disease for the United States and it spread very rapidly through infected seed and was found in all rice growing regions of California by 2002. The California rice industry faced a significant production threat from the new disease that was not well understood, and there were no available control options. This challenge was effectively addressed in a timely and systematic fashion through the support and efforts of the staff provided by four prominent cooperating organizations; the California Cooperative Rice Research Foundation (CCRRF), the University of California Davis (UCD), the University of California Cooperative Extension (UCCE), and the California Rice Commission (CRC).

Understanding the biology and epidemiology of the pathogen became the primary focus for UC pathologists. Factors influencing incidence and spread of Bakanae disease of rice and the population structure and variability of *Fusarium fijikuroi* in California were the broad research area for Drs. Robert Webster and Laurel Carter. This provided the information needed to understand and control the disease. Mr. Jeffery Oster focused attention on evaluation of seed treatments and protocols to fit the water-seeded system predominant in California. This involved seed assays, greenhouse, and multi-location field testing of experimental treatments. It also led to information recognizing the risk of planting infested seed, estimated yield losses, varietal susceptibility, and modification of the protocol that significantly reduced concentrations needed for control, reducing both treatment costs and environmental impact. Dr. Chris Greer through his role as a cooperative extension farm advisor participated in cooperative research field activities with UC Davis and CCRRF. This close research involvement and his pathology training made him particularly effective as he provided outreach information to the industry through the meetings, publications, and contact with growers and seed producers. This also became a mechanism for information to flow back to the researchers to help assess the extent of the problems and formulate a workable solution. The solution, a sodium hypochlorite seed soak, was effective but would require regulatory approval. The expertise and attention provided by Ms. Roberta Firoved of the CRC solved the complex regulatory challenge by quickly obtaining an effective product to control this disease. A "label for rice" was achieved in concert with the completion of the research activities. That was soon followed by a modification to reduce total product needed and disposal complexities.

The efforts, dedication, credibility, and success of this team is ultimately demonstrated by the rapid adoption of the sodium hypochlorite seed treatment to control Bakanae by California rice growers and the elimination of this industry threat.

Distinguished Service Award

Richard T. Dunand

This scientist of the LSU Agricultural Center has contributed 30 years of service to the U.S. rice industry and compiled an impressive list of accomplishments during his tenure. His dedication to both the U.S. rice industry and the scientific community are evidenced by a portfolio thick with original, scholarly contributions. His research was highlighted by his investigations into rice physiology and production as affected by plant growth regulators.

His pioneering research efforts led to the identification of plant growth regulators to reduce plant height in tall stature varieties to reduce lodging and improve harvest efficiency. Early in his career, he recognized the negative impact of red rice on rice yield and quality and began researching the potential for using plant growth regulators to suppress red rice seed production. These original experiments, to determine if plant growth regulator application to red rice at specific timings could selectively inhibit red rice seed production without hindering the yield or quality of the cultivated rice crop, resulted in several EUPs and Section 18s.

The most outstanding contribution made by this scientist to the U.S. rice industry was his work with gibberellic acid. He was instrumental in the development of gibberellic acid as a seed and foliar treatment to improve seedling vigor. Gibberellic acid, due in part to his research, is one of the most widely used agrochemicals in U.S. rice production. As a service to the industry, he voluntarily screened commercial varieties and advanced experimental lines of rice breeders throughout the United States for seedling vigor with and without application of gibberellic acid. He also researched the potential for improving ratoon crop production with plant growth regulator applications. His investigations were fundamental to our current knowledge of the effect of plant growth regulator application on panicle exertion and heading uniformity.

His experiences also led him to evaluate rice production as it relates to crawfish production. He tested plant growth regulators for their potential to improve rice as a forage in crawfish production. He also researched using photoperiodic traits to control heading and maturity, in a sense providing a single variety that is early-maturing for seed production and late-maturing for crawfish production based solely on date of planting.

This scientist also played an important role in identifying the growth stages of first crop rice in U.S. production systems. With so many management factors in rice production directly related to physiological growth stage, this body of work has been an invaluable resource for rice producers and research scientists alike.

During his career, he closely cooperated with other university scientists (both research and extension) in Arkansas, California, Louisiana, Mississippi, Missouri, and Texas. His research and scholarly activities frequently led to multi-disciplinary interaction with agronomists, aquaculturists, plant breeders and geneticists, entomologists, physiologists, pathologists, and weed scientists, and he was frequently in contact with various consultants, growers, and extension agents in the U.S. rice industry.

Distinguished Service Award

Carl W. Johnson

Carl W. Johnson received his Bachelor's degree in Agronomy from Kansas State University and his Master's degree in Agronomy form North Dakota State. Dr. Johnson spent three years with the U. S. Army where he was given a direct promotion from Sp.4th class to 1st lieutenant. After receiving his PhD in Agronomy and Plant Genetics from the University of Nebraska, he and his family moved to California where he began his work as a plant breeder for the California Cooperative Rice Research Foundation at the Rice Experiment Station in l974. He has devoted his entire professional career to developing improved rice cultivars for the California rice industry. He plans to retire in July of 2008 after 34 years at the Rice Experiment Station.

During his employment, 38 rice varieties have been developed by the Rice Experiment Station and released to California. Dr. Johnson's primary responsibility has been developing improved Calrose varieties. Of the 14 Calrose-type medium-grain varieties, several have been particularly successful. M-202 was released in l985 and is still grown on more than 30% of the California rice acreage. More recent releases, M-205 and M-206, that combine high yield potential and improved milling are now grown on comparable acreages. M-208, with resistance to the race of rice blast disease found in California, marks another accomplishment. Dr. Johnson played a major role in the release of 10 premium quality medium grains, short grains, and waxy varieties and was a contributor to 10 long-grain releases from the Rice Experiment Station, as well as several germplasm releases. He was instrumental in obtaining Plant Variety Protection for CCRRF varieties and holds three utility patents on rice cultivars and two additional patents pending on a cultivar and a plant height mutant allele. The dollar return to California rice growers credited to improved varieties during Dr. Johnson's tenure at Rice Experiment Station has been conservatively estimated to be well beyond 1 billion dollars.

Dr. Johnson has certainly been a well recognized member of the U.S. rice research community, always willing to participate in discussions on rice improvement and share his experience and expertise. He is a strong advocate of "in the field plant breeding" that is clearly reflected in his comments and in how he conducted his professional plant breeding career.

Dr. Johnson is a member of many honorary societies, including Sigma Xi, Gamma Sigma Delta, Phi Kappa Theta, has been a member of ASA since l970, CAST since l974, and serves on the USDA Plant Variety Protection Board. Dr. Johnson has been a guest lecturer at many scientific gatherings, such as the American Society of Horticultural Science and the International Temperate Rice Conference. He received the l984 "Distinguished Rice Research and Education Award" from the Rice Technical Working Group, the l997 "Genetics and Plant Breeding Award for Industry" from CSSA and National Council of Commercial Plant Breeders, the l998 "Distinguished Service in Agriculture Award" from Kansas State University, and the 2004 California Rice Industry Award.

Distinguished Service Award

Milton C. (Chuck) Rush

This scientist of the LSU AgCenter has dedicated over 37 years in education, research, and service to the U.S. rice industry. His program pioneered the development of rating scales for rice diseases in the southern United States. He first reported eight new diseases in Louisiana rice. His extensive fungicide testing programs were critical for the labeling of new fungicides for the foliar application, which included Benlate 50WP, the first foliar fungicide labeled for rice in the U.S. He and his students elucidated the importance of leaf surface interactions between the host and pathogen in resistance of rice to *Rhizoctonia solani*, the cause of sheath blight. They demonstrated the importance of epicuticular wax thickness on sheath blight resistance and the effects of cultural practices on wax formation. They conducted the first studies to show that the effect of flooding on controlling leaf blast was due to a change in the plant's resistance rather than to the effects of leaf-wetness period. They also developed information on variation within rice pathogens including classifying the races of *Cercospora oryzae.* Recently, they successfully identified *Burkholderia glumae* and *B. gladioli* as cause agents of the perennial rice panicle blight disease in United States.

This scientist first succeeded in regenerating plants from anthers of a U.S. rice cultivar (Labelle). He was instrumental in the establishment of the anther culture laboratory at the International Rice Research Institute in the Philippines during his sabbatical leave there from 1979 to 1980. He developed a highly efficient somaculture technique, with which thousands of somaclones were regenerated from U.S. cultivars, including two sheath blight-resistant Labelle somaclones, LSBR-5 and LSBR-33. By crossing elite long-grain cultivars with newly identified resistance sources, over 300 lines showing sheath blight resistance and high yield potential have been developed and turned over to the various breeding programs. One of the lines, MCR00661, has been adopted by the USDA-CSREES RiceCap project as a sheath blight-resistant parent for the development of molecular markers.

During his career, he published over 300 refereed journal articles, book chapters, and research reports. He has served the RTWG as a member of the Award Committee, Germplasm Advisory Committee, and Local Arrangement Committee, and a panel moderator several times. His numerous honors include: the Distinguished Academy Scientist Award by the Louisiana Academy of Sciences in 1989; the RTWG Distinguished Rice Research and Education Award in 1994; the Louisiana Agricultural Experiment Station Doyle Chambers Award for Outstanding Research Contributions in 1995; the Outstanding Plant Pathologist in the Southern Division of the American Phytopathological Society in 1997; and the RTWG Distinguished Rice Research and Education Team Award, with Drs. Don Groth and A.K.M. Shahjahan, in 2002.

Distinguished Service Award

C. Michael (Mike) French

Dr. C. Michael (Mike) French grew up near Lake Providence, Louisiana, on a cotton, soybean, and wheat farm. He attended the University of Louisiana at Monroe, earning the B.S. degree in Agronomy in 1973, then completing the M.S. and Ph.D. degrees in Agronomy – Weed Science at Oklahoma State University in 1975 and 1978, respectively. After college, he first worked for the University of Georgia Cooperative Extension Service as an Extension Agronomist – Weed Science at Tifton, Georgia. He was later hired as Head and Professor of the Extension Agronomy Department at the University of Georgia Cooperative Extension Service located in Athens, Georgia.

In his time at Georgia, he was responsible for developing weed management information for commodities such as soybeans, pastures, small grains, Christmas trees, and non-cropland areas. Dr. French was a prolific author of Extension publications, as well as popular press articles on weed management. He was a strong advocate of the county-based Extension system and would hold several in-service educational sessions that were designed to improve the weed management expertise of county agents and ag-industry professionals. Similarly, he was highly involved with both in-state organizations, such as the Georgia Weed Science Society, and regional and professional weed science societies, such as the Southern Weed Science Society and the Weed Science Society of America. He is primarily remembered in Georgia for his overwhelming dedication to the Extension Service, his enthusiasm for and willingness to help county agents and producers with difficult weed control situations, and his high level of proficiency in weed management.

After 15 years with the University of Georgia Cooperative Extension Service, Dr. French was selected as Associate Director – Agriculture and Natural Resources for the University of Arkansas Division of Agriculture Cooperative Extension Service on May 17, 1993 and became Associate Director – Programs on August 1, 2005. While at the University of Arkansas, he has been responsible for fiscal and programmatic oversight of a diverse agricultural program, including row crops, environmental sciences, poultry and livestock, forestry, aquaculture, turf management, and horticulture. After moving to his new role, he has added responsibility for oversight of all programs, including 4-H and family and consumer sciences. During his tenure at the University of Arkansas, he has continued to emphasize the importance of county-based programs and meeting the needs of producers.

Dr. French has served the Rice Technical Working Group for much of his tenure at the University of Arkansas. He has served as the academic advisor and ex-officio member of the RTWG Executive Committee representing the Cooperative Extension Service for 12 years. His guidance and other contributions to the RTWG Executive Committee have been invaluable as the direction of the organization has evolved during the challenging and changing times of the past decade. His commitment and dedication to the success and continuation of the RTWG have been unwavering, and his support of the rice industry in Arkansas and the United States unquestioned.

Dr. French, his wife Nona, and their three children currently reside in Conway, Arkansas.

Minutes of the 32nd RTWG Meeting

Opening Executive Committee Meeting

In attendance: Garry McCauley (Chair), Don Groth (Past Chair), Randall 'Cass' Mutters (Secretary), Mike Salassi (Publication Coordinator), Chuck Wilson (Website Coordinator), Rick Cartwright (Arkansas Rep.), Chris Greer (California Rep.), Dave Jones (Industry Rep.), Steve Linscombe (Louisiana Rep.), Tim Walker (Mississippi Rep.), Gene Stevens (Missouri Rep.), Lee Tarpley (Texas Rep.), Jim Thompson (UC Davis), Anna McClung (USDA-ARS Rep.).

Chair Garry McCauley called the meeting to order at 11:00 a.m. on February 18, 2008, at the Westin San Diego Hotel in San Diego, California.

<u>Old Business</u>

Garry McCauley asked for questions or comments regarding the minutes of the opening executive committee meeting published in the 2006 Proceedings. Don Groth moved that the minutes be accepted as presented. Gene Stevens seconded the motion and the motion passed.

The financial report was presented by McCauley. Expenses (computer connections and others) have been covered and some very good contributions helped the RTWG along. The personnel cost includes staff time and travel and has factored in web page design.

The budget presented was just for the information of the members. The contingency, which is basically a buffer in case the RTWG has a meeting and the committee approves the costs for the meeting, will be discussed at a later date.

McCauley commended Rick Norman for putting the working document on the Manual of Operations (MOP) together. The MOP is an important first step in documenting how things operate. It also provides the complete organizational structure. There are a couple of revisions to the MOP that were received by McCauley, one of which was the time of the meetings. Mutters commented that the person in charge of making arrangements needs the flexibility to move the date a day earlier or a day later. Cass Mutters motioned to leave the flexibility to the host state with the starting day as Monday. Mike Salassi seconded and the motion was passed.

Steve Linscombe moved that any other revisions to the MOP will be brought before the committee by the secretary and the chair. Don Groth seconded and the motion was passed. The revisions will then be forwarded, in typed form, to the publications committee; and uploaded to the web site.

A few suggestions were received on the RTWG website – make it easier to navigate through the website and find more direct links to web pages, make sure the links are correct, add more links to the website, and establish a committee that would oversee maintenance and update. McCauley suggested that the host state (this time, Arkansas) look into the possibility of forming a website committee. McCauley requested the members to forward more comments on the website to Chuck Wilson. Wilson will also communicate with each of the states and ask them for the correct web links.

There has been some discussion about getting a representative (Ronald Rice) from Florida. McCauley has communicated with Rice and sent the document to Florida. No action was required from the committee on the representation.

Tim Walker moved that RTWG vote to keep the awards submission via email. Wilson seconded the motion and the motion passed. The committee will continue to do the way it has been done in the past, which is emailing the word file to the Executive Committee.

<u>New Business</u>

Garry McCauley announced the following awards:

• Distinguished Service Award – Carl Johnson, Chuck Rush, and Richard Dunand

• Distinguished Rice Research and Extension Individual Award – Don Groth

• Distinguished Rice Research and Extension Team Award – Foolish Seedling Control Team

Garry McCauley asked for inputs for the Necrology Report:

• Henry Hank Beachell – Consultant, RiceTec (Texas)
• Rey Wu – Geneticist, Cornel University (New York)
• Ted Johnston – USDA Rice Breeder (Arkansas)

Other Business

Cass Mutters introduced a motion to allow the host state to distribute the proceedings in CD format with option for hard copy distribution that factors in costs for printing and international mailing. Garry McCauley moved to take up this approach. Lee Tarpley seconded and the motion was passed. There will continue to be a pdf copy available on the Website.

Cass Mutters motioned that the outgoing Chair be the reviewer of the proceedings, with the exception of abstracts. Mike Salassi will handle editing of abstracts. Chris Greer seconded and the motion was passed. This starts in Mississippi. Jim Thompson as panel chair will take note of the motion.

There were no major objections to let the gavel stay with the Chair. The committee also saw no need for approval of this action.

Lee Tarpley asked if Missouri is still considering hosting future meetings. McCauley said Missouri requested that they be removed and majority of the executive committee members agreed on this. McCauley further said this was noted in the past minutes of the meetings.

Anna McClung asked if Richard Norman will be replaced. Mutters will discuss more on this in the next business meeting on Thursday, February 21.

At the time that the RTWG was established, there was validity for the existence of the Resolutions Committee. At this time, though, Don Groth raised the question on the need for the Resolutions Committee. Groth motioned to eliminate the Resolutions Committee and responsibilities be taken over by the secretary. Tim Walker seconded and the motion was passed.

Anna McClung moved that a 250-word summary of the contributions to rice of a person that has passed on be submitted by the geographic representative(s). These summaries will be included in the current proceedings. The motion was passed.

Don Groth moved that the meeting close. The motion was seconded by Tim Walker and the motion passed.

Minutes of the 32nd RTWG Meeting

Opening Business Meeting

Chair Garry McCauley called the meeting to order at 3:02 p.m. on February 18, 2008, at the Westin San Diego in San Diego, California. Minutes of the previous meeting were accepted unanimously without reading after moved by Neil Rutgers and Jim Hill seconded.

Chair Garry McCauley presented a summary of the opening Executive Committee meeting.

- A motion was passed to allow the host state to decide whether to convene future meetings on Sunday or Monday.
- The proceedings will be distributed in CD format with option for a hard copy at an additional cost to cover printing and mailing.
- Future awards submission will be via email.
- Missouri requested that they be removed from the list of host states. The Executive Committee approved the motion.
- The Resolution Committee was eliminated and the responsibilities will be taken over by the secretary.
- A 250-word summary of the contributions to rice of a person that has died is to be submitted by the geographic representative(s). These summaries will be included in the current proceedings.

Chair Garry McCauley read the Necrology Report and asked for a moment of silence for Henry 'Hank' Beachell, Rey Wu, and Ted Johnston.

Garry McCauley asked that the Panel Chairs and committees to submit materials and reports as soon as possible to accelerate the publication of the 32nd RTWG Proceedings.

Cass Mutters announced the program changes since the program was published and acknowledged UC staff that assisted with meeting arrangements.

Garry McCauley asked for a motion to adjourn the business meeting, Carl Johnson moved for adjournment, and Neil Rutgers seconded the motion. The motion passed and Garry McCauley closed the meeting at 3:20 p.m., February 18, 2008.

Minutes of the 32nd RTWG Meeting

Closing Executive Committee Meeting

In attendance: Garry McCauley (Chair), Don Groth (Past Chair), Randall 'Cass' Mutters (Secretary), Mike Salassi (Publication Coordinator), Chuck Wilson (Website Coordinator), Rick Cartwright (Arkansas Rep.), Chris Greer (California Rep.), Dave Jones (Industry Rep.), Tim Walker (Mississippi Rep./ Nominations Chair), Gene Stevens (Missouri Rep.), Lee Tarpley (Texas Rep.), Yulin Jia for Anna McClung (USDA-ARS Rep.).

Chair Garry McCauley called the meeting to order at 7:00 a.m. on February 21, 2008, at the Westin San Diego Hotel in San Diego, California.

Garry McCauley will send out any suggested changes to the Manual of Operating Procedures (MOP) for approval of the committee members.

The Nominations Committee report was presented by Tim Walker. These are:

Secretary/Program Chair:
Tim Walker

Geographic Representatives:
- Arkansas - Karen Moldenhauer
- California - Chris Greer
- Florida - Ronald Rice
- Louisiana - Eric Webster
- Mississippi - Jason Bond
- Missouri - Gene Stevens
- Texas - Rodante Tabien
- Industry - Frank Carey

Nominations Committee:
- Arkansas - Chuck Wilson, Chair
- California - Luis Espino
- Florida - Ronald Rice
- Louisiana - Eric Webster
- Mississippi - Nathan Buehring
- Missouri - Gene Stevens
- Texas - Rodante Tabien

Panel Chairs:
- Breeding, Genetics, and Cytogenetics - Dwight Kanter
- Processing, Storage and Quality - Elaine Champagne
- Economics and Marketing - Steve Martin
- Rice Culture - Dustin Harrell
- Plant Protection - Tom Allen
- Rice Weed Control and Growth Regulation - Jason Bond

Tim Walker will complete the list of nominees.

McCauley called attention to the need for the Nominations Committee to have eight members, including the Chair of the Nominations Committee. This is one of the changes that the Executive Committee needs to approve of and, consequently, be reflected in the revised MOP.

Don Groth, on behalf of Steve Linscombe who was not able to attend the meeting, informed the committee members that the U.S. Agency for International Development (US AID) is considering reducing financial support to the International Rice Research Institute (IRRI). The proposed reduction in funding will substantially affect the capabilities of IRRI as a lead institution providing new technologies to rice farmers and consumers throughout the world. A motion was made by Don Groth for RTWG to send a letter to US AID in support of IRRI with a second by Cass Mutters. The motion passed. A final version of the letter (with a copy to IRRI Director General Robert Zeigler, U.S. Secretary of Agriculture, and the congressional representatives of the rice states) will be circulated to the Executive Committee members.

Yulin Jia, on behalf of Anna McClung, asked that the host state invite more people from the Biotechnology industry. Cass Mutters and Yulin Jia will put together a list of possible participants to the next RTWG meeting.

Rick Cartwright made a motion to send a letter of recognition to Mike French for his dedicated service to RTWG, and for Mike French to receive a Distinguished Service Award. Dave Jones seconded the motion and the motion passed. Cartwright will write a paper for the recognition of French.

Garry McCauley called for any unfinished business or new business to be brought before the committee. None was introduced.

Motion was made and passed to adjourn the meeting.

Minutes of the 32nd RTWG Meeting

Closing Business Meeting

Chair Garry McCauley called the meeting to order at 8:30 a.m. on February 21, 2008, at the Westin San Diego Hotel in San Diego, California.

Garry McCauley announced that the Mississippi delegation will replace Missouri in the rotation to host the RTWG meetings in 2010.

Garry McCauley called for committee reports.

Carl Johnson announced that the Executive Committee has decided to bring to a close the term of the Resolutions Committee. Johnson mentioned that it has been an interesting career for him and thanked everyone that provided support to the Resolutions Committee since its creation in 1982. McCauley, on behalf of the RTWG, thanked Carl Johnson and others on the committee.

The Rice Crop Germplasm Committee had no report.

The Acreage Committee report was presented by Johnny Saichuk.

Tim Walker read the nominations for 2008-2010. These are:

Secretary/Program Chair:
- Tim Walker

Geographic Representatives:
- Arkansas - Karen Moldenhauer
- California - Chris Greer
- Florida - Ronald Rice
- Louisiana - Eric Webster
- Mississippi - Jason Bond
- Missouri - Gene Stevens
- Texas - Rodante Tabien
- Industry - Frank Carey

Nominations Committee:
- Arkansas - Chuck Wilson
- California - Luis Espino
- Florida - Ronald Rice
- Louisiana - Eric Webster
- Mississippi - Nathan Buehring
- Missouri - Gene Stevens
- Texas - Rodante Tabien

Panel Chairs:
- Breeding, Genetics, and Cytogenetics – Dwight Kanter
- Processing, Storage, and Quality – Elaine Champagne
- Economics and Marketing - Steve Martin
- Rice Culture - Dustin Harrell
- Plant Protection - Tom Allen
- Rice Weed Control and Growth Regulation – Jason Bond

A motion to accept the Nominations Committee report was made by Dave Jones. This was seconded and the motion passed.

Dave Jones, on behalf of the Industry Committee, reported that the annual industry luncheon, which provided a good opportunity for people to interact, was a success.

The Publications Committee had no report. Chair Garry McCauley announced that Don Groth will be stepping down as Chair after the 2008 proceedings is published. Mike Salassi will replace Groth and handle the editing of abstracts. The outgoing Chair will be the reviewer of the proceedings, with the exception of abstracts. McCauley thanked the Publications Committee for its major job.

Garry McCauley announced the decision of the Executive Committee to make the starting day of the RTWG meeting to Monday. The Executive Committee will leave it to the host state to save on costs as the host state discusses arrangements with the hotel.

The Executive Committee is tasked to review the manual of operating procedures (MOP) each year, McCauley said. Any changes to the MOP will be approved by the committee members and will be forwarded to the Publications Committee.

The U.S. Agency for International Development (US AID) is considering reducing its financial support to the International Rice Research Institute (IRRI). IRRI is a premier institution that has a long-term repository of rice germplasm useful and available to rice breeders worldwide. The RTWG believes that funding should be maintained and has decided to send a letter to US AID.

McCauley announced that Cass Mutters will put together a list of contacts from the biotechnology industry as possible participants to the next RTWG meeting.

McCauley, on behalf of the RTWG, appreciated the efforts of Mike French as administrative advisor on cooperative extension across the United States. The RTWG will send a letter of recognition to French and he will also be receiving a Distinguished Service Award.

Chair Garry McCauley thanked Cass Mutters and the California delegation for their hard work that went into making the 32nd RTWG a success. Garry McCauley passed the gavel to Cass Mutters. Cass Mutters said hosting the 32nd RTWG was worth it. He mentioned that the 2008 RTWG had close to 300 participants representing eight countries. Cass Mutters thanked Garry McCauley for his hard work during his years of service to the RTWG. He presented McCauley a plaque recognizing his contributions to the RTWG. Garry McCauley thanked all those that had supported his efforts during those two years.

Cass Mutters recognized Tim Walker as Secretary of the 2010 RTWG. Mutters announced that the meetings would be in Mississippi on February 22-24, 2010, at a yet to be determined location.

There was no additional business for the 32nd RTWG. A motion to adjourn the meeting was made by Carl Johnson, seconded by the group, and the motion passed. The meeting was adjourned at 9 a.m.

SPECIAL COMMITTEE REPORTS

Nominations Committee

The Nominations Committee proposed the following individuals for membership on the 2010 RTWG Executive Committee and Nominations Committee:

Executive Committee:

Chair:	Randall Mutters
Secretary:	Tim Walker

Geographical Representatives:

Arkansas	Karen Moldenhauer
California	Chris Greer
Florida	Ronald Rice
Louisiana	Eric Webster
Mississippi	Jason Bond
Missouri	Gene Stevens
Texas	Rodante Tabien
Industry	Frank Carey

Nominations Committee:

Arkansas	Chuck Wilson, Chair
California	Luis Espino
Florida	Ronald Rice
Louisiana	Eric Webster
Mississippi	Nathan Buehring
Missouri	Gene Stevens
Texas	Rodante Tabien
Industry	Frank Carey

Submitted by
Tim Walker

Rice Crop Germplasm Committee

The 28th meeting of the Rice Crop Germplasm Committee was held Monday, February 18, 2008, in San Diego, California. Members in attendance were James Gibbons (Chair), Karen Moldenhauer, Farman Jodari, Dwight Kanter, Jim Oard, Billie Woodruff, M.O. Way, Georgia Eizenga, Harold Bockelman, Clarissa Maroon-Lango, and Anna McClung. Members absent were James Correll, Robert Fjellstrom, Kay Simmons, and Mark Bohning.

The minutes of the 27th Rice Crop Germplasm Committee held February 14, 2007, in Memphis, Tennessee, was read and approved by a motion from Karen Moldenhauer and seconded by Dwight Kanter.

A report on the status of the rice collection given by Harold Bockelman stated PI assignments for 263 accessions ranging from PI 642943-PI 652774 had been made. Since 2006, about 200 accessions were removed from quarantine, received PI numbers, and all the descriptors were added. A majority of the material introduced included the introductions from Japan, described below by Clarissa Maroon-Lango. Varieties that were patented or had a PVP (utility patent) are included in the list. These accessions can be registered in the *Journal of Plant Registrations* (formerly these were in *Crop Science*) and the developer distributes the seed for the first five years, after this period the variety is placed in the germplasm collection and distributed from the collection. The software for GRIN is being rewritten so that it will accommodate molecular marker data with the new version. This will allow accessions to be fingerprinted.

Clarissa Maroon-Lango provided a written report on the activities at APHIS Plant Germplasm Quarantine Program related to rice quarantine. During 2007, 460 rice introductions were processed with assistance from John Guerber at the University of Arkansas. In summary, of the 58 introductions from Japan, 55 were released from quarantine and sent to the National Small Grains Collection. This completes the grow-out of the Japanese introductions. Of the 411 introductions from Indonesia, only 39 introductions were released from quarantine and sent to NSGC, highlighting the very low viability of the Indonesian introductions. Clarissa questioned whether the remaining 500 Indonesian introductions brought in 20 years ago still need to be a priority. The decision was to prioritize the Indonesian introductions.

A procedure for introducing clonal wild *Oryza* species introductions was adapted from procedures used for other grass species and bud sticks from tree species. Ten wild species imported from IRRI underwent the first round of testing this fall, and after the second round of testing in spring 2008, these introductions may be released in late spring or summer to the requestor. Through collaborations with IRRI, CIAT, and YARI (Korea), serological tests for rice tungro bacilliform virus, rice tungro spherical virus, and rice hoja blanca virus were developed. ELISA techniques are under development for rice grassy stunt virus and rice ragged stunt virus. Future introduction of clonal material needs to be in quarantine for two seasons, this could be spring to fall but must be coordinated with Clarissa. (The hot water treatment will not be eliminated because of the white tip nematode.) Also, Clarissa and the "Poaceae Team" visited the Dale Bumpers National Rice Research Center on June 14, 2007, besides meeting people and facilities, ideas for making the quarantine and indexing program less labor intensive were shared.

Harold Bockelman discussed the International Treaty on Plant Genetic Resources for Food and Agriculture, referred to in several MTAs, including the SMTA (standard MTA) which all the International Agricultural Research Centers of the Consultative Group on International Agricultural Research (CGIAR) including IRRI and CIAT now use. The State Department has approved the agreement and it is now in the senate for approval. Also, Harold mentioned the Svalbard global seed vault, which is being built near the North Pole, is to be a permanent seed vault to preserve the world's germplasm. It is time to think about the next question of prioritizing what seed will go into the vault.

Fleet Lee, rice pathologist, mentioned that the "Compendium of Rice Diseases" is being updated and the editors are looking for persons to write the sections.

Wengui Yan, who coordinates rice germplasm evaluation, requested discussion relating to the following descriptors in GRIN. Groups providing descriptor information include the NSGC at Aberdeen, ID, which provides endosperm type (based on amylose data), hull color and cover, rough rice weight, and sterile lemma color. Resources at the DB NRRC are committed for ASV, amylose, brown rice weight, protein, days to flowering, lodging, plant height, plant type, awn type, bran color, kernel length, kernel width, L/W ratio, and panicle type. It was clarified the protein descriptor is done on brown rice not milled rice and the definition in GRIN should reflect this. Changing the descriptor "kernel weight-milled" to "kernel weight-brown" to reflect other kernel measurements and avoid the variation due do milling, was approved. Descriptors that require substantial time/resources are blast, sheath blight, straighthead, aromatic, parboil loss, allelopathy, and salt tolerance; thus, there are limited data. It was noted that for the core collection, Fleet Lee has evaluated 500 to 600 accessions per year for blast and sheath blight in the field. Drought stress in the field affects the blast evaluations. In the greenhouse, Fleet evaluates for seven blast races.

Dr. Yan stated that the entire rice collection has about 20,000 accessions at the present time from 116 different countries. This past year, 2,288 accessions were regenerated with 730 kg of seed produced. Long-season accessions were grown in Puerto Rico. For the core collection, 48 SSR markers were completed and an additional 27 SSRs were added that will be completed spring 2008, with both genome-wide and targeted markers. In summary, the core is characterized for 30 morphological traits and there will be fingerprints of the core collection with markers about every 30 cM. Subsequently, these data will be subjected to an association mapping analysis.

Anna McClung suggested the SSR marker data on the core could be correlated with any trait of interest and used for mining that trait. Shannon Pinson, in collaboration with David Salt, Purdue University, will evaluate mineral content of the grain for the core collection. There is a collaboration with China to look at about 100 accessions for out-crossing based on stigma.

M.O. Way, a member of the APHIS committee for the rice panicle mite, stated that APHIS is not pushing the methyl bromide treatment of greenhouses where the panicle mite has been identified. The plant pathology group suggested a formal letter to APHIS from the Germplasm Committee regarding the direction APHIS plans to take in dealing with the panicle mite. M.O. Way stated that Brian Kopper is the chair of the APHIS group, thus the letter should be addressed to him. After more discussion, it was decided that the letter would help but it would be better to wait and see if the panicle mite is found in fields this summer. It was noted that the panicle mite is definitely in Puerto Rico but has not been found at the University of Mayaguez station where the University and USDA rice winter nursery is located. M.O. stated that the mite has been found in a commercial field in Louisiana, and if it is found in other fields, APHIS will assume the mite cannot be contained. Natalie Hummel from the LSU AgCenter is tasked with research on the rice panicle mite.

The update of the committee membership concluded the meeting. Alan Stoner has retired and his position has not been filled thus, this Ex-Officio position on the committee will not be filled at this time. James Gibbons nominated Farman Jodari for another 6-year term, motion was seconded by Dwight Kanter, and approved. Dwight Kanter nominated Xueyan Sha to replace Robert Fjellstrom for a 6-year term, motion was seconded by Karen Moldenhauer, and approved. Karen Moldenhauer nominated Georgia Eizenga for a 2-year term as the committee chairman, motion was seconded by Dwight Kanter and approved. Motion to adjourn the meeting was made by Karen Moldenhauer and seconded by Dwight Kanter.

Submitted by
Georgia Eizenga

Publication Coordinator/Panel Chair Committee

Publication Coordinators Don Groth and Mike Salassi met with the 2008 Panel Chairs at 2:00 p.m. on February 18, 2008, at The Westin San Diego, San Diego, California.

Discussion centered on session operating procedures, including panel recommendations, procedural issues regarding concurrent sessions, CCA credit, and publication of abstracts in the 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 2010 proceedings. Proceedings should be available in both hard copy and CD format within 12 months of the meetings.

Submitted by
Don Groth and Mike Salassi

Rice Variety Acreage Committee

In attendance were: Bruce Beck, (Missouri), Don Groth (Louisiana), David Jones (California), Steve Linscombe (Louisiana), Garry McCauley (Texas), Kent McKenzie (California), Donna Mitten (BASF), Lorenzo Pope (California), Johnny Saichuk (Louisiana), Tim Walker (Mississippi), and Chuck Wilson (Arkansas).

The minutes of the 2006 meeting were presented and approved as presented following a motion by Garry McCauley and seconded by Chuck Wilson.

C. Wilson presented the Arkansas report. He said in 2006 Wells led all varieties at 30% followed by CL131 at 13%, Cheniere at nearly 11%, and Francis at almost 10%. The absence of CL131 and Cheniere in 2007 caused an increase in Wells, Francis, and CL161. Total acreage was 1.4 million in 2006 and decreased to 1.325 million in 2007. He said he expected acreage to remain flat with a possible 3% plus or minus margin. Clearfield lines are expected to increase in 2008. The availability of soybean seed will likely influence rice acreage in Arkansas in 2008.

K. McKenzie was only able to provide a distribution of California acres based on seed production. This estimate did not include Koshihikari and Akitakamachi and other Japanese types or any of the private varieties grown in California. Depending on water availability, California acreage could drop below 500,000 acres in 2008. Many of the reservoirs are low and demand from cities continues to put pressure on agricultural use. S. Linscombe asked if McKenzie expected any long-term interest in growing long-grain varieties in California. He indicated it was not likely. In answer to McKenzie's question, C. Wilson explained his use of the Arkansas DD50 program to estimate Arkansas rice acreage. Wilson reported about 40% of the growers participate in the program. He used various methods to compare the DD50 numbers and found them very reliable.

J. Saichuk reviewed the Louisiana acreage data for 2006 and 2007. In 2006, CL131, Cheniere, and Cocodrie each made up about 25% of the planted rice acreage. The absence of CL131 and Cheniere in 2007 resulted in an increase planting of Cocodrie, CL161, Trenasse, and hybrids. Linscombe said he thought 2008 acreage could be as high as 400,000 acres while Saichuk agreed with the caveat that it depended on soybean acreage, especially in northeast Louisiana. He said he expected rice acreage to drop in northeast Louisiana but increase in southwest Louisiana. David Jones asked about the possibility of an increase in medium-grain acreage. Saichuk and Linscombe agreed that without a significant premium medium-grain acreage will remain the same or lower for 2008 in comparison with 2007.

Missouri figures were reported by Bruce Beck. He said the loss of key rice personnel in Missouri to industry has made a rice acreage survey difficult. He said he expected Missouri's acreage to increase by about 10% to just fewer than 200,000 acres. He expected an increase in hybrid and Clearfield acreage.

Tim Walker presented the report for Nathan Buehring who had not arrived yet due to flight problems. In 2007, acreage was about the same as in 2006 with 66% of the acreage devoted to Cocodrie because of the absence of Cheniere and CL131. The 2008 acreage in Mississippi is expected to remain flat to increase slightly depending upon availability of soybean seed and need to fill soybean contracts. He did not expect the acreage to drop below 190,000. More acreage will be planted to hybrids and Clearfield lines in 2008 than the previous two years but Cocodrie should remain the number one variety.

The Texas report was presented by Garry McCauley instead of the ill Ted Wilson. As in the other southern states, Cheniere and CL131 had been important varieties in 2006 but in 2007 were replaced by an increase in Cocodrie, which has dominated Texas acreage for several years, Trenasse, Presidio, and hybrids, especially XL723. He said 2008 acreage will be dominated by Cocodrie because CL131 and Trenasse did not perform well in Texas. Hybrid acreage is likely to increase while Presidio acreage will remain constant. There could be a rebound of acreage planted to CL161. Acreage in 2008 should be flat to up slightly. The big story in Texas was the 15,000 acres of organically grown rice - a figure that could increase. The increase is price driven and dependent upon land meeting the qualifications for organic production.

Following a motion, the meeting was adjourned.

Submitted by
Johnny Saichuk

Industry Committee

The Rice Technical Working Group Industry Committee again held a successful luncheon at the 32nd RTWG meeting in San Diego, California, on Tuesday, February 19, 2008, at the Westin San Diego. 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 2008 Industry luncheon met all of these goals. The luncheon was attended by over 50 guests who heard Mr. Tim Johnson, President and CEO of the California Rice Commission speak about the unique challenges California rice growers face in an urban state in his talk entitled "California Rice: An Industry as Unique as Its State."

The Industry Committee would like to thank Dr. Randall (Cass) Mutters, Chairman, Local Arrangements Committee, and Ms. Angela Oates, Local Arrangements Committee member for their invaluable assistance in coordinating the luncheon.

And finally, the Industry Committee would like to welcome and congratulate Dr. Frank Carey, Field Market Development Specialist with Valent U.S.A. Corporation in Olive Branch, Mississippi, as the new Industry Committee Chairman for the RTWG.

The Industry Committee looks forward to again hosting a luncheon at the 33rd RTWG meeting in Mississippi in 2010.

Submitted by
Dave Jones

2006 Arkansas Harvested Rice Acreage Summary

COUNTY/ PARISH	2005 ACREAGE	2006 ACREAGE	MEDIUM GRAIN		LONG GRAIN								
			Bengal	Others	Cheniere	CL131	CL161	CL XL8	CLXL 730	Cocodrie	Francis	Wells	Others
Arkansas	121,513	110,867	2,020	1,210	13,551	11,568	3,085	2,754	992	4,737	27,763	35,915	7,271
Ashley	17,211	11,536	0	0	1,823	3,541	692	311	288	1,973	0	473	2,434
Chicot	37,011	25,228	0	0	5,399	4,995	1,791	1,665	177	2,725	0	6,736	1,741
Clay	86,295	79,826	2,120	986	5,244	13,311	1,694	5,002	4,760	1,936	9,197	17,264	18,313
Craighead	86,637	79,274	7,188	0	11,807	11,557	9,894	6,402	3,908	748	1,663	22,865	3,243
Crittenden	39,534	36,167	953	447	321	5,130	712	962	356	0	214	26,788	285
Cross	111,433	98,038	3,903	813	1,058	4,618	20,685	2,501	962	1,347	10,198	48,970	2,982
Desha	50,422	26,536	239	531	6,767	4,007	372	1,937	3,901	3,184	0	5,121	478
Drew	19,492	11,176	0	0	469	6,196	960	201	592	514	0	1,998	246
Faulkner	3,256	2,628	0	0	0	0	944	0	581	0	836	268	0
Greene	75,440	73,078	2,034	0	7,735	15,326	5,228	9,024	12,963	2,650	3,939	9,525	4,655
Independence	13,025	9,607	0	0	0	0	0	0	0	0	0	9,607	0
Jackson	99,990	89,945	10,536	5,117	7,032	6,000	10,126	6,657	3,844	1,688	0	36,847	2,063
Jefferson	69,308	56,049	43	0	10,652	11,493	785	0	0	12,446	0	20,183	449
Lafayette	4,280	3,966	0	0	178	119	167	301	0	2,443	0	531	226
Lawrence	109,063	102,712	1,958	5,307	11,703	34,572	7,730	8,482	8,697	5,476	3,006	9,448	6,335
Lee	30,891	21,449	1,051	99	2,366	992	1,577	1,645	2,254	0	5,341	6,873	0
Lincoln	33,676	26,740	68	0	560	13,216	0	1,998	1,599	0	6,821	2,478	0
Lonoke	88,030	76,145	8,527	0	13,259	8,031	5,986	4,470	3,334	1,591	8,940	18,790	2,955
Miller	6,864	3,047	0	0	0	0	0	0	0	0	0	3,047	0
Mississippi	49,263	39,489	0	40	635	40	1,270	437	397	397	3,056	28,178	5,040
Monroe	58,581	47,943	570	958	6,024	6,518	296	1,778	2,469	3,901	10,369	13,283	1,778
Phillips	30,985	28,077	0	0	11,034	393	533	1,460	1,432	6,149	4,998	2,078	0
Poinsett	133,339	119,389	32,349	338	4,402	4,280	7,582	6,604	2,201	611	11,128	46,958	2,935
Prairie	72,328	55,721	4,616	297	12,378	5,627	1,350	2,138	2,588	3,488	7,708	11,197	4,332
Pulaski	4,718	3,243	80	0	79	0	0	816	215	231	746	206	870
Randolph	34,789	33,094	957	0	3,490	5,202	4,774	3,918	3,721	428	1,383	3,885	5,334
St.Francis	54,835	39,126	4,389	1,062	2,259	837	0	0	502	753	4,518	21,795	3,012
White	15,618	13,950	462	0	2,248	524	2,207	1,186	1,255	372	0	2,207	3,489
Woodruff	63,574	57,867	3,110	649	5,958	4,134	2,189	4,195	3,526	1,581	12,341	17,752	2,432
Others	8,252	7,591	736	0	572	539	716	581	127	134	247	2,378	1,560
Unaccounted	5,346	10,497											
2006 Total		1,400,000	87,160	17,854	149,002	182,766	93,345	77,426	67,638	61,503	134,413	433,643	84,456
2006 Percent		100.00%	6.23%	1.28%	10.64%	13.05%	6.67%	5.57%	4.83%	4.39%	9.60%	30.97%	6.03%
2005 Total	1,635,000		80,801	22,089	118,018	1,477	311,491	39,473	4,000	153,309	164,443	609,499	130,400
2005 Percent	100.00%		4.94%	1.35%	7.22%	0.09%	19.05%	2.41%	0.24%	9.38%	10.06%	37.28%	7.98%

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

[2] - Other varieties: AB647, Ahrent, Banks, Clearfield 131, Cybonnet , Cypress, Della, Delmati, Dellrose, Drew, Jupiter, Koshihikari, LaGrue, Medark, Newbonnet, Nortai, Pirogue, Presidio, RiceTec XP 710, RiceTec XP712, RiceTec XP716, RiceTec XP 723, Saber, Spring, and Trenasse.

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

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

2007 Arkansas Harvested Rice Acreage Summary

COUNTY/ PARISH	2006 ACREAGE	2007 ACREAGE	MEDIUM GRAIN			LONG GRAIN							
			Bengal	Jupiter	Others	CL161	CL XL 729	CL XL 730	Cocodrie	Francis	Wells	XL 723	Others
Arkansas	110,867	105793	4220	1447	124	7516	313	2192	12213	29541	32047	8142	8,038
Ashley	11,536	11182	0	0	0	1543	0	0	1018	0	950	5692	1,979
Chicot	25,228	25051	0	0	68	2230	1629	326	7092	0	7818	2155	3,734
Clay	79,826	73323	4484	1753	0	3831	3381	3906	901	10968	26895	11269	5,935
Craighead	79,274	78031	6535	5097	319	9711	3632	3868	8526	1974	27790	6000	4,579
Crittenden	36,167	36703	2206	0	145	757	908	2081	492	0	25499	2346	2,270
Cross	98,038	84918	3129	725	420	26169	2395	941	684	12742	30787	3592	3,335
Desha	26,536	27528	2202	73	0	0	1821	440	4786	1850	7958	4170	4,229
Drew	11,176	10217	0	0	0	0	0	1124	419	0	5660	725	2,289
Faulkner	2,628	2313	0	0	0	0	771	771	0	0	0	771	0
Greene	73,078	67450	222	2729	0	9885	15005	14009	4978	0	10951	6329	3,342
Independence	9,607	10364	609	306	0	0	6929	1529	0	0	991	0	0
Jackson	89,945	91660	11264	9308	0	11174	3082	3660	2023	1926	34966	7513	6,743
Jefferson	56,049	58040	488	241	0	2808	458	745	5846	3553	26936	4986	11,978
Lafayette	3,966	1971	0	0	0	0	0	389	858	0	655	69	0
Lawrence	102,712	98234	2657	10176	0	25300	11269	2099	6960	1436	20881	8949	8,507
Lee	21,449	17849	586	215	0	397	435	0	946	4863	10407	0	0
Lincoln	26,740	26505	0	0	0	2680	0	876	663	6553	6314	9419	0
Lonoke	76,145	73533	11461	1250	741	5922	2260	2883	2338	11923	24313	3273	7,169
Mississippi	39,489	37346	0	0	63	226	0	0	0	5358	27056	4641	0
Monroe	47,943	46545	3223	47	0	2199	795	2152	4491	11181	19134	889	2,433
Perry	1,755	1377	0	0	0	809	0	0	0	0	0	0	568
Phillips	28,077	19857	0	0	0	1847	0	1033	6533	6593	2998	0	854
Poinsett	119,389	117228	27084	4649	40	11319	1368	2115	1493	11693	50999	2488	3,982
Prairie	55,721	59743	6378	2688	81	2584	1022	2404	4026	8232	17126	4988	10,215
Pulaski	3,243	3379	260	0	0	0	0	0	0	0	2353	0	766
Randolph	33,094	32509	2129	200	0	427	6976	1708	0	1388	4840	5623	9,218
St.Francis	39,126	34157	6218	1858	0	331	0	298	3078	2913	18634	397	430
White	13,950	12386	602	284	267	423	0	472	653	0	3362	3918	2,406
Woodruff	57,867	56399	3343	1484	0	5168	3645	1741	4243	10500	21162	3210	1,904
Others	7,591	3,411	0	0	0	280	409	0	427	173	855	820	447
Unaccounted	10,497	0											0
2007 Total		1,325,000	99,298	44,527	2,267	135,536	68,502	53,762	85,688	145,361	470,339	112,373	107,349
2007 Percent		100.00%	7.49%	3.36%	0.17%	10.23%	5.17%	4.06%	6.47%	10.97%	35.50%	8.48%	8.10%
2006 Total	1,400,000		87,160	11,309	7,046	93,345	556	67,638	61,503	134,413	433,643	26,688	476,699
2006 Percent	100.00%		6.23%	0.81%	0.50%	6.67%	0.04%	4.83%	4.39%	9.60%	30.97%	1.91%	34.05%

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

[2] - Other varieties: AB647, Banks, CL 171 AR, Cybonnet , Cypress, Della, Dellrose, Drew, Kaybonnet, Koshihikari, Medark, Nortai, Pirogue, Presidio, Rice Tec CL XL8, Rice Tec XP716 , Rice Tec XP 744, Rice Tec CL XP 745, Spring, and Trenasse .

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

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

2007 California Rice Acreage Summary

Variety	2004 ACREAGE	2004 PERCENT	2005 ACREAGE	2005 PERCENT	2006 ACREAGE	2006 PERCENT	2007 ACREAGE	2007 PERCENT
A-201	55.7	0.2	192.7	0.9	133.5	0.6	224	1.0
A-301	96	0.4	99.7	0.5	61.7	0.3	61.7	0.3
Calamylow-201	0	0	0	0	3.8	0.0	13.3	0.1
Calhikari-201	34.9	0.1	3.6	0.0	17.7	0.1	30.5	0.1
Calmati-201	40.7	0.2	40.7	0.2	4.7	0.0	22.1	0.1
Calmati-202	0	0	2.5	3.1	35.5	0.2	122.9	0.6
Calmochi-101	852.6	3.5	683.5	3.1	753.1	3.6	787.6	3.6
L-204	105.9	0.4	310.8	1.4	312,1	1.5	0	0.0
L-205	5.7	0.0	101.7	0.5	30.7	0.1	5.1	0.0
L-206	O	0.0	3	0.0	25.5	0.1	296.2	1.3
M-103	8.2	0.0	0	0.0	0	0.0	0	0.0
M-104	1758	7.2	1464.7	6.6	1073.1	5.1	1038.8	4.7
M-202	6,182.2	25.2	4743	21.5	4685.4	22.2	4541.5	20.6
M-204	1320	5.4	929.9	16.5	917	4.3	472	2.1
M-205	4780.9	19.5	3650	16.5	4195.8	19.8	4504.7	20.4
M-206	6884.6	28.0	7,021.2	31.8	6539.4	30.9	7,223.1	32.7
M-207	3.3	0.0	60.3	23.7	0	0.0	0	0.0
M-208	0	0.0	5.8	0.0	239.8	1.1	313.8	1.4
M-401	1890.8	7.7	2388.6	10.8	1690.9	8.0	1779.1	8.1
M-402	311.3	1.3	104.3	0.5	154.3	0.7	203.9	0.9
S-102	240.6	1.0	254.5	1.2	278.8	1.3	426.1	1.9
Total	24571.4	100.0	22060.5	100.0	21152.6	100.0	22066.4	100.0

2007 Florida Rice Acreage by Variety Report

10,160 acres planted
12,680 acres harvested (2nd crop accounts for larger harvested than planted acreage)

Most popular varieties:
Wells
Cypress
Cocodrie

2007 LOUISIANA RICE ACREAGE SUMMARY

Parish	2006	2007	MEDIUM GRAIN			LONG GRAIN							
	Acreage	Acreage	Bengal	Jupiter	Pirogue[1]	Cocodrie	Cypress	CL 161	Trenasse	CLXL-729	CLXL-730	Blend[2]	Other[3]
Acadia	65,281	64,695	2,135	4,981	0	23,150	4,750	5,900	8,750	6,500	3,650	0	4,879
Allen	9,830	11,640	0	170	0	6,770	20	2,095	870	0	0	520	1,195
Avoyelles	12,638	12,800	0	0	0	3,077	0	4,844	4,879	0	0	0	0
Beauregard	808	955	0	0	0	230	0	0	0	415	227	0	83
Bossier	50	24	0	0	0	24	0	0	0	0	0	0	0
Caddo	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcasieu	8,100	11,439	0	0	0	1,801	0	4,989	200	1,639	1,900	510	400
Caldwell		1,275	0	0	0	1,275	0	0	0	0	0	0	0
Cameron	3,625	10,964	457	969	0	4,578	0	2,098	1,860	0	0	0	1,002
Catahoula	2,643	2,360	0	0	0	1,652	0	236	0	0	0	0	472
Concordia	7,943	9,805	0	0	0	8,127	0	392	599	98	99	0	490
East Carroll	11,907	6,002	0	0	0	4,322	0	0	0	0	0	0	1,680
Evangeline	34,139	36,475	454	1,256	0	16,700	2,333	3,302	1,200	2,820	1,810	5,400	1,200
Franklin	0	0	0	0	0	0	0	0	0	0	0	0	0
Iberia	524	460	0	0	0	73	227	115	20	25	0	0	0
Jeff Davis	60,825	66,500	1,685	3,850	0	22,000	2,700	4,140	11,453	5,920	2,560	7,300	4,892
Lafayette	4,862	3,317	50	116	0	1,251	350	400	450	300	150	0	250
Madison		5,566	0	0	0	5,566	0	0	0	0	0	0	0
Morehouse	22,426	21,233	0	0	0	19,000	0	500	133	0	0	0	1,600
Natchitoches	2,200	3,641	132	400	500	2,000	0	609	0	0	0	0	0
Ouachita	5,086	5,528	0	0	0	5,528	0	0	0	0	0	0	0
Pointe Coupee		2,187	0	0	0	800	0	0	1,187	0	0	0	200
Rapides	8,390	8,785	692	144	0	6,156	0	1,531	0	0	0	0	262
Richland	4,616	5,243	0	0	0	4,194	225	524	0	0	0	0	300
St. Landry	21,214	20,307	146	0	0	14,113	1,965	3,573	0	0	0	0	510
St. Martin	4,206	4,593	0	0	0	1,748	1,969	583	165	0	128	0	0
Tensas	876	952	0	0	0	952	0	0	0	0	0	0	0
Vermilion	33,543	48,699	2,570	527	488	13,468	6,485	16,760	4,024	675	591	0	3,111
West Carroll	2,950	3,076	0	0	0	1,431	0	1,491	0	0	0	154	0
2007 Total		368,521	8,321	12,413	988	169,986	21,024	54,082	35,790	18,392	11,115	13,884	22,526
2007 Percent		100	2.26	3.37	0.27	46.13	5.70	14.68	9.71	4.99	3.02	3.77	6.11
2006 Total	328,682												
2006 Percent	98.00												

[1]Pirogue is a short grain variety.

[2] Blend is a mixture of two or more hybrids and/or pure lines produced by RiceTec.

[3]Other long grains include: Cybonnet, Spring, Cheniere, Wells, CLXL8, CL 171, XL723, Special Purpose: Toro 2, Hidalgo, Sabine, Della, Jasmine.

2007 Mississippi Rice Acreage Summary

COUNTY/ PARISH	2006 ACREAGE	2007 ACREAGE	CL 161	CLXL 729	CLXL 8	CLXL 730	Cocodrie	Hidalgo	Francis	Sabine	Wells	XL 723	Others[1]
Bolivar	52,076	55,371	8,859	2,301	2,525	111	35,761	80	0	0	1,661	3,923	150
Coahoma	9,473	12,150	100	400	0	500	7,750	0	100	0	3,100	100	100
DeSoto	643	1,869	0	0	0	0	1,869	0	0	0	0	0	0
Grenada	0	0	0	0	0	0	0	0	0	0	0	0	0
Humphreys	3,240	3,650	700	350	0	0	2,450	0	0	0	0	0	150
Issaquena	902	0	0	0	0	0	0	0	0	0	0	0	0
Leflore	17,138	8,025	75	0	0	0	6,700	0	0	0	1,250	0	0
Panola	5,606	3,700	0	0	0	0	3,700	0	0	0	0	0	0
Quitman	11,858	13,800	0	90	0	0	10,450	80	1,242	0	1,110	828	0
Sharkey	2,535	1,052	0	0	0	0	762	0	0	180	0	0	110
Sunflower	27,300	28,284	1,500	500	500	500	20,450	0	0	800	3,000	750	284
Tallahatchie	9,694	11,322	1,700	1,020	510	161	4,532	0	2,266	1,133	0	0	0
Tunica	22,776	17,821	551	1,739	1,493	0	9,833	0	0	0	0	4,205	0
Washington	25,464	24,218	1,719	245	245	0	18,912	80	0	2,702	0	245	70
2007 Total		188,262	15,204	6,645	5,273	1,272	123,169	240	3,608	4,815	10,121	10,051	864
2007 Percent		100	8.4	3.7	2.9	0.7	68.0	0.1	2.0	2.7	5.6	5.5	0.5
2006 Total	188,159												
2006 Percent	100												

[1] Other includes: CL 171 and Priscilla.

[2] Does not mean this variety or hybrid was not grown in 2006. 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.

Rice Acreage in Missouri by Variety 2001-2005
Percent of Acreage Planted

	Chenier	Cocodrie	Cypress	Wells	Drew	Clearfield	Francis	RiceTec	Others
2001	0	44	21	17.5	11	0	0	0	6.5
2002	0	45	14	34	3	2	0	0	2
2003	0	24	5	58	1	6	4	0	2
2004	3	18	0	46	0	9	21	1	2
2005	16	13	0	40	0	12	16	1	1

Rice Varieties in Missouri, 2005

Variety	Approximate Acres	Percent of Acres
Wells	84,400	40%
Francis	33,700	16%
Cheniere	33,700	16%
Cocodrie	27,400	13%
Clearfield 161	25,300	12%
Banks	2,100	1%
RTX8	2,100	1%
Cybonnet	2,100	1%

2007 Texas Rice Acreage by Variety

Update:10/19/2007

Variety Acres By County

COUNTY	2006 ACREAGE	2007 ACREAGE	ACREAGE Change	% MC Ratooned	LONG GRAIN COCO	PRES	TREN	XL723	CLXL730	WELLS	XL729	SIER	MILA	CYBO	CLXP	XL8	MEDIUM JUPI	OTHER*
East Zone																		
Brazoria	12997																	
Chambers	8088	8088	0%	0	2588	2507	2588										404	
Galveston	314	314	0%	0	314													
Hardin																		
Jefferson	14234	14234	0%	10		7971						1566					4697	
Liberty	5440	5440	0%	69		495		3721			919				305			
Orange																		
East	41308	39773	-3.7%	32	2902	10973	2588	3721			919	1566			305		5102	
Northwest Zone																		
Austin	904	900	-0.4%	33	900													
Colorado	25465	25404	-0.2%	60	22000		330	2845						229				
Fort Bend	4496	4236	-5.8%	45	3016			932	199		89							
Harris	195																	
Lavaca	1039	958	-7.8%	15	670		287											
Robertson																		
Waller	6260	6642	6.1%	95	1315			4045	66		737					126		352
Wharton	35417	31751	-10.4%	26	21051	603	5969	190	1492	603			1206	635				
NorthWest	73857	70056	-5.1%	39	48952	603	6587	8012	1758	603	826		1206	864		126		352
Southwest Zone																		
Calhoun	2767	2767																
Jackson	9929	8795	-11.4%	10	5770		1733		431	431								431
Matagorda	18075	15901	-12.0%	14	10320	2528	2258		572				223					
Victoria																		
SouthWest	31336	27717	-11.5%	12	16089	2528	3991		1003	431			223					431
Northeast Zone																		
Bowie	608	800	31.6%	0						800								
Hopkins																		
Red River	440	440																
NorthEast	1048	1240	18.3%	0						800								
State	147549	138786	-5.9%	21	67943	14105	13166	11733	2761	1834	1746	1566	1429	864	305	126	5102	783

Acreage Source: USDA/CFSA Certified Acreage

Update:10/19/2007

Percent Variety Acres By County

COUNTY	2006 ACREAGE	2007 ACREAGE	ACREAGE Change	% MC Ratooned	LONG GRAIN COCO	PRES	TREN	XL723	CLXL730	WELLS	XL729	SIER	MILA	CYBO	CLXP	XL8	MEDIUM JUPI	OTHER*
East Zone																		
Brazoria	12997																	
Chambers	8088	8088	0%	0	31	32	32										5	
Galveston	314	314	0%	0	100													
Hardin																		
Jefferson	14234	14234	0%	10		56						11					33	
Liberty	5440	5440	0%	69		9		68			17				6			
Orange																		
East	**41308**	**39773**	**-3.7%**	**32**	**10**	**39**	**9**	**13**			**3**	**6**			**1**		**18**	
Northwest Zone																		
Austin	904	900	-0.4%	33	100													
Colorado	25465	25404	-0.2%	60	87		1	11						1				
Fort Bend	4496	4236	-5.8%	45	71			22	5		2							
Harris	195																	
Lavaca	1039	958	-7.8%	15	70		30											
Robertson																		
Waller	6260	6642	6.1%	95	20			61	1		11					2		5
Wharton	35417	31751	-10.4%	26	66	2	19	1	5	2			4	2				
NorthWest	**73857**	**70056**	**-5.1%**	**39**	**70**	**1**	**9**	**12**	**2**	**1**	**1**		**2**	**1**		**0**		**0**
Southwest Zone																		
Calhoun	2767	2767																
Jackson	9929	8795	-11.4%	10	66		20		5	5								5
Matagorda	18075	15901	-12.0%	14	65	16	14		4				1					
Victoria																		
SouthWest	**31336**	**27717**	**-11.5%**	**12**	**58**	**9**	**14**		**4**	**2**			**1**					**2**
Northeast Zone																		
Bowie	608	800	31.6%	0						100								
Hopkins																		
Red River	440	440																
NorthEast	**1048**	**1240**	**18.3%**	**0**						**65**								
State	**147549**	**138786**	**-5.9%**	**21**	**49**	**10**	**9**	**8**	**2**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**4**	**1**

Acreage Source: USDA/CFSA Certified Acreage

2006 Texas Rice Acreage by Variety

Update: 12/18/2006

Variety Acres By County

COUNTY	2005 ACREAGE	2006 ACREAGE	ACREAGE Change	% MC Ratooned	LONG GRAIN COCO	CHEN	CL131	XL723	TREN	MILA	CLXL730	CLXL8	JEFF	CL161	DIXI	TEXM	WELLS	CYPR	PRES	SIER	XP710	XP729	MEDIUM JUPI	OTHER*
East Zone																								
Brazoria	15976	12997	-18.6%	14	7603			104			1768					1690								1832
Chambers	12792	8088	-36.8%	26		2831			2224	3033														
Galveston	833	314	-62.3%	0	314																			
Hardin	298	235	-21.1%	0	235																			
Jefferson	19355	14234	-26.5%	35	2847	285	7117												285	285			569	2847
Liberty	9381	5440	-42.0%	60			424	3688	218			1110												
Orange																								
East	58634	41308	-29.5%	30	10999	3116	7541	3792	2442	3033	1768	1110				1690			285	285			569	4679
Northwest Zone																								
Austin	2359	904	-61.7%	20	633	271																		
Colorado	30903	25465	-17.6%	45	15254	4940		1502	76	433				1961										1299
Fort Bend	6409	4496	-29.8%	50	3489	157	148	477	36				18											171
Harris	1067	195	-81.7%	95	195																			
Lavaca	1804	1039	-42.4%	54	598	166												116						158
Robertson	87	81	-6.9%																					
Waller	7672	6260	-18.4%	97	3305		732	1922			175	56										69		
Wharton	50678	35417	-30.1%	37	15017	7048	1062	1133	4073	460	1204	1346	496	319	1169		850	319						921
NorthWest	100978	73857	-26.9%	46	38490	12583	1943	5034	4185	893	1380	1402	514	2280	1169		850	435				69		2548
Southwest Zone																								
Calhoun	2438	2767	13.5%							1660	1107													
Jackson	12713	9929	-21.9%	41	3833	1877	576	348	1529	89	477	437	60	268	159			189				30		60
Matagorda	21863	18075	-17.3%	34	8080	2187	253	488	1265	596	777	596	2675		850									307
Victoria	1705	564	-66.9%	0		564																		
SouthWest	38720	31336	-19.1%	35	11912	4628	829	836	2794	2346	2361	1033	2735	268	1008			189				30		367
Northeast Zone																								
Bowie	2054	608	-70.4%	0													608							
Hopkins																								
Red River	639	440	-31.1%	0							136	136									167			
NorthEast	2693	1048	-61.1%	0							136	136					608				167			
State	201024	147549	-26.6%	39	61402	20327	10313	9662	9422	6272	5644	3682	3248	2548	2177	1690	1458	624	285	285	167	99	569	7594

Acreage Source: USDA/CFSA Certified Acreage

Update:12/18/2006

Percent Variety Acres By County

COUNTY	2005 ACREAGE	2006 ACREAGE	ACREAGE Change	% MC Ratooned	LONG GRAIN COCO	CHEN	CL131	XL723	TREN	MILA	CLXL730	CLXL8	JEFF	CL161	DIXI	TEXM	WELLS	CYPR	PRES	SIER	XP710	XP729	MEDIUM JUPI	OTHER*
East Zone																								
Brazoria	15976	12997	-18.6%	14	58			1			14					13								14
Chambers	12792	8088	-36.8%	26		35			28	38														
Galveston	833	314	-62.3%	0	100																			
Hardin	298	235	-21.1%	0	100																			
Jefferson	19355	14234	-26.5%	35	20	2	50												2	2			4	20
Liberty	9381	5440	-42.0%	60			8	68	4			20												
Orange																								
East	58634	41308	-29.5%	30	27	8	18	9	6	7	4	3				4			1	1			1	11
Northwest Zone																								
Austin	2359	904	-61.7%	20	70	30																		
Colorado	30903	25465	-17.6%	45	60	19		6	0	2				8										5
Fort Bend	6409	4496	-29.8%	50	78	4	3	11	1				0											4
Harris	1067	195	-81.7%	95	100																			
Lavaca	1804	1039	-42.4%	54	58	16												11						15
Robertson	87	81	-6.9%																					
Waller	7672	6260	-18.4%	97	53		12	31			3	1										1		
Wharton	50678	35417	-30.1%	37	42	20	3	3	12	1	3	4	1	1	3		2	1						3
NorthWest	100978	73857	-26.9%	46	52	17	3	7	6	1	2	2	1	3	2		1	1				0		3
Southwest Zone																								
Calhoun	2438	2767	13.5%							60	40													
Jackson	12713	9929	-21.9%	41	39	19	6	4	15	1	5	4	1	3	2			2				0		1
Matagorda	21863	18075	-17.3%	34	45	12	1	3	7	3	4	3	15		5									2
Victoria	1705	564	-66.9%	0		100																		
SouthWest	38720	31336	-19.1%	35	38	15	3	3	9	8	8	3	9	1	3			1				0		1
Northeast Zone																								
Bowie	2054	608	-70.4%	0													100							
Hopkins																								
Red River	639	440	-31.1%	0							31	31									38			
NorthEast	2693	1048	-61.1%	0							13	13					58				16			
State	201024	147549	-26.6%	39	42	14	7	7	6	4	4	2	2	2	1	1	1	0	0	0	0	0	0	5

Acreage Source: USDA/CFSA Certified Acreage

RECOMMENDATIONS OF THE PANELS

BREEDING, GENETICS, AND CYTOGENETICS

K. MCKENZIE, Chair; D. KANTER, Chair-Elect (2010); V. ANDAYA; D. BEIGHLEY; E. CASTANEDA; Q. CHU; G. EIZENGA; K. FOSTER; J. GIBBONS; F. JORARI; C. JOHNSON; K. JOHNSON; D. KANTER; J. LAGE; S. LINSCOMBE; J. LUNDBERG; C. MARTINEZ; K. MOLDENHAUER; J. OARD; S. ORDONEZ, JR.; A. ROUGHTON; J. RUTGER; X. SHA; R. TABIEN; and Z. YANG, 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 feasibility of economic production of hybrid seed and amount of heterosis obtainable under grower cultural practices is needed. Genetic control of efficiency of solar energy conversion, including photosynthetic efficiency, respiration losses, translocation rates, source-sink relationships, plant morphology, chlorophyll quality and quantity, etc., must be explored to determine if such factors can benefit the development of superior yielding varieties. Particularly in some areas along the Gulf Coast, improving ratoon crop yield potential is very important to the profitability of producers. Developing an understanding of the genetic, physiological, morphological, and environmental factors that influence ratoon crop yield is important for varietal improvement. Genetic stocks that have current or as-yet-unanticipated value should be preserved by entry into the newly-established Genetic Stocks-Oryza (GSOR) collection. Materials contributed will be accessible through GRIN and will be available to all interested researchers.

Molecular Genetics and Genetic Engineering
Molecular genetic studies of rice have accelerated rapidly due to the favorable qualities of this species, including its small genome size and ease of transformation. 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 such as microsatellites that can be used in crosses between Japonica rice. Genetic engineering is considered an emerging tool that will complement traditional methods for germplasm and varietal development. Genes for herbicide, insect, and disease resistance 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 and grain quality should be transferred into elite lines.

Response to Environment
Superior-yielding, widely adapted varieties should be developed that have increased tolerance to low soil, water, and air temperatures; greater tolerance to prolonged extremes in day/night temperatures during flowering and grain filling stages that reduce grain and milling yields and increase spikelet sterility; greater tolerance to saline or alkaline conditions; plant types with the capability of utilizing maximum available light energy and of possessing reduced water requirements. However, because of the geographical and climatic diversity among rice-producing areas in the United States, a need still exists to develop varieties for specific areas. New varieties and advanced experimental lines should be tested for reaction or response to registered/experimental pesticides in order to determine whether they are tolerant or susceptible to chemicals already in wide usage for which may be widely used in weed, disease, or insect control.

Resistance to Diseases and Insects

Intensive studies are required to develop varieties resistant to economically important diseases and insects. Breeding for increased resistance to all known races of rice blast fungus *(Pyricularia oryzae)*, rice sheath blight fungus *(Rhizoctonia solani),* aggregate sheath spot fungus *(Rhizoctonia oryzae sativae)*, and stem rot fungus *(Sclerotium oryzae)* should be emphasized with the objective of obtaining highly resistant varieties within all maturity groups and grain types. Efforts should be made to develop varieties with greater field resistance to these and other diseases. Breeding for resistance to brown spot *(Bipolaris oryzae)*, kernel smut *(Neovossia horrida),* 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 physiologic disease straighthead should be continued. A continuing emphasis on sources of resistance to these diseases in intensified cultural systems is needed. Breeding for insect resistance to rice water weevil *(Lissorhoptrus oryzophilus* (Kuschel)*)*, rice stink bug *(Oebalus pugnax* (Fabricius)*)*, and stored grain insects is also encouraged.

***Oryza* Species**

Other species of *Oryza* may contain the needed resistance or tolerance genes to important diseases, insects, and environmental stresses and/or grain chemical qualities that have not been recovered in *O. sativa*. Evaluation of these species and the transfer of desirable factors into adapted rice lines should be pursued. As germplasm lines are recovered from interspecific crosses, cooperative evaluation for disease resistance, insect resistance, and other features of interest would be desirable. 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 increased to develop varieties that give maximum yield per unit of nitrogen fertilization.

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, and nutritional value. As these properties are 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, and cooking properties. 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, 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. 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 information. Increased efforts are also needed to evaluate and maintain all entries in the active, working collection and to enter all descriptive data into the automatic data storage and retrieval system developed for the USDA Rice World Collection.

Germplasm Evaluation and Enhancement

Efforts should be made to develop relatively adapted, broad-based gene pools having a diversity of phenotypic and genotypic traits. Characteristics include components required for increasing yields of future cultivars and/or hybrids, such as straw strength, seed size, and number of florets per panicle. Other useful characteristics as may be identified during evaluation efforts may be incorporated into existing or new pools as appropriate. Genetic male steriles and/or gametocides may facilitate these efforts. This should not detract from continuing to develop a gene pool of high grain yield irrespective of quality or other undesirable characters. Development of indica germplasm with high yield and grain quality standards similar to U.S. cultivars should be pursued. The core subset strategy should be an effective way to evaluate germplasm collections. A core subset of about 10% of the U.S. rice collection has been established. Comprehensive evaluations of the core subset for phenotypic descriptors and DNA fingerprinting should be pursued by cooperative federal, state, and industry efforts.

Training of New Rice Breeders

There is concern about the shallow talent pool from which to select new breeders and geneticists to supplement and replace current and retiring U.S. rice researchers. New and specific efforts to develop and train our next generation of scientists 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. But it is believed that the model crop advantages are already waning. Interaction with K-12 students, teachers, science curriculum coordinators, and advisors is strongly urged as a means to encourage students to select pre-breeding fields of study for their B.S. Interaction with B.S. students will be required to encourage them to continue their studies with higher degrees to become knowledgeable breeders and geneticists. In addition to genetics knowledge, 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.

ECONOMICS AND MARKETING

D. SUMNER, Chair; S. MARTIN, Chair-Elect (2010); K.B. WATKINS; E. CHAVEZ; M.A. DELIBERTO; M. SALASSI; N. CHILDS; E. WAILES; D.A. SUMMER; J.M. RAULSTON; G. TIBBITTS; J.A. HIGNIGHT; and M. ROSEGRANT, 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

LARRY GODFREY**,** Chair; T.W. ALLEN, Chair-Elect (2010); M.O. WAY; M.S. NUNEZ; R.A. PEARSON; M. JIANG; M.J. STOUT; S. LANKA; G. BARBEE; M.R. RIGGIO; J.C. HAMM; R.M. RIGGIO; S. POURIAN; L. ESPINO; M. WEISS; R. LEWIS; W. PINKSTON; K. WINDBIEL-ROJAS; N. HUMMEL; J. BERNHARDT; T. MOSS; J.C. HAMM; J. LV; L.T. WILSON; D.E. GROTH; J. OSTER; Y. JIA; B. VALENT; and F.N. LEE, 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 cause 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.

PROCESSING, STORAGE, AND QUALITY

Z. PAN, Chair; E. CHAMPAGNE, Chair-Elect (2010); J. KENDALL; C. GRIMM; F. SHIH; M. FITZERALD; T. SIEBENMORGEN; R. BAUTISTA; D. HIMMELSBACH; and C. EARP, 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 components 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

R. PLANT, Chair; D. HARRELL, Chair-Elect (2010); N. BUEHRING; R. DELONG; D. FRIZZELL; B. GOLDEN; D. JONES; E. MASCHMANN; R. MAZZANTI; R. NORMAN; N. SLATON; J. SATTERFIELD; L. TARPLEY; T. WALKER; and 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.

RICE WEED CONTROL AND GROWTH REGULATION

A.J. FISCHER, Chair; J.A. BOND, Chair-Elect (2010); T.W. WALKER; N.W. BUEHRING; L.C. VAUGHN; J.A. BULLINGTON; E.P. WEBSTER; V.K. SHIVRAIN; N.R. BURGOS; K.L. SMITH; D.R. GEALY; S.L. BOTTOMS; J.B. HENSLEY; J.S. ATWAL; H. YASUOR; G.N. MCCAULEY; J.M. CHANDLER; N.R. BURGOS; J.R. MEIER; R.C. DOHERTY; R.C. SCOTT; B.J. WILLIAMS; R.K. GODARA; and A.B. BURNS, 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.

Symposium: Yield Barriers, Environment, and World Market: Contemporary Challenges to Research, Production, and Trade Moderator: J.E. Hill

Imitation and Invention: C4 Rice, Crop Production, and Poverty Alleviation

Sheehy, J.E., Ferrer, A.B., Dionora, M.J.A., Pablico, P.P., and Mabilangan, A.E.

Agriculture is the indispensable base of human society, and the nature and productivity of agriculture are determined by water, climate, and the products of research. Over the next 50 years, the population of the world will increase by about 50%, climate change will likely result in more extreme variations in weather and cause adverse shifts in the world's existing climatic patterns, water scarcity will grow, and the demand for biofuels will result in competition between grain for fuel and grain for food, resulting in price increases. Currently, a billion people live on less than a dollar a day and spend half their income on food, 854 million people are hungry, and each day, about 25,000 people die from hunger-related causes. Sixty percent of the world's population lives in Asia where each hectare of land used for rice production currently provides food for 27 people, but by 2050, that land will have to support at least 43 people. However, the elite rice cultivars, which dominate the food supplies of the millions of poor people in Asia, have approached a yield barrier, plant breeding seems to have exploited all of the intrinsic high yield-linked genes, and growth in production is slowing. Theoretical models suggest that, for rice, further increases in yield potential can be achieved only by converting it from a C3 to a C4 plant. This will require the integration of efforts from those engaged in fundamental and applied research. However, funding mechanisms to integrate the research required for C4 rice, across national and disciplinary boundaries, are almost non-existent. Skepticism concerning such a project exists. Questions arise: Is it feasible and could it really deliver a quantum increase in yield, water-use efficiency, and nitrogen-use efficiency simultaneously?

Carbon Sequestration Potential and Greenhouse Gas Emissions in Rice

Horwath, W.R.

World rice production represents a significant agricultural land use encompassing 154 million hectares of cropland. Rice production represents about one third of the major world cereal production. World rice production per hectare ranges from 1 to 11 tons/ha. Higher production values are often associated with double or triple annual cropping systems in warm climates. In addition, high production areas are often associated with low lying landscape positions with higher soil C contents. California rice is known for its high yield potential, averaging up to 9.0 tons/ha for single season rice. Rice production in the United States is less than 1% of world production. Nitrogen fertilization is a key component of increasing rice yields. Fertilizer N applications average 73 kg N/ha globally. In the United States, typical application rates are 165 kg N/ha. Fertilizer uptake efficiency by rice ranges from 50 to 80% of applied N. This is typical of cereals in general, and whether needed or not, the high fertilizer N rates are perceived necessary to achieve maximum production potential. The low fertilizer use efficiency can lead to environmental impacts from leaching of nitrates to greenhouse gas emissions in the form of nitrous oxide. The high grain yield is also associated with high straw production; straw contains a labile source of C that can exacerbate an already present phenomenon of methane emission in rice.

Rice production systems are intensively managed wetlands that introduce N and C in the form of fertilizer and crop residue far in access that occurs in natural wetlands. These sources of N and C can contribute significantly to the production of greenhouse gases; specifically methane and nitrous oxide. Methane emissions from rice account for 1.3% of total global emissions, increasing 6.2% since 1990. Methane emissions from California rice have been estimated to be in the range of 80 to 120 kg C/ha annually being affected by both straw and water management. California methane emissions are lower than other parts of the world, which can be attributed to lower soil C contents. The effect of water management in rice has shown positive effects in reducing methane emission but potential negative effects of increased N_2O emission. Midseason draining to accommodate herbicide and fertilizer applications has been shown to dramatically reduce methane emissions. The midseason drain aerates the soil sufficiently to raise redox potential above the point where methanogens can produce methane. In addition, the higher redox potential promotes the oxidation of methane to carbon dioxide, a less potent greenhouse gas with 27 times lower heat trapping potential. The timing and duration of the drain events are critical in determining the amount of methane that will be emitted.

Nitrous oxide emissions from rice are less understood than CH_4 emissions. This is evident in the fact that estimates of N_2O emissions from rice production are not listed in global greenhouse gas inventories. Continuously flooded rice is not expected to be a significant source of nitrous oxide emission. Continuous flooding maintains sufficiently reduced conditions to prevent the oxidation of ammonium to nitrate. However, fluctuating water heights that create alternating reducing and oxidizing conditions can lead to significant nitrate production, the substrate for a group of microbes called denitrifiers. Denitrifiers use nitrate as an alternative electron acceptor and produce dinitrogen, a benign gas composing approximately 80% of the atmosphere. During denitrification, nitrous oxide is formed as an intermediate gas before dinitrogen is formed. Under continuous flooding, little intermediary nitrous oxide emission occurs. However, under fluctuating water management where deliberate in-season draining is done, conditions may promote nitrous oxide production. Nitrous oxide is a potent greenhouse gas with 297 times the heat- trapping potential of carbon dioxide. In California rice, fluctuating early-season water management is becoming common cultural practice for the application of herbicides. The changing cultural practices have the potential to increase nitrous oxide emission, depending on drain length and timing and amount of fertilization N application. Little information exists on the impacts of midseason drainage on nitrous oxide emission. It is critical to assess and predict potential changes in baseline greenhouse gas emissions as a result of changing cultural practices in order to develop optimal Best Management Practices for rice production. Alternative irrigation practices adopted elsewhere demonstrates that midseason drainage can substantially reduce methane emission with minimal affects on rice yield. However, the effect on nitrous oxide emission must be assessed to determine any greenhouse emission mitigative value, especially in regards to N inputs. This information is required so the rice farmers can actively participate in future C trading markets and to ensure rice cropping remains sustainable with minimal environmental impact.

Abstracts of Papers on Breeding, Genetics, and Cytogenetics
Panel Chair: K.S. McKenzie

Expensive Lessons Created by Unassuming Biological Facts

Johnson, C.W.

The evolution of biotechnology has created a revolution in the university, seed industry, governmental agencies, and breeding organizations developing varieties with traits for the marketplace. In the rush to get various products developed, registered, and protected by intellectual property rights, there has been and will continue to be expensive lessons for those ignoring sound experimental procedures, realistic protocol, and production practices.

A thorough knowledge is needed of the varieties serving a particular market need(s), germplasm in the breeding pipeline, and new introgression sources for disease, quality, and other traits and its phenotypic response to a regional geographic area with similar soil types and environmental ecotypes. The primary site of early generation grow outs and other sites with limiting factors such as high/low temperatures can contribute to differential selection pressure for breeding lines.

New technologies demand greater training and specializations. Actual field experience in experimental design, plot layout, trait(s), phenotype(s) observations, appropriate data analysis, statistical models, expected mean squares and G x E interactions often suffer. Reading varietal development histories of successful breeding lines, including off-season nurseries, modified breeding schemes, and utilizing specific character tests in early generations yield positive results. Various breeding objectives require appropriate selection pressures (weighted tests) at each generation. You don't want to create information overload by collecting data that results in a poor return on resources (time and money). Early generation testing and crossing with the appropriate screens are the key to handling a large volume of material.

Yield and Agronomic Performance of Variety and Hybrid Rice Blends in Louisiana

Blanche, S.B., Linscombe, S.D., and Sha, X.

Multi-environment trials were conducted in 2006 and 2007 at the Rice Research Station near Crowley, Louisiana, and five on-farm test locations throughout the rice-growing regions of the state using seed of different varieties and hybrids blended prior to planting.

The objective of this research was to determine if blending varieties and hybrids increases grain and milling yield and stability compared with the components planted alone (monoculture). Cultivars used in the studies were the variety Cocodrie, an experimental line designated RU 0402152, and two uniform F_1 hybrid cultivars. All possible combinations were blended at 50/50 in the stability study, and different ratios were used in the ratio study. The amount of seed of each component in a blend was determined by adding a percentage of a typical seeding rate for that component. The percentages used in each treatment did not exceed 100% of the collective seeding rates for the two components, i.e., 10% x 90%, 50% x 50%, 25% x 75%. Normal seeding rates are 112 kg/ha (100 lb/A) for varieties and 34 kg/ha (30 lb/A) for hybrids. For a 50/50 two-variety blend, both components were blended at a rate of 56 kg/ha (50 lb/A). For a 75/25 two-variety blend, varieties A and B were blended at ratios to equal 84 and 28 kg/ha (75 and 25 lb/A), respectively. For a 50/50 variety x hybrid blend, rates equivalent to 56 kg/ha for the variety and 17 kg/ha (15 lb/A) for the hybrid were blended. Rates were calculated as such based on the assumption that typical seeding rates for varieties and hybrids will maximize use of the available resources (light, fertility, etc.).

The most appropriate comparison for yield, milling quality, and agronomic performance is between a cultivar blend and the weighted average of the components that constitute that blend. Thus, grain and milling yield of various cultivar blends were compared with the weighted mean of the components of each blend, which is the expected performance if the components had been planted traditionally.

Hybrid Rice Research and Development in the Americas

Chu, Q.R., Cuevas, F., and Nelsen, J.

Commercial exploitation heterosis allows maintaining a 20 to 25% yield advantage over traditionally bred varieties. This technology has been successfully deployed to traditional small seed- and grain-producing farms in China since 1976. RiceTec is the only company able to exploit heterosis in large highly-mechanized farming operations in the United States. Global germplasm, wide genetic diversity, trait conversion, pyramid crossing, test-crossing, pedigree selection, mutation, and marker-assisted selection are all integrated into the current RiceTec breeding program. Using the template of Chinese male sterility systems, RiceTec scientists have developed genetically diverse lines amenable for mechanized hybrid seed production and with agronomic and grain quality standards demanded by the U.S. farmer. Shuttle breeding from spring-winter locations in Texas and Arkansas to winter locations in Puerto Rico have expedited the line development cycle. More than 3,000 hybrid combinations are included in preliminary yield and advanced trials every year to identify the best 2 to 3 hybrid combinations. The best candidates are included in on-farm trials conducted in over 70 locations allowing for identifying commercially viable hybrids. Hybrid breeding not only targets high grain yield but also improves other characteristics, such as early maturity, grain and milling quality, disease resistance, lodging resistance, and second crop (ratoon) yield potential. Breeding activities annually include 500 new breeding crosses, 5,000 test-crosses, 50,000 progeny row selection, and 5,000 hybrid evaluations. Multi-location and multi-year testing of the Advanced-Yield Trials conducted by RiceTec have demonstrated the performance advantage of RiceTec hybrids compared with conventional cultivars. Large scale mechanization of hybrid seed production provides commercially viable hybrid seed for U.S. farmers. Since 2002, RiceTec has released 16 hybrids to the U.S. market and six new hybrids into the Latin and South American markets. In 2007, RiceTec hybrids accounted for over 20% of the market in the southern U.S. rice-producing states with rapidly growing market shares in Latin and South America.

Characterization of Very High Tillering and Dwarf Rice Mutant Lines

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

Rice is a good model crop for the study of branching in monocotyledonous plants. Tillering in rice is a very important agronomic trait, which determines the yield potential of a particular variety. A number of high tillering rice mutants have been identified, but most of them are not fully characterized due to poor vigor or very stunted growth. Rice mutants are potential resources for new gene discovery, functional characterization, as well as germplasm. Very high tillering and dwarf mutants will be useful in understanding the genetic factors that control tiller number and plant height in rice. These mutants can also be used in studying bud dormancy.

A very high tillering dwarf rice mutant was selected from an early generation of L-202 x Saber cross at the Texas A&M University System, Agricultural Research and Extension Center, at Beaumont. Saber is a long-grain semi-dwarf variety with excellent lodging resistance and high tillering capacity. L-202 is an early maturing long-grain variety. Several lines were advanced by panicle to a row planting, and two lines were used in phenotypic characterization. Based on Takeda's classification of dwarfing pattern of the top four internodes, the very high tillering and dwarf mutant could be categorized into a dn-type dwarf, but a few plants had a different dwarfing pattern not included in the classification. Germination percentage in Petri dishes was very low (30-40%). However, higher germination (55-60%) was observed for different lines when direct seeded to soil. The identified mutants were 50 to 55 cm tall in field conditions and produced 80 to 105 tillers per plant at maturity. The first tiller emerged at the 5-leaf stage. Tiller production doubled every week, resulting in a final tiller number that was approximately four times that of Cocodrie or Zhe733. The production of new tillers continued even at the late reproductive stage. Thus, these mutants might be useful for higher biomass production and ratooning studies if the trait is not pleiotropic with plant height. It was observed that 80 to 85% of the tillers were productive tillers bearing a very short panicle (10-12 cm) and few grains (25-30 grains/panicle). The mutants produced small seeds that could be considered as long grain since the seed length-to-width ratio ranged from 3.73 to 3.75. The number of days to heading and harvest of the mutant was 95 and 121 days after planting, respectively. The pattern of flowering was normal, and grain filling was always very good under field conditions. A separate study was conducted in the greenhouse to determine the response of the mutant lines to varying plant density and nitrogen fertilization. Three levels of nitrogen and five levels of plant densities were used to determine their effects on different agronomic traits of the mutants, such as total tiller number, flag leaf length, panicle length, filled grain per panicle, non-filled grain per panicle, total number of grain per panicle, and plant height. The analysis of variance showed no significant differences among the three different levels of nitrogen and two plant densities (four and five plants) for total tiller number, flag leaf length, filled grain per panicle, total number of grain per panicle, and plant height. Reciprocal crosses were made with Cocodrie to determine the inheritance pattern of very high tillering and the dwarf trait. The response of the mutant lines to growth regulators such as gibberillic acid is currently being evaluated.

***Rc-g*: A New Allele for Red Pericarp Discovered in Cultivated Rice**

Brooks, S.A., Yan, W., Jackson, A.K., and Deren, C.W.

The occurrence of grain with red pericarp in rice production is normal where red rice is a common weed problem. Classic weedy red rice can usually be distinguished morphologically without the need to de-hull seed to reveal pericarp color. However, rice with red pericarp is also found in cultivated grain types and has typically been attributed to outcrosses of cultivated rice to red rice. Recently, typical long grains with red pericarp were identified at a very low frequency in a seed lot of the cultivar Wells. The goal of this project was to fully characterize red pericarp-Wells and determine the source of red pericarp in these seeds.

The *Rc* locus regulates pigmentation of the rice bran layer, and selection for the *rc* allele (white pericarp) is ubiquitous among cultivated rice varieties. Using molecular markers and DNA sequence for the *Rc* locus, it was demonstrated that red pericarp in Wells was not the result of an outcross or seed mixture. A new allele that arose by natural mutation within the *rc* pseudogene was identified. The mutation restored the reading frame of the gene and reverted the bran layer pigmentation to red (wild-type). Using DNA sequence and linkage analysis, it was demonstrate that mutation within *rc* resulted in the new, dominant, wild-type allele *Rc-g*.

The *Oryza* Map Alignment Project (OMAP) Introgression Lines for Allelic Diversity and New Germplasm Development

Sanchez, P.L., Kudrna, D., Eizenga, G., and Wing, R.

The *Oryza* Map Alignment Project (OMAP) has developed a genus-wide model system for the study of rice that will ultimately provide a complete understanding of the genus. The purpose of this project is to capitalize on the strengths of the Arizona Genomics Institute (AGI), OMAP participants, and the rice breeding community to continuously provide, for years to come, useful and previously unexplored germplasm materials to increase rice genetic diversity and initiate new cultivar development. At this point in the project, the AA genome species can be crossed to cultivated rice for creating new diverse genotypes. Three approaches were used: (1) advanced backcross (ABC) populations for allele identification, (2) chromosome substitution lines (CSSL) for analytical introgression of wild germplasm segments using marker-assisted selection (MAS), and (3) construction of the first molecular genetic maps of more distant *Oryza* species for long-term mining of useful genes and alleles from rice relatives. In the ABC and CSSL populations, MAS and QTL mapping will be used for identifying environmentally useful traits (i.e., cold and aluminum tolerance, stress, drought, etc.), disease and insect resistance, milling quality and yield traits.

For particular interest, we selected elite rice cultivars M-202, LaGrue, and Nipponbare as introgression recipient lines. M-202 and LaGrue are grown largely in California and southern regions in the United States; both are in line for alignment re-sequencing to the IRGSP pseudomolecules that will strengthen their utility and usefulness. Nipponbare was the first cultivated rice genome completely sequenced and has vast molecular resources for downstream research that may involve structural and functional genomics, as well as proteomics. The AA genome wild rice accessions are of interest for identification of potential useful alleles and genes, as well as for advanced scientific study. Of interest: *O. meridionalis* (IRGC104092) and *O. glumaepatula* (IRGC100969) because of their geographical origin (Australia and Suriname), which is different from *O. rufipogon* accession used in CSSL development. In addition, *O. meridionalis* has been reported to have drought tolerance and rare secondary branching. *O. glumaepatula* may provide a new cytoplasmic male sterility source for hybrid rice. The *O. meridionalis* (W2112) from Australia may provide interesting alleles for drought tolerance due to possible evolution of the species in a semi-dry environment. The *O. barthii* (IRGC101937) has good potential as a donor for abiotic stress tolerance, especially if we consider the possibility of observing transgressive effects. The *O. glumaepatula* (GEN1233) was chosen for its good level of aluminum tolerance, which represents a promising trait for cultivating rice on acid soils. In addition, useful agronomic, biotic, and abiotic traits from the wild rice species outside the AA genome will also be utilized.

For ABC and CSSL, each cultivar (M-202, Nipponbare, and LaGrue) is crossed to the following *Oryza* accessions: *O. glaberrima* (IRGC96717), *O. barthii* (IRGC105608), *O. nivara* (IRGC100897), *O. rufipogon* (IRGC106424), *O. meridionalis* (IRGC104085), *O. glumaepatula* (W2199), and *O. longistaminata* (IRGC110404). For ABC, F_1 hybrids are confirmed and advanced to BC_2F_2, genotyped, advanced to F_3, and seed collected. The resultant lines will be used by collaborative U.S. rice researchers for assessment and identification of useful alleles. For CSSL, introgressed segments of approximately 10cM are tracked. Following genotyping of 300 BC_2F_1 plants per segment, lines are advanced and backcrossed to the BC_4F_1, genotyped to confirm introgression segments and seed produced from the BC_4F_3 prior to release.

For molecular genetic map construction of the 10 distinct *Oyrza* genome groups, crosses are as follows: **AA**: *O. glaberrima* (IRGC 96717) x *glaberrima* (IRGC 103544), *glaberrima* (IRGC 96717) x *nivara* (IRGC 100897), *glaberrima* (IRGC 96717) x *barthii* (IRGC 105608), *glaberrima* (IRGC 96717) x *meridionalis* (W1625), *glaberrima* (IRGC 96717) x *meridionalis* (W2112), *glaberrima* (IRGC 96717) x *longistaminata* (IRGC 110404), *glaberrima* (IRGC 96717) x *rufipogon* (IRGC 106424); **BB**: *punctata* (IRGC 105690) x *punctata* (IRGC 104154); **CC**: *officinalis* (IRGC 100896) x *eichingeri* (W1519), *eichingeri* (W1519) x *eichingeri* (SL6); **BBCC**: *minuta* (IRGC 101141) x *malamphuzaensis* (IRGC 105223); **CCDD**: *alta* (IRGC 105143) x *grandiglumis* (IRGC 101405); **EE**: *australiensis* (IRGC 100882) x *australiensis* (W2084); **FF**: *brachyantha* (IRGC 101232) x *brachyantha* (W1057); **GG**: *granulata* (IRGC 102118) x *meyeriana* (IRGC 104989); **HHJJ**: *ridleyi* (IRGC 100821) x *longiglumis* (IRGC 106525); and **HHKK**: *coarctata* (IRGC 104502) x *schlechteri* (IRGC 82047). F_1 hybrids are confirmed by polymorphic identification of several alleles in comparison with parental screenings and backcrossed to the recurrent wild parent. Following hybrid confirmation, BC_1F_1 plants are selfed to produce BC_1F_2 seed.

SNP Discovery and Utilization: Are We Finally Looking at the Holy Grail of Blending Plant Breeding and Molecular Biology?

Scheffler, B.E.

The total replacement of rice breeders by molecular biologists is an unrealistic hypothesis. Presently, there is nothing that can replace the skill of a plant breeder, and the old saying that plant breeding is a mixture of science and art has never been truer as it is today. The artistic skill of a breeder can be improved by experience but there is little that can be done about their natural ability. Otherwise, they would all eventually become Michelangelos. However, science is part of the equation that can be improved and utilized to improve every breeding program. Therefore, the big question is how we can use science so plant breeders can spend their time using their most important abilities?

The sequencing of the rice genome has opened the possibility and reality of many basic and applied research projects that were never possible before today. The translation of this information to breeding programs has been successful, but it could be better. SNPs (Single Nucleotide Polymorphisms) represent a way that DNA markers can be quickly and relatively inexpensively associated with desired traits. SNPs also can be cheaper to apply to breeding programs than current marker technology and the amount of data handling is also reduced. This talk deals with current efforts to develop SNPs for the RiceCAP effort and will hopefully lead to discussions for their proper implementation and utilization.

Analysis of Plant Traits in Rice Sub-Populations and *O. rufipogon*

Eizenga, G.C., Ali, M.L., McCouch, S.R., and McClung, A.M.

The main objective of this project is to determine if the sub-population structure in rice is predictive of transgressive variation (the occurrence of progeny displaying phenotypes more extreme than either parent) and begin to characterize the underlying genetic basis of this phenomenon in part by developing chromosome segment substitution lines (CSSLs) between rice (*Oryza sativa*) and its progenitor, *O. rufipogon*. At this time, the preliminary data collected on agronomic and seed traits on a diverse collection of *O. sativa* and *O. rufipogon* accessions for an association mapping study are reported.

The 400 *O. sativa* accessions included 174 diverse accessions genotyped in previous studies by S.R. McCouch, 165 accessions which are a subset of the USDA-ARS NSGC core collection, 57 accessions from the USDA-ARS *O. sativa* germplasm collection, and four reference cultivars (Spring, Cocodrie, Cybonnet, and 93-11). In 2006, these accessions were grown as space plants in two replications and a single plant selected for purification, evaluation, and seed increase in the 2007 growing season with a similar plot design. Also, 100 *O. rufipogon* accessions were selected from 208 accessions based on genotyping with 36 SSR markers, plant type, seed set, and crossability. The *O. rufipogon* accessions were purified as single plant selections and are being characterized for most of the same traits as the *O. sativa* accessions. All accessions are being genotyped with 30-36 SSR markers. These SSR markers overlap significantly with those being used for genotyping on the USDA-ARS NCGC core collection, the standard panel for rice used at Cornell University, and those being used for genotyping as part the Generation Challenge Program at the International Rice Research Institute, Philippines.

In the field during 2006 and 2007, the *O. sativa* accessions were characterized for days to heading that ranged from 47 to 127 days; plant height (62-208 cm), number of panicles per plant (3-104 panicles), and plant type grouped into five categories. In 2006, the plants matured about 9 days earlier and were shorter compared with data for these traits collected in 2007. The primary panicle was characterized for flag leaf length, ranging from 12-85 cm; flag leaf width (0.5-2.3 cm); panicle length (12.8-50.0 cm); number of primary panicle branches per panicle (5-19 branches); florets per panicle (57-404 florets); and seeds per panicle (0-344 seeds). The percent lodging, type of panicle, type of awn, seed shattering, and leaf pubescence also were noted.

The seeds are being characterized with the WinSEEDLE Image Analysis system. Preliminary data on paddy rice (with hull) from 167 accessions grown in 2006 included hull color that divided into six categories, seed length ranged from 6.4-12.8 mm, seed width (2.2-3.9 mm), curved seed length (6.5-12.9 mm), curved seed width (2.2-3.9 mm), and seed volume (3.6-17.4 mm^3). Subsequently, similar data were collected on dehulled grains, including seed color that divided into six categories, grain length (4.6-9.0 mm), grain width (1.8-3.6 mm), curved grain length (4.7-8.2 mm), curved grain width (1.8-3.3 mm), and grain volume (2.7-12.4 mm^3). The chemical characteristics of percent amylose, alkali spreading value, and grain protein also will be determined.

The genotype of the 400 *O. sativa* accessions is being confirmed with 30 SSR markers. A cluster analysis will group the *O. sativa* accessions with one of the two rice sub-species, *indica* or *Japonica,* and most accessions should group into one of the five rice sub-populations (*indica*, *tropical Japonica*, *temperate Japonica*, *aromatic,* or *aus*). These sub-populations will be an important consideration in the analysis of the phenotypic trait data.

Similarly, the 100 *O. rufipogon* accessions are being evaluated for most of the same traits as the *O. sativa* accessions in the greenhouse. Preliminary data collected on many of the 208 *O. rufipogon* accessions determined that the plant height ranged from 30 to 200 cm, number of tillers per plant from 1 to 220 tillers, and the plant type grouped into nine categories. Seed traits that were measured with the WinSEEDLE Image Analysis included hull color, seed length, seed width, curved seed length, curved seed width, seed surface area, and seed volume.

In co-operation with co-PI: Carlos Bustamante (Dept. of Biological Statistics & Computational Biology, Cornell Univ.), these data will be used to conduct an association mapping analysis with the 10,000 SNPs to identify marker-trait associations for the 32 phenotypic traits presently being characterized in the 400 *O. sativa* and 100 *O. rufipogon* accessions.

Using Molecular Markers SSR to Search Wild Introgressions from a Relative Tetraploid Species in the Diploid *Oryza Sativa* L.

Sanabria, Y., Carabalí, J., Olaya, C., Martínez, C.P., and Tohme, J.

The genus *Oryza* consists of two cultivated rice species (*O.sativa* and *O.glaberrima*) and about 20 related species, which represent a source of new alleles for improving the yield, quality, and stress resistance of cultivated rice. Genome differentiation at the diploid and tetraploid levels has been considerable, which makes difficult the transfer of alleles of interest to cultivated rice by crossing. Triploid sterile hybrids between an accession of allotetraploid species *Oryza latifolia* (2n=48) and the diploid *O. sativa* (2n=24) by embryo rescue were obtained. After three backcrosses to *O. sativa,* fertile progenies were obtained. Citogenetical evaluation in all generations showed some pairings between the *O. latifolia* and *O. sativa* chromosomes in the F_1 and a trend to complete diploidy in later generations. To show wild introgressions into *O. sativa,* 312 SSRs were proved in the *O. latifolia* accession, of which 80 were polymorphic. A total of 28 BC_2 and BC_3 individuals were obtained and evaluated using the polymorphic SSRs distributed throughout the whole genome. Molecular data were analyzed with the CSSL Finder software in order to look for wild chromosomal segments introgressed into *O. sativa*. Additional chromosomes were observed in 21 BC_2 and BC_3 individuals (11 individuals with one, and 10 with two), but seven of them had no additional chromosomes. SSRs showed clearly the additional chromosomes in some plants; however, in some individuals, presence of additional chromosomes was not clear, possibly due to several null alleles. Also, wild alleles were detected in chromosomes 1, 2, 3, 5, 6, 8, 9, 10, 11 and 12 in some progenies, which would suggest chromosomal segments introgressed by recombination, maybe in $F_{1,}$ since some wild alleles, as RM220 and RM236 markers, were present in almost all BC_2 and BC_3 individuals. With some markers, it was possible to observe translocations between *O. latifolia* and *O. sativa* chromosomes. Data obtained further confirm that gene transfer from a distant tetraploid relative to the diploid *O. sativa* is possible, and that understanding of some meiotic processes involved in these types of crosses is very important from a breeding perspective. Additional work using other accessions and more markers would give more information about recombination capacity between these species and their evolutionary relationships.

Characterization of the USDA Rice World Genebank Using a Core Collection Strategy

Yan, W.G., Agrama, H., Fjellstrom, R., Bryant, R., and McClung, A.

The USDA Rice World Genebank contains more than 18,000 accessions originating from 116 countries displayed at www.ars-grin.gov with descriptive data for each. Agronomic and plant morphological descriptors have been characterized for more than 80% of the accessions, but only about 40% were characterized for kernel dimension and cooking quality descriptors while 2% of the collection has been evaluated for blast and sheath blight diseases. The resources and expertise required to fully characterize the collection are limited by the sheer number of accessions.

Development of a Core Collection, which is defined as a subset of a large genebank that captures most of the genetic variability, is an effective tool to improve characterization efficiency. The USDA rice (*Oryza sativa* L.) core subset (RCS), including 1,790 entries from 114 countries, was assembled by stratified random sampling in 2002 and comprehensively characterized. Comparative analyses for 14 important descriptors demonstrated that the RCS was highly correlated with the entire genebank ($r=0.94$, $P<0.0001$), and information drawn from the RCS could be effectively used to assess the genebank with 88% certainty.

A joint effort of federal and state scientists has characterized the RCS for the descriptors identified by the Rice Germplasm Committee, including blast, sheath blight, and straighthead. Recently, four other research groups have been attracted to study the RCS for 16 minerals in rice grain. The RCS was purified with a single plant selection in 2006 and was genotyped using 48 SSR markers. These include random markers distributed across all 12 chromosomes, as well as markers for targeted genes. An additional 32 markers will be genotyped for the RCS, which gives marker coverage every 30 cM. All the phenotypic and genotypic information will be displayed at www.ars-grin.gov and through Gramene. Seeds of the purified stocks will be available through the USDA Genetic Stock Oryza (GSOR) collection located at the Dale Bumpers National Rice Research Center.

These data will be used for population genetic structure analysis, association mapping for important traits, and identification of gaps and redundancies in the collection. A mini-core collection, about 10% of the RCS, will be subsequently developed for more comprehensive genotypic and phenotypic studies. This will serve as a resource for geneticists to identify genes and alleles for new and more complex traits.

Development of a Mini-Core Subset from the USDA Rice Core Collection

Hesham, A., Yan, W.G., Fjellstrom, R., and McClung, A.

A core strategy is an effective tool to extensively describe a large germplasm collection, and a mini-core strategy further increases the effectiveness in describing the collection on the molecular level. The USDA rice core collection, including 1,790 entries, proved to be representative of the whole collection with 88% certainty, from which a mini-core subset has been developed with Maximizing (M) strategy for exploring allelic diversity. The M strategy is the most powerful function for selecting entries with the most diverse alleles and eliminating redundancy that comes from non-informative alleles, which arise from co-ancestry and certain assertive mating systems in establishing core sets.

Twenty-nine phenotypic traits and 50 simple sequence repeat (SSR) markers were used to develop the mini-core. The traits included 12 morphological and 2 cooking quality descriptors, 4 micronutrient contents, and 11 different disease rating scores. A total of 1,776 entries originating from 113 countries that were characterized for the 29 traits and 50 SSR markers participated in the development. The SSR markers distributed evenly across the 12 rice linkage groups and 605 alleles were detected in the core accessions. The number of alleles produced by SSR ranged from 2 for Rid12, RM338 to 30 for RM474. A set of nested mini-core subsets using advanced M strategy was applied to comparatively analyze captured genetic diversity and mini-core size. The developed mini-core subset successfully captured the existing molecular diversity, as well as the morphological diversity present in the core collection. The mini-core subset consisted of 176 entries (9.8% of the core collection) from 73 countries in 14 regions and captured 100% of alleles.

Due to its greatly reduced size and representing a great majority of diversity, the rice mini-core can be economically evaluated extensively for beneficial traits and provides a gateway for enhanced utilization of germplasm for sustainable crop improvement. The mini-core subset will be genotyped with about 200 SSR markers or SNP (single nucleotide polymorphism) markers for characterization of allelic diversity and genetic distance among the *Oryza* accessions in the USDA collection. Then, it can be more efficiently used by breeders and researchers to exploit valuable genes from the existing collection of rice.

Using a Set of TeQing-into-Lemont Chromosome Segment Substitution Lines for Fine Mapping QTL: Case Studies on Sheath Blight Resistance, Spreading Culm, and Mesocotyl Elongation

Pinson, S.R.M., Wang, Y., Liu, G., Jia, M.H., Jia, Y., Sharma, A., and Fjellstrom, R.G.

U.S. rice breeders presently utilize marker-assisted selection (MAS) to breed for several major gene traits, including semidwarf plant height, grain aroma, grain amylose content, and several major genes for blast resistance. Quantitative trait loci (QTL) are more difficult to detect phenotypically, thus molecular QTL-tags are more desired yet more difficult to develop. Gramene (www.gramene.org) cites more than 6,000 rice QTL, most of which were mapped within F_2, RIL, or DH populations comprised of progeny containing *random* assortments of genes from two parental lines. Random gene assortment allows QTL to be mapped using relatively small populations of 200 to 300 progeny, but the location estimates from small populations are imprecise. QTL are generally mapped to chromosomal intervals of 5 to 20 cM – not precise enough to be considered ‘tagged’ for MAS. Mapped QTL are not fully useful to breeders until they are 1) verified, usually by finding a QTL with similar location and genetic effect in a second mapping population and 2) mapped to intervals of 1 to 4 cM so that closely-linked molecular markers can be identified and used as QTL-tags.

One of the most studied rice gene-mapping populations available today is a set of 280 Lemont/TeQing recombinant inbred lines (LT-RILs) in which more than 200 agronomically important QTL have been mapped by various research groups. A new gene-mapping population comprised of 123 TeQing-into-Lemont backcross introgression lines (TILs) was developed to speed the verification, molecular tagging, and incorporation of desired TeQing QTL into improved U.S. rice varieties. Initially 284 $BC_{(2\ to 3)}F_{(4\ to\ 5)}$ introgression lines were developed at IRRI and selected for phenotypic similarity to Lemont. Final population phases were funded by USDA-ARS and USDA-NRI RiceCAP. TILs were characterized for 145 SSR markers representing the rice genome at < 30 cM spacing. TILs were omitted from further consideration if they did not have a predominantly Lemont genetic background (< 70% Lemont alleles), contained no detectable TeQing introgressions, or were molecularly and phenotypically redundant with other progeny lines. The remaining 123 TILs ranged from 70 to 97% Lemont allelic content. They support efficient verification, *de novo* mapping, and fine mapping of both major genes and QTL. In addition to smaller population size, the TILs are an improved gene-mapping population in that they contain molecularly defined TeQing QTL introgressed individually (Mendelized), or in various combinations, into a U.S.-adapted genetic background. The TILs allow a more direct measure of how useful a particular QTL will be for improving U.S. rice varieties. Epistasis is observable in selected TILs, or TIL crosses. Furthermore, the TILs serve as improved germplasm for donating just the desired TeQing genes into U.S. breeding populations. Seed and marker data will be available through the GSOR (www.ars.usda.gov/Main/docs.htm?docid=14200).

While *de novo* mapping of QTL can be accomplished via study of all 123 TILs, verification of previously mapped QTL can be efficiently accomplished with phenotypic evaluation of as few as 50 strategically selected TILs. Previous QTL mapping using the LT-RILs revealed the existence of three QTL affecting mesocotyl elongation, one each on chromosomes 1, 2, and 7. The QTL on chromosomes 1 and 7 appeared epistatic; RILs needed the Lemont allele for *qMES7* on chromosome 7 combined with the TeQing allele for *qMES1* on chromosome 1 to develop mesocotyls > 2.5 cm in length. Marker data were used to identify 29 TILs into which *qMES1*, *qMES2*, and *qMES7* were introgressed individually, and in various combinations. Twenty 20 TILs with various TeQing introgressions not previously associated with mesocotyl length were used as checks along with Lemont and TeQing. TIL observation rapidly verified the QTL mapping results, with TILs having *qMES1* or *qMES7* alone producing short mesocotyls, and TILs having the TeQing allele at *qMES1* combined with the *qMES7* Lemont allele producing long mesocotyls. Three of the 20 TILs molecularly selected as not containing any long mesocotyl alleles were found to produce long mesocotyls. These TILs were found to contain a common TeQing introgression on chromosome 6. Studies are now underway to determine if there is indeed an additional mesocotyl QTL on chromosome 6 or if these TILs contain instead small, not-yet-detected TeQing QTL introgressions encompassing *qMES1*. TIL introgressions ranged in size from single marker introgressions (<60 cM in length) to the entire length of chromosome 7. Single-marker introgressions were more common on the chromosome tips than in their middles, consistent with there being more recombination in telomeres than elsewhere in the genome. Because gene-mapping precision is determined by the amount of recombination observed, genes in regions with several small introgressions provide several fixed recombination points with which to pursue fine-mapping in the TILs as they presently exist. This was demonstrated with *de novo* mapping of a major spreading culm gene to a 4-cM region near the end of chromosome 9. To fine-map loci in chromosomal regions where TILs contain few recombination points and large introgressions, selected TILs are being crossed with Lemont to generate new recombination within progeny.

Field Performance of Marker-Assisted-Derived Elite Blast Lines

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

Developing higher yielding breeding lines with improved disease resistance is important in a cultivar development program. Molecular markers linked to blast-resistant genes can be utilized to increase selection efficiency for those associated traits. A simple crossing schedule was created to pyramid three blast-resistant genes during development of breeding lines. In addition, separate backcrossings were carried out to transfer the blast genes into recurrent parents of popular cultivars to facilitate forward breeding upon achieving desirable levels of recurrent genetic backgrounds. Following the accumulation of target alleles through marker-assisted selection, fixation of target genotypes commonly in the heterozygous form was done through generations of selfing while phenotypic selection for other traits were carried out through pedigree evaluation or anther culture. The objective of this study was to evaluate field performance of pyramided lines developed from (1) tandem crosses followed by pedigree selection, (2) tandem crosses followed by double haploidization, and (3) marker-assisted backcrosses.

A leaf sample was collected using a paper hole punch, three leaf pieces per entry, and placed into the corresponding tube in the 96-well PCR plate. Three stainless-steel beads were added into each microtube, and the DNA samples were extracted using a simple heating method prior to use in PCR reactions. The PCR mix consisted of 3.13 µl of

Sigma Jumpstart, 1.87 µl DNA template, and 0.63 µl (0.1 µM) each of forward and reverse microsatellite primers. Target markers were amplified on a thermal cycler using a 96-well plate, programmed to initial denaturation at 94°C for 4 min followed by 35 cycles of 45 sec at 94°C, 45 sec at 55°C, and 1 min at 72°C, with a final extension step of 1 min at 72°C for amplification. PCR products were separated on a polyacrylamide gel unit using a volume of 6.25 µl per well and run at 300 volts for 2 hours and 30 minutes. The resulting bands were visualized under 254-nm UV light, and information was used in plant selection.

A schedule of crosses to systematically pyramid the three blast genes was arranged in tandem. The recipient line was placed at the first cycle of crosses. Three separate schedules were made to accommodate three recipient lines. Cultivars Cocodrie, Cheniere, and Trenasse were used as recipient lines, and crosses were conducted during growing seasons and off seasons. Markers corresponding to the target loci were used to select progeny lines before entering the next cross. The minimum numbers of population size to obtain the ideotype were calculated at P>95%. Upon identifying target genotypes containing the three target alleles, field selection was carried out. Marker screening, along with phenotypic evaluation for the traits other than marker-associated traits, was conducted through pedigree selections of early-generation materials. Two hundred panicles were selected from progeny rows and used to grow 200 headrows from which 200 panicles were selected from in the following season. The selections were repeated and promising F_5 lines were verified for marker-related traits and evaluated in replicated trials. To accelerate development of homozygous breeding lines from marker-assisted selection, a portion of target genotypes were subjected to anther culture. Anther cultured-derived lines that carried target alleles were included in the replicated trials.

Marker-assisted backcrosses were carried out using the three popular cultivars Cocodrie, Cheniere, and Trenasse as recurrent parents. Donor parents possessed the three blast-resistant alleles. Backcrossing to introgress genes of interest was conducted during growing seasons and off seasons in the greenhouse. Genome scanning was carried out to facilitate faster elimination of unwanted parts of genome before subjected to the next backcross. Progenies with desirable genomic characteristics were selected and further evaluated in replicated tests in the field. Lines that were nearly identical to the recurrent recipient parent and also contained the desirable allele introduced from the donor parent were selected.

Replicated row-based trials indicated that even though several anther culture-derived lines exhibited high yielding potential, the average performance of anther culture entries was the lowest among the three groups tested. The group developed from tandem crosses followed by progeny selections showed more promising lines that have high row yield potential, good maturity, plant height, grain appearance, and plant type. The group from marker-assisted backcrosses showed moderate performance levels. The backcross lines, however, would provide forward breeding in a conventional breeding setting that will require minimum or no DNA marker involvement for the target alleles.

Mechanisms of Rice Blast Resistance and Its Implication for Breeding for Improved Resistance

Jia, Y.

A major *Pyricularia (Pi)* resistance (*R*) gene to the blast pathogen *Magnaporthe oryzae* prevents only isolates of *M. oryzae* that contain the corresponding avirulence (*AVR*) genes. The *AVR* genes in *M. oryzae* are presumably meant to promote diseases and are often evolved for the adaptation and fitness of the pathogen. Despite over 40 major *Pi* genes that have been described, seven of which have been isolated in rice germplasm worldwide, the *R* genes in rice are outnumbered by the *AVR* genes in the pathogen. In addition, most isolated blast *R* genes were predicted to be cytoplasmic proteins with NBS-LRR domain that are the most pre-dominant type of *R* genes in the plant kingdom. An outstanding question arises: How are these conserved blast *R* genes in rice able to cope with the *AVR* genes in the pathogen?

To address this question, a detailed analysis of structural and functional properties of a blast *R* gene *Pi-ta* and the corresponding *AVR* gene *AVR-Pita* has been undertaken in the USDA-ARS Dale Bumpers National Rice Research Center. *Pi-ta* is a single gene located at 10.6 megabase (MB) near the centromere (12 MB) of rice chromosome 12. *Pi-ta* in different genetic backgrounds has been shown to vary in resistance effectiveness. Mechanisms of alternative splicing in *Pi-ta* resistance are being investigated to determine if expression of these different transcripts of *Pi-ta* has any functional correlations to the resistance. Results of genetic studies suggest *Pi-ta* requires a new locus [*Ptr(t)*] for recognizing the pathogen signals. In addition, another *R* gene *Pi-ta*^{2} was also mapped nearby *Pi-ta,* and both *Pi-ta* and *Pi-ta*^{2} required the same locus [*Ptr(t)*] to be functional. All of them are mapped at the *Pi-ta* region. These findings suggest that *R* genes and their required components are clustered in a small genetic region that is one of the most effective systems to fight against the pathogen.

AVR-Pita encoding a putative metalloprotease with a protease motif, located near the telomeres of chromosome 3 of some isolates, is induced during the invasive growth of the pathogen. A protease with intact motif in *M. oryzae* is essential for its function in pathogenesis; however, this may become an advantage for *Pi-ta* to recognize *AVR-Pita* in triggering sophisticated multifaceted defense responses. In fact, amino acid substitutions of *AVR-Pita* are often observed in other regions of the protein, and these alterations are presumed advantageous for pathogenesis and for other essential needs for the survival of the pathogen.

A compressive study utilizing classical techniques of biochemistry and molecular biology is being undertaken to unravel the molecular interactions of *Pi-ta* with *AVR-Pita*. The knowledge learned from this system is being used to design the genetic strategies to prevent blast disease, and progress in this endeavor will be presented.

Mapping of a Genetic Component Required for *Pi-Ta*-Mediated Signal Recognition

Costanzo, S., Jia, M.H., and Jia, Y.

A large deletion population of rice plants using an adapted U.S. tropical Japonica cultivar, Katy, was developed during 2001-2005 to identify mutants with “interesting” phenotypes. These mutants can be used to screen for specific changes at a gene of interest or to discover single or multiple genes regulating a particular plant phenotype. Among this material, a rice mutant 2354, derived from Katy irradiated with fast neutrons, lost its resistance to all races of *Magnaporthe oryzae,* including race IB49, indicating the loss of *Pi-ta*-mediated resistance. However, it was shown that *Pi-ta* was intact and expressed in 2354. To investigate the genetic components affected by this mutation, we have developed and analyzed an F_2 segregating population from a cross between ‘2354’ and an indica cultivar Te Qing from China that is resistant to IB-49 (isolate ZN61) and has *Pi-ta* intact and expressed. Results of artificial inoculations with isolate ZN61, confirmed the presence of a single dominant gene that segregates with a ratio of 3:1 (resistant:susceptible) in the F_2 population. This result suggests that the genetic component defected in 2354 was complemented by the allele from Te Qing. This new locus was designated as *Ptr (t)*; Ptr for the *Pi-ta* mediated resistance and (t) for temporary designation.

Pi-ta and its critical component(s) co-segregated in several mapping populations and the genomic regions responsible for resistance were delimited within a 9-Mb region spanning the *Pi-ta* locus of the centromere of chromosome 12. To isolate *Ptr (t)* a few available polymorphic Simple Sequence Repeat (SSR) markers in this region were not sufficient for high resolution mapping. To generate new molecular markers, a total of 16 chromosomal regions were selected based on publicly available rice genome sequences (www.tigr.org), and primers were designed to amplify approximately 1.8-kb fragments from the genomic DNA of both parents. DNA sequences of these fragments were analyzed, and new primers designed in the presence of Single Nucleotide Polymorphism (SNP) or Insertion and Deletions (*InDels*) sites to obtain dominant markers specific to one of the two parents. A total of seven new markers were developed which were positioned approximately 1.3-Mb from each other spanning a 9-Mb region. Identified SSR markers and these new dominant markers are being used to genotype 600 blast susceptible plants. The initial results obtained from this work will be presented.

Developing a Bengal/*O. nivara* Advanced Backcross Mapping Population to Identify Sheath Blight QTLs

Prasad, B. and Eizenga, G.C.

Rice sheath blight disease, caused by the soilborne necrotrophic fungus *Rhizoctonia solani* Kühn, is one of the most important diseases of cultivated rice (*Oryza sativa* L.). Wild relatives of rice (*Oryza* spp.) are a valuable source of genes for biotic and abiotic stress tolerance and may contain novel resistance genes or QTLs for sheath blight that could be used to enhance resistance to this very important disease in commercial rice. To identify possible resistant sources for sheath blight disease, three greenhouse/growth chamber-based screening methods were evaluated with 73 *Oryza* genotypes. There are significant limitations to screening the wild *Oryza* spp. under field conditions with the most important being that many of the wild *Oryza* spp. have a seed-shattering trait. For the micro-chamber method, 4-week-old seedlings were inoculated with a potato dextrose agar plug containing mycelia, covered with a 2-liter soft drink bottle, and rated 1 week after inoculation. The detached-leaf method involved placing an agar plug containing mycelia on the abaxial surface of a leaf section that was cut from a 5-week-old plant and placed on moist filter paper in a Petri dish under constant light, then evaluated after 72 hours. For the toothpick inoculation method, toothpicks colonized with mycelia were placed in the leaf collar region of plants at the panicle initiation stage, plants were placed in a growth chamber, and disease symptoms evaluated after 7 days. The micro-chamber method gave a more uniform and reproducible response and was better correlated with the disease reactions of the reference cultivars grown under field conditions. The micro-chamber and detached leaf data were subjected to a cluster analysis, and seven Oryza spp. accessions were identified as moderately resistant. *O. nivara* (IRGC 100898) was identified as one of the most resistant accessions.

In order to incorporate the resistance identified in *O. nivara* (IRGC 100898), the advanced backcross (ABC) method was selected for developing a mapping population from which sheath blight QTLs could be identified, and subsequently, the most resistant lines made available as germplasm to rice breeders. The ABC method is an attractive procedure, especially when the donor parent is very poorly adapted like the *Oryza* spp. Also, when the recurrent parent is adapted, the ABC method can greatly reduce the number of undesirable segments being transferred from the wild parent into the advanced progenies. To develop this ABC population, a single plant selection of *O. nivara* (IRGC 100898) was crossed as the male (donor) parent with a single plant selection of Bengal, a medium-grain rice cultivar that is moderately susceptible to sheath blight. The resulting F_1 plant was confirmed by phenotype. Subsequently, the F_1 plant was crossed as the male parent to Bengal and 104 BC_1F_1 seed were produced. From these 104 BC_1F_1 plants, 54 were selected based on fertility, phenotype, and genotype as verified with 24 SSR markers. The selected BC_1F_1 were used as male parents in crosses with Bengal, and approximately 1,000 BC_2F_1 seed were produced. These BC_2F_1 seed were grown in the greenhouse and the plants were allowed to self, generating BC_2F_2 families. To discover sheath blight QTLs, a set of 279 BC_2F_2 families from 44 BC_1F_1 plants were selected based on fertility. Presently, these families are being phenotyped for sheath blight using the micro-chamber method and genotyped with 200 SSR markers distributed throughout the 12 rice chromosomes.

Identification of Sheath Blight Resistance QTLs in Rice Using Recombinant Inbred Line Population of Lemont x Jasmine 85

Liu, G., Jia, Y., Correa, V.F., Jia, M.H., McClung, A., Groth, D., Correll, J.C., and Rutger, J.N.

Rice sheath blight (RSB), caused by the soilborne 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 gene(s) governing the resistance to RSB have not been found in cultivated rice worldwide. However, the different resistance reactions of rice cultivars to RSB have been well documented. Several phenotyping methods for evaluating disease reaction to RSB, such as “Tooth pick method” and “Inoculum injection,” have been applied to map the quantitative trait loci (QTLs) of RSB resistance using molecular markers of restricted fragment length polymorphism (RFLP) and simple sequence repeat (SSR) markers. The QTLs responsible for RSB resistance have been commonly found on rice chromosomes 3, 9, and 11. Fine mapping of these QTLs will facilitate the marker-assisted selection in rice breeding programs.

One goal of the RiceCAP project is to develop user-friendly molecular methods to tag resistance to RSB to improve the breeding efficiency. Jasmine 85, having the strong resistance to RSB in both seedling and adult stages evaluated using micro-chamber and field methods, is being used as the donor for genetic resistance to RSB. After infecting Jasmine 85 with the sheath blight pathogen, 400 highly induced and 400 differentially induced genes have been isolated using Robust-Long Range Serial analysis of Gene Expression and DNA microarray, and their mapping positions *in silico* have been constructed for fine mapping onto the genetic map of SB-QTL using Jasmine 85.

So far, we have improved a micro-chamber screening method that was originally used by rice breeders in Bangladesh observed by Dr. Shannon Pinson to evaluate the RSB resistance of seedlings at 3- to 4-leaf stage in the greenhouse. In addition, a mist chamber method routinely used by breeders in Colombia to evaluate adult resistance in the greenhouse has the important value to identify and verify the genetic resistance identified by the micro-chamber.

These methods have been used as an effective approach to accurately quantify the resistance to RSB in this study. Thus far, the disease reactions of 250 recombinant inbred lines (RILs) of the Lemont x Jasmine 85 F_5 population to RSB were evaluated in a greenhouse at CIAT, Colombia using both micro-chamber and mist chamber methods. The F_5 RIL population has been genotyped using ≥200 SSR markers. The first genetic linkage map is being constructed, and progress in the identification of the novel QTLs in controlling RSB in Jasmine 85 will be presented.

Factors Contributing to Milling Quality Differences in MY3, a 'RiceCAP' Project Milling Population

Jodari, F., Roughton, A.I., Fjellstrom, R.G., Scheffler, B., and Nelson, J.C.

Rice milling yield or whole grain milled rice recovery rate is a major quality trait that is influenced by a number of factors. Varietal improvement of milling yield, in turn, is a lengthy process that requires integration of various desirable quality components and often multi-year evaluation of those components. Development and use of DNA markers in breeding programs that can identify desirable components of milling quality, especially in early generation can be a substantial improvement in the efficiency of breeding efforts in this area. This study is part of 'RiceCAP,' a USDA-ARS-funded project that is designed to develop quantitative trait loci (QTLs) and candidate gene markers for milling yield and fissuring resistance using three milling populations, including MY3 from California.

Parents of MY3 are L-204 and an advanced selection, 01Y110. Average milling yield (HR) of L-204 and 01Y110 from 2001 to 2003 tests was 63.8 and 56.0%, respectively. The difference of 7.8% that is seen between these parents is larger than among most California breeding lines. Consequently, it is expected that phenotyping this population will provide sufficient contrasting information necessary for association with genotyping results. The F_7 generation RILs was grown in 2007 and phenotyped for milling yield at Research Experiment Station, Biggs, CA. Average milling yields of L-204 and 01Y110 parents within the population was 64.4 and 57.7% for L-204 and 01Y110, respectively, with the population HR yield ranging from 49 to 66%.

Comparison of the parental lines is indicating that differences do exist in the grain dimension, grain shape, grain uniformity, seed weight, amylose content, and chalkiness, all of which can contribute to different degrees to milling yield differences. The high milling parent L-204 is characterized by bolder and more uniform grain, while the low milling parent is exhibiting a small degree of chalkiness and non-uniformity. The analysis of phenotypic data after completion is expected to quantify the degree of contribution of each factor to milling yield, as well as unexplained differences that may be due to unknown factors such as grain density and starch structure. Data suggest that for MY3 population, even though no single factor can account for the large HR yield differences, degree of chalkiness may account for a large part of it.

Flowering and Maturity-Related Traits as Potential Indirect Selection Index for Milling Qualities in Rice

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

The percentages of whole (at least ¾ the length of a whole milled kernel) and total milled rice have significant positive direct effects on farm gross income and determine the commercial value of the harvested rice grain. These milling qualities are common objectives in the breeding programs, with direct selection for these traits usually practiced at the more advance generations. Due to delayed selection, genotypes with low whole and total milled rice percentages are kept but later eliminated. High milled rice percentages are priority traits bred for in long-grain rice. Thus, the identification of traits that can be used to indirectly evaluate the genotypes and reduce the number of lines that undergo the actual determination of milling percentages is essential. It is commonly observed that the flowering duration (from onset to 100% flowering) varies across genotypes. Leaf color and green grain percentages at 30 days after heading (DAH) are also observed to vary across genotypes. It is hypothesized that flowering and maturity-related traits, such as duration of flowering, rate of flowering, number of days to heading, duration from heading to harvest, and leaf color and green grain percentage at 30 DAH affect whole and total milled rice percentages.

Each year at the Uniform Regional Rice Nursery in the United States, 200 entries are evaluated in randomized complete block design with two and four replications for the preliminary and advanced trial, respectively. Each plot has six 3-m long rows spaced 25 cm apart. Field experiments are fertilized with 225 kg N/ha equally split into three and applied at planting, 1 month after planting, and at panicle differentiation. The 105 long grain genotypes that were common across the 2005 and 2006 trials conducted at Beaumont, TX, were used in this study. Data gathered and analyzed for all traits were obtained from the first two replications. Field data obtained included: days from emergence to onset (start), 25%, 50% (heading), 75%, and 100% flowering; days to harvest; plant height at maturity; leaf color at 30 and 37 DAH (1 = dark green, 9= brown); and green grain percentage at 30 and 37 DAH. Milling samples were obtained from a 1-m^2 area in each plot at maturity and milled following the standard procedures. The following were estimated from the field data: start (onset) of flowering to heading; heading to 100% flowering; start of flowering to 100% flowering; rate of flowering; and change in leaf color and green grain percentage.

Flowering-related traits (flowering duration, rate of flowering) were negatively related to whole and total milled rice percentages, whereas leaf color and green grain percentage at maturity were positively correlated with milling traits. Rice genotypes with early heading tended to have shorter flowering duration and produced higher whole and total milled rice percentages. Green leaf 30 DAH was a desirable trait, and high green grain percentage at both 30 and 37 DAH favored high whole milled rice percentage. Faster change in leaf color and green grain percentage between 30 and 37 DAH resulted in better milling qualities. These results indicated the potential of these traits as indirect selection criteria in breeding rice for high whole and total milled rice percentages. Actual use in the breeding program will test efficiency of these traits in improving milling qualities.

Parental Selection and Cross Combination in Breeding for Jasmine-Type Aromatic Rice Cultivars

Sha, X. and Linscombe, S.D.

Jasmine aromatic rice, which originated and is largely produced in Thailand, makes up about 80% of U.S. aromatic rice imports. Typical Jasmine rice has a strong popcorn-like aroma, a low amylose content of 15 to 18%, a low gelatinization temperature with an alkali spreading value of 6 to 7, translucent slender kernels, and soft-cooking characteristics. Development of improved Jasmine-type cultivars with similar specialty characteristics (aroma, texture, and flavor) to the imports and with competitive grain and milling yields while adapted to the southern U.S. environment will help the rice industry to gain access to this fast growing and high value domestic niche market. However, the taxonomical, physicochemical, and genetic differences between Thai Jasmine and U.S. long-grain rice pose a great challenge for the development of adapted Jasmine-type rice cultivars. In this study, genetic and physiochemical properties of specialty attributes of Jasmine rice are reviewed in detail. Different rice germplasm and cross combinations are proposed and compared to maximize the chance of creation and identification of ideal Jasmine-type recombinants.

Based on the known genetic and physicochemical mechanisms of three critical Thai Jasmine specialty traits; aroma, amylose content, and gelatinization temperature, different crossing schemes, including single crosses, three-way crosses, and backcrosses, are proposed and compared, which involved different parental genotypes. The most common crosses between Thai Jasmine or its derived lines and elite U.S. long-grain genotypes have the least chance to produce new Jasmine-type recombinants and, thus, have the lowest efficiency. Using single seed descent in early generations (F_2-F_4) followed by pedigree selection will improve efficiency. The chances of recovery can be further increased by the inclusion of U.S. specialty rices, such as Della and Toro-2, as parents, which have some of the specialty traits but are agronomically acceptable. However, the best cross to generate novel Jasmine-type recombinants is that among different partially improved Jasmine lines. Thus, development and stepwise improvement of specialty germplasm are the keys for the success of breeding for Jasmine-type rice.

Abstracts of Posters on Breeding, Genetics, and Cytogenetics
Panel Chair: K.S. McKenzie
Poster Session Chair: C.A. Greer

The Straighthead Susceptibility Trait is Not Related to Grain Arsenic Concentration

Raghvan, T., Yan, G.W., Agrama, H.A., James, W.D., Gentry, T.J., and Loeppert, R.H.

Straighthead, a physiological disorder that causes severe loss of grain yield in rice, has been screened in the United States by growing rice in monosodium methylarsonate (MSMA) treated soil under continuous flooding. The MSMA-based straighthead test is based on the similarity between naturally occurring straighthead symptoms in the field and injuries resulting from soil arsenic (As) in the form of MSMA. In different parts of the world, straighthead is also reported to occur in continuously flooded soil with low soil-As concentration and can be artificially induced by crop residue or sugar application to the soil, hence bringing into question the requirement of As in straighthead-symptom development. Therefore, an experiment was undertaken to investigate the relationship between straighthead susceptibility of cultivars and As accumulation in the rice grain.

Field studies were conducted in 2004 and 2005 with 37 cultivars selected from the USDA world-germplasm collection. The experiments were conducted in a split block design, where soil As was the main plot and cultivar was the sub-plot with four replicates. The cultivars were grown under continuous flooding and two soil treatments, a soil with a total As concentration of approximately 6 ppm (predominantly as inorganic As) and a conventional straighthead-testing plot with a higher As level of approximately 19 ppm resulting from MSMA application. The As treatments and cultivars were compared for straighthead rating, grain yield, and grain-As concentration.

No straighthead was observed in the non-amended plots. The straighthead ratings and grain-As concentrations were relatively uniform between replicated plots, indicating reliable observations for these traits. A wide variability in grain-As concentration between cultivars suggested that grain-As concentration was strongly impacted by rice genotype. Even in the non-MSMA plots, grain-As concentration of some cultivars was 160% greater than that of others. The grain-As concentrations were considerably higher with the MSMA treatment compared with the non-amended soil, indicating a dependence of grain-As concentration on soil-As concentration, As speciation and As bioavailability in soil. In the MSMA-treated plots, highly straighthead-susceptible cultivars exhibited grain-yield loss of 80% or more; however, the straighthead-susceptibility rating was poorly correlated with grain-As concentration. This study has demonstrated that straighthead susceptibility and grain-As concentration are independent traits. The straighthead symptom induced by application of MSMA under continuous flooding likely results from specific changes in the plant at the biochemical level that result in abnormal growth of the panicle that is not necessarily related to As concentration in the grain.

Analysis of the Effectiveness of the Rice Blast Resistance Gene *Pi-ta*

Costanzo, S., Wang, X., and Jia, Y.

The causal agent of rice blast, *Magnaporthe oryzae*, continues to remain a serious threat for rice production and, in general, for the world food supply. The most economically and environmentally viable strategy to control this pathogen is the development of cultivars that possess major resistance genes conferring resistance to predominant races of *M. oryzae*. However, it is also well-known that the resistance based on a single major gene can be easily overcome in a few years after its deployment. The major blast resistance gene *Pi-ta*, originally introduced from a Vietnamese variety Tetep, has been bred into several U.S. elite cultivars, Katy, Madison, Kaybonnet, Drew, Ahrent, Cybonnet, and Spring. Some of these cultivars have been commercialized for over a decade with little incidence of blast disease, while others were short lived after their initial deployment. In order to investigate the molecular mechanisms of the stability of resistance based on *Pi-ta*, an extensive study is being undertaken, including the detailed characterization of the possible protein variants that are produced by the *Pi-ta* gene in different genetic backgrounds by alternative splicing.

Alternative splicing is an important mechanism that allows multiple transcripts and protein diversity being generated from the same DNA sequence of a single gene. This process has been previously reported in several plant genes and gene families. However, recent computational and experimental studies suggest this event could play a significant role in plant resistance genes enhancing protein diversity against their pathogen counterpart. Using reverse transcription PCR to study expression levels of a major blast resistance gene *Pi-ta* during infection, we detected two differentially processed RNA transcripts of this gene. Transcripts detected in this study encode two open reading frames (ORF). One ORF is with 2,787 base pairs with two exons and one intron encoding the *Pi-ta* protein, and another ORF with 3,102 base pairs was discovered with four exons and three introns. These two ORFs each encode a centrally located NB-ARC domain while one of them (the *Pi-ta* protein) is lacking a C-terminus thioredoxin domain. The biological significance of this important mechanism in the *Pi-ta* gene is currently under investigation. Particularly, we would like to determine if the presence of both variants is required to obtain effective resistance and if both are involved in resistance in different genetic backgrounds.

Enhancement of Yield Using Chromosomal Introgressions from *Oryza rufipogon*

McClung, A.M., Moon, S., Eizenga, G., and McCouch, S.

Over the past decade, the McCouch lab has developed a network of collaborators to explore the gene space of the wild ancestral species, *Oryza rufipogon,* by crossing it with an array of elite *O. sativa* international cultivars. Advanced backcross populations were constructed in which transgressive variation could be genetically dissected. Using a common set of molecular markers to identify quantitative trait loci (QTLs) associated with enhanced performance in wild x cultivated populations in different regions of the world, it was demonstrated that specific *O. rufipogon* introgressions confer superior performance for an array of agronomic and yield-related traits (flowering time, panicle size, seed size and shape, number of seeds per plant). The superior performance is due to transgressive variation associated with alleles from the low-performing *O. rufipogon* parent that enhance the performance of the elite *O. sativa* recurrent parent.

As part of the NSF-funded project "GEPR: Exploring the genetic basis of transgressive variation in rice," we are using near isogenic lines (NILs) to explore what happens when 'adapted gene complexes' are disrupted, giving rise to positive transgressive variation. We suggest that the introduction of selected 'wild QTLs' into commercial cultivars has the potential to enhance elite varieties. In addition, this may lead to a better understanding of how 'wild QTLs' are associated with key regulatory elements, or master switches, located near the top of critical gene networks associated with yield and other aspects of agronomic performance.

In this study, a set of 70 NILs that had been developed from a cross of Jefferson/*O. rufipogon* and identified to possess QTLs associated with yield components were evaluated in replicated field trials in 2007. These studies were conducted at Beaumont and Alvin, Texas, and Stuttgart and Jonesboro, Arkansas. The study consisted of six families of introgression lines, each family possessing a "yield" QTL located on a different chromosome, either chr 1, chr 2, chr 3, chr 6, chr 8, or chr 9. Each QTL family was represented by 4 to 12 independent introgressions of the targeted QTLs and several check NILs, having a common background but lacking the introgression. The NILs were evaluated in standard yield plots, replicated three times at each location. In addition, four commercial cultivars, Jefferson (parent), Cocodrie, Trenasse, and XL723, were included in the evaluation as repeated checks. The materials were evaluated for main crop yield, yield components, agronomic traits, and milling quality.

Early results from this study indicate that some of the QTL introgressions were associated with significantly improved yield and agronomic traits relative to the Jefferson parent. In addition, several individual NILs were ranked high for yield across the four locations, indicating that the impact of the introgression was stable across environments. These results indicate that this approach provides a way of selectively introducing components of quantitative trait variation from a wild gene pool into an elite cultivar, without the requirement for whole-genome compatibility. It can serve as the basis for both inbred and hybrid varietal improvement and has the potential to expand the cultivated gene pool of cultivated rice.

Genotype x Trait Interaction in U.S. Rice Cultivars

Samonte, O.S.P.B., Tabien, R.E., and Wilson, L.T.

High performing U.S. rice cultivars are included as checks in the Uniform Regional Rice Nursery (URRN). The evaluation of these cultivars for multiple yield-related traits using Genotype plus Genotype x Trait (GGT) biplot analysis would assist rice breeders in identifying significant relationships among traits. It would also enable the identification of cultivars that perform well in several desirable traits and hence be recommended as parents of crosses in rice improvement programs. The objective of this study was to use GGT biplot analysis in comparing U.S. long-grain rice cultivars on the basis of multiple traits and in identifying relationships among traits.

This study used 17 long-grain rice cultivars that were common across the 2005 and 2006 URRN at the Texas AgriLife Research and Extension Center, Beaumont, TX. Seedling emergence dates were 14 April 2005 and 15 April 2006. Replicated data of 14 traits were gathered for each cultivar. The traits analyzed included: flag leaf length, width and area; number of days to heading and maturity; flowering duration; main culm panicle mass; plant height at 34 days after emergence (DAE) and at harvest; tiller density at 40 DAE; panicle type; whole and total milled rice percentages; and grain yield. The GGT biplot analysis by Yan and Rajcan was performed using a SAS program written by Burgueño et al.

Based on GGT biplot analysis, in 2005, the top three cultivars that performed well in both grain yield and whole milled rice percentage were Trenasse, Presidio, and Spring, and these had lower-than-average flag leaf area and number of days to heading. In 2006, the top three cultivars that performed well in both grain yield and whole milled rice percentage were Trenasse, Cocodrie, and Spring, and these had lower-than-average number of days to heading and flower duration. High whole milled rice percentage was associated with short flowering duration in 2006. In both 2005 and 2006, the mean trait axis for grain yield and whole milled rice percentage was negatively associated with number of days to heading and main culm panicle mass. Based on the mean trait axis for grain yield and whole milled rice percentage in both 2005 and 2006, Trenasse was identified as the best long-grain rice performer.

Accounting for Spatial Yield Variability in URRN Yield Trials

Samonte, S.O.P.B., Tabien, R.E., and Wilson, L.T.

The traditional statistical analysis of the Uniform Regional Rice Nursery (URRN) yield data is to conduct an analysis of variance (ANOVA) for each of its seven genotype groups, whose genotypes are replicated and arranged in a randomized complete block design, and then conduct a means separation test. The ANOVA uses blocking to account for spatial variability. In contrast, the use of nearest neighbor analysis accounts for a substantial amount of spatial variability, reduces the variability due to random error, and increases the significance of treatment effects. This is useful in improving the precision of analysis of replicated yield trials. The objective of this study was to evaluate the significance of genotype effects in the URRN yield trials with and without nearest neighbor analysis.

This study used the seven groups of genotypes of the URRN that was conducted at the Texas A&M Univ. System, Texas AgriLife Research and Extension Center, Beaumont, TX, in 2006 and 2007. Groups 1 to 4 consisted of 20 entries each, while the groups 5 to 7 consisted of 40 entries each. Each of the 14 data sets was analyzed separately for genotype effects using both the traditional ANOVA and the analysis of covariance (ANACOVA) with the nearest neighbor estimates of position effect as covariates as suggested by Scharf and Alley. Yield residuals for each plot were computed as the difference between an individual plot yield and genotype's mean yield for the genotype grown on that plot. Mean comparison using the least significant difference (LSD) was conducted for both analyses.

Surface graphs showed the variation in yield residuals among plots. Lowest yield residual variation was shown by plots of the 2006 Group 3 genotypes, while highest variation was shown by the 2007 Group 1. Coefficient of determination (R^2) was higher in the ANACOVA than the ANOVA in all 14 data sets analyzed. Coefficient of variation (CV) was lower in the ANACOVA than the ANOVA in 13 of 14 data sets analyzed. The mean improvement of ANACOVA over ANOVA was 3% in R^2 and 4% in CV. Furthermore, mean separation results using LSD were different between the two analyses in all 14 data sets in terms of genotype ranking and identification of significantly different genotypes.

DNA Markers to Assist in Breeding Louisiana Special Purpose Rice Varieties

Zhang, W., Sha, X., Ordonez, S., and Oard, J.

Special purpose aromatic rice varieties occupy a niche market in the United States that currently relies on imports from Asia. The LSU AgCenter Rice Research Station's Rice Breeding Project is developing special purpose varieties for the Louisiana rice industry. Rapid development of varieties would be possible if suitable DNA markers were available. Four DNA markers corresponding to genes that govern cooking quality and blast resistance in Louisiana breeding lines were evaluated. The DNA markers identified parents, F_1 hybrids, and individual F_2 plants for aroma, amylose content, starch gelatinization temperature, and rice blast resistance. The results demonstrate that the DNA marker technology can identify individual plants with the best available combination of genes for cooking quality and disease resistance. DNA markers used in this study should facilitate rapid development of Louisiana special purpose rice.

Association Genetics in Rice: Evaluation of Mixed Model and "Model Selection" Procedures

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

Composite Interval Mapping and related procedures are commonly used to identify QTLs in plants, but power and precision may be hampered by limited recombination events and small population size. Association genetics is an alternative strategy to standard QTL methods that is used in human studies and one that is gaining support in the plant research community. The mixed model approach is now popular for association genetics of inbred and outcrossing plant species. A second approach is the "model selection" strategy that identifies the fewest number of variables that minimize information criteria as opposed to standard hypothesis testing to build the optimal predictive model. The first research objective was to evaluate the mixed model as presented in the TASSEL software program (http://www.maizegenetics.net) for three agronomic traits among 192 closely related rice inbred lines evaluated in five U.S. locations. The results showed that kinship estimates incorporated into the TASSEL mixed model did not increase the ability to explain observed phenotypic variation, reduce Type I errors, or enhance predictive ability of selected markers. The model selection method as implemented in SAS GLMSelect identified marker effects that explained a large proportion of phenotypic variation among the inbred lines for the three traits. Modeling of epistatic variables coupled with a validation step resulted in the highest predictive ability with fewest selected marker effects. All results indicated that the model selection approach should be explored further for association genetic studies in rice and other crops plants.

RICECAP – The Coordinated Agricultural Project for Rice

Lemaux, P.G., Alonso, B., Cartwright, R.D., Korth, K., and Greer, C.

Rice is the most important crop, providing daily nourishment to as much as 50% of the world's population. Like other crops, rice has many problems and constant research and education programs are needed to maintain improvements and keep pace with rapid population growth in certain regions. The biotechnology revolution in crop plants has been fueled by basic genomics research, and recently the rice genome was completely sequenced. This level of information offers great promise for new genetic tools useful to rice producers, but applied rice breeders must first be trained and recruited to use the tools to develop new and improved cultivars in a more efficient manner. USDA/CSREES recognized this need and funded an initiative called the Coordinated Agricultural Project in 2004 to address needed research and education to encourage the development of applied rice genomics.

The Coordinated Agricultural Project for Rice, RiceCAP, is a multi-institutional effort coordinated by the University of Arkansas Division of Agriculture and involving research personnel from USDA/ARS Labs in Arkansas and Texas; molecular research labs at Kansas State, Colorado State, Wisconsin, University of Arkansas, Missouri, LSU, UC Davis, and Ohio State; breeders in California, Texas, Louisiana, Arkansas, Mississippi, and Missouri; bioinformatics personnel from Kansas State; a researcher in South America; and extension personnel at UC Berkeley, Arkansas, UC Davis, and other rice growing states. Goals of the project include the training of breeders and support personnel in applied rice genomics and methods; identification of marker genes for sheath blight resistance and milling quality in selected rice breeding populations; and education of members of the rice industry about rice biotechnology. The project is in its fourth year (2008).

Results of the RiceCAP project have already been many and diverse, from increasing communication between molecular rice scientists and breeders to the discovery of new methods to screen rice germplasm more efficiently. The accomplishments include the completion of three workshops for breeders and other participants, two at the Noble Foundation in Oklahoma and one at the Dale Bumpers National Rice Germplasm Center near Stuttgart, AR. Several mapping populations for sheath blight resistance and milling quality have been developed and partially characterized. A micro-mist-chamber screening method was also developed to improve screening efficiency for sheath blight resistance. A number of putative sheath blight-resistant breeding lines have been developed for breeder use, while a large number of milling yield population samples have been completely characterized for fissuring resistance. RNAi-silence lines for at least three defense response genes were developed and QTLs have been identified for sheath blight resistance in one mapping population. An on-line project data center was developed to maintain and allow usage of all data. Education tools for the rice industry were developed, including brochures, a poster, a logo, and a flipchart. Educational presentations have been repeatedly made in all rice production states at field days, grower meetings, and other venues, and a workshop was conducted in Arkansas and Texas to introduce rice genomics to public school science teachers.

Planned outcomes of this project include increased acceptance and usage of molecular tools by rice breeders and the development of improved conventional rice cultivars in a timely manner for use by U.S. rice producers. Additional outcomes include increased awareness and understanding of rice genomics and biotechnology by rice industry and related personnel.

Development and Characterization of RiceCAP QTL Mapping Population for Sheath Blight Resistance

McClung, A.M., Groth, D., Oard, J., Utomo, H., Moldenhauer, K., Boza, E.,
Sheffler, B., Jia, Y., Liu, G., Correa, F., and Fjellstrom, R.

RiceCAP is a USDA CSREES-funded project that has as one of its main objectives developing genetic markers associated with sheath blight resistance. Sheath blight, caused by *Rhizoctonia solani*, is an important disease of rice in the southern United States. Tolerance to the disease is quantitatively inherited and easily confounded by plant height and maturity. Developing selectable markers associated with resistance to this disease will help breeders to develop improved varieties more efficiently and effectively. A mapping population consisting of 325 double haploid (DH) lines developed from a cross of Cocodrie (susceptible) and MCR01–0277 (partial resistance) was used to identify QTL regions associated with resistance. Some 225 polymorphic SSR markers were evaluated to identify over 100 markers that could be readily scored in the population. The families were evaluated in replicated field trials conducted in Crowley, LA, and Stuttgart, AR, during 2005, 2006, and 2007 that were inoculated prior to heading. In addition, the population was evaluated using inoculated seedlings evaluated in a micro-chamber (Stuttgart) and a mist-chamber (Cali, Colombia). The micro-chamber method was strongly correlated with the 2006 field results (AR r=0.69 and LA r=0.59), indicating that it identifies at least some of the same resistance components that are important under field conditions. The mist-chamber technique had good repeatability compared with the micro-chamber method but took longer to evaluate. Although the population mean was more susceptible than the Cocodrie parent, 2% of the population was more tolerant than the resistant parent, MCR010277. These results verify that this is an excellent mapping population that appears to be segregating widely for sheath blight resistance that can be detected using a number of disease screening methods.

Refining Induced Fissuring Procedures Used in Characterization of 'RiceCAP' Milling Populations

Roughton, A.I., Jodari, F., Moldenhauer, K., Linscombe, S.D., and McClung, H.A.

The three milling populations used in the RiceCAP project differ considerably in grain characteristics. Parents of these populations were used to develop protocols for induced fissuring that would maximize and clearly show parental differences in fissuring susceptibility. In the process of developing these protocols, it was discovered that different populations require different treatment protocols.

In 2005, the MY1 (Cypress x RT0034) population was analyzed for fissuring using a 16-hour moisture exposure protocol. This protocol proved to be sufficient in distinguishing fissuring differences between MY1 parents and other checks. Using this protocol, 30 samples could be treated, shelled, and analyzed in a 24-hour period. However, the 16-hour treatment was insufficient to induce significant fissuring in MY2 (Cypress x LaGrue) and MY3 (L-202 x 01Y110) parents grown in 2006. Samples treated in this manner in 2006 were indistinguishable from untreated (field fissuring) samples, therefore, it was necessary to develop a new induced fissuring protocol.

Extensive testing was performed, and it was discovered that by exposing samples to a period of "pre-drying" in an incubator before moisture exposure, the desired fissuring differences between parents were produced. A number of combinations were tested using variable drying and treatment times. Drying alone and drying after treatment did not produce significant fissuring. Samples were sealed in plastic bags after drying and treating and shelled the day following treatment using a gentle machine-shelling technique in combination with hand shelling. The use of a machine husker had no impact on total fissuring percentages and sped up the shelling process significantly, allowing more time to analyze samples. Using this protocol, 80 samples could be treated at one time and shelled in the course of a week without a significant drop in percent fissuring.

In summary, it was discovered that fissuring susceptibility can change from one harvest to the next. In order to adjust to this change, a development of a more efficient fissuring protocol that allows us to analyze larger number of samples without sacrificing the integrity of the results was made.

QTL Mapping for Milling-Quality Traits in a U. S. *Japonica* x *Indica* Rice Cross

Nelson, J.C., Sun, X., McClung, A., Fjellstrom, R., Moldenhauer, K., Boza, E.,
Jodari, F., Oard, J., Linscombe, S., and Guo, Z.

Quantitative trait locus (QTL) mapping was carried out for selected quality-related traits in a cross of Cypress, a high milling yield U.S. J*aponica* cultivar, with RT0034, a low milling yield *indica-Japonica* breeding line. A population of 129 recombinant inbred lines was genotyped at 152 SSR loci and phenotyped for many traits in Louisiana and Arkansas in 2005. Multi-environment interval mapping was used to identify QTLs. QTLs consistently expressed across locations were identified for highly heritable traits, such as kernel dimension, amylose, and days to heading, but not for milling yield. Head rice (whole kernel) recovery was correlated with days to heading within but not between locations, and a putative pleiotropic QTL on chromosome 8, expressed in Louisiana, reduced kernel quality, perhaps owing to delayed maturity from a Cypress lateness allele. Small population size and segregation systematically skewed towards *indica* alleles may account for the absence of clear milling yield QTLs in this cross.

Thickness and Cultivar Effects on Rice Fissuring Due to Adsorption

Tolbert, A.C., Moldenhauer, K.A.K., Siebenmorgen, T.J., Bautista, R.C., Blocker, M.M., and Prislovsky, S.E.

One of the main goals of rice producers is to deliver rice with excellent milling performance. Because of the premiums normally paid for head rice relative to brokens, head rice yields are a major economic determinant of the value of rice. Therefore, high head rice yields have been a major breeding goal for many years.

One of the major causes of head rice yield reduction is kernel fissuring. Fissuring structurally weakens the kernel endosperm, rendering the kernel very susceptible to physical breakage during milling and handling operations. Harvest and post-harvest processing of rough rice, kernel thickness, milling duration, and cultivar all have significant effects on both head rice yield and degree of milling. Rapid adsorption of moisture by low moisture content kernels causes fissuring and has been considered a major cause of rice breakage. Many studies have noted that the thickness, the least of the three axial dimensions of a rice kernel, has a large effect on fissuring rates. Thickness of individual rough rice kernels may vary greatly not only by cultivar but also within a given cultivar. Within-cultivar variation can be due to individual kernel maturity and location on a panicle. This study examined rice fissuring differences among cultivars, kernel thickness fractions and environments, and their interactions. Rice cultivar and kernel thickness were the main factors observed.

Rough rice samples of the long-grain cultivars Cybonnet, LaGrue, Wells, and RU0501173 collected from the 2004, 2005, and 2006 Arkansas Rice Performance Trials conducted at the Rice Research and Extension Center (RREC) at Stuttgart, AR, were treated to induce fissuring due to moisture adsorption. Data were analyzed using the SAS General Linear Model procedure using a split plot design with cultivars as the main treatment factor, thickness fractions as sub-factors, and years as replications.

The cultivar Wells was the thickest, followed by RU0501173, LaGrue, and Cybonnet. Each cultivar was separated into thickness fractions using a laboratory thickness grader. The mass percentage of each thickness fraction by cultivar was averaged over all years. RU0501173 had the greatest fissuring percentage among the treated kernels, followed by Cybonnet, Wells, and LaGrue, respectively. Among the treated and untreated kernels, trends among thickness fractions were seen, with the thick fraction showing the most and the thin fraction showing the least percentage of fissures. The data indicated few differences in the number of fissured kernels by year and cultivar, but a significant difference for kernel thickness. The only significant factor for fissuring rates due to moisture adsorption was thickness at the 0.0001 probability level.

Among the variables involved in this experiment, differences in year and cultivar had no statistical significance in fissuring rates. The interactions between cultivar and thickness were also insignificant. Thickness was the only significant factor among the variables tested. Thickness has been shown to be of importance in fissuring rates in the past and is now shown to be more significant than cultivar and year effects.

Using TeQing-into-Lemont Introgression Lines (TILs) to Dissect Sheath Blight Resistance QTLs and Fine-Map a Spreading Culm Gene

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

One of the most studied rice gene-mapping populations available today is a set of 280 Lemont/TeQing recombinant inbred lines (LT-RILs) in which more than 200 agronomically important quantitative trait loci (QTL) have been mapped by various research groups around the world. Among the 200+ QTLs mapped within the LT-RILs are 18 SB-QTLs conferring resistance to sheath blight disease, nine of which, having been identified in more than one gene-mapping study, are now considered no longer putative, but confirmed. Fine-mapping one or more of these confirmed SB-QTLs to make them amenable to marker-assisted selection (MAS) by U.S. rice breeders became one of the objectives funded by the USDA-NRI RiceCAP. A new gene-mapping population comprised of 123 TeQing-into-Lemont backcross introgression lines (TILs) was developed for the purpose of providing a uniquely efficient gene-mapping population for verifying, molecularly tagging, and incorporating desired TeQing QTLs into improved U.S. rice varieties. The TILs were characterized for 145 SSR markers that covered the rice genome at <30 cM spacing. Introgressions within the TILs ranged in size from small, single marker introgressions (<60 cM in length) to the entire length of chromosome 7. Single-marker introgressions were more common on the chromosome tips than in their middles, consistent with there being more recombination in telomeres than elsewhere in the genome. Introgression sizes also varied between chromosomes. For example, single-marker introgressions were common among the TILs on chromosome 9 but rare on chromosome 12.

One of the SB-QTLs targeted for fine mapping, *qSB9b*, was known to reside within 37 cM from the lower tip of chromosome 9; one of the regions where small introgression sizes and multiple recombination points were already fixed within the TILs. The data on 145 SSRs were used to identify a subset of 31 TILs containing TeQing introgressions in and around the *qSB9b* region. Seven additional SSRs were evaluated to tag this genomic region every 0.5 Mbp, or approximately every 2 cM in this telomeric region. Recombination in one or more TILs was found to be already fixed for all but two of these nine marker intervals. Plants were grown in pots in a greenhouse at the Dale Bumpers National Rice Research Center, Stuttgart, AR, to provide leaves with which to evaluate response to *Rhizoctonia solani* toxin. Because these TILs were known to be genetically pure, and toxin response can be replicated multiple times on a single plant, only one plant per TIL was grown. Response to *R.s.* toxin extract was attempted twice by Steve Brooks in Stuttgart, AR. Unfortunately, high leaf injury from the application process to a majority of the plants limited the genotypes from which reliable ratings were obtained. One of the TILs that appeared reliably resistant to the toxin was TIL:567, which has been molecularly determined to not contain any of the other 18 previously mapped SB-QTLs, and was not statistically different from Lemont in previous inoculated field-plot studies. Because TIL:567 contains only the bottom 1.3 Mbp tip of chromosome 9, the toxin resistance exhibited by TIL:567 suggests that a locus for *R.s.* toxin resistance may reside in the lower half of the previously mapped 37 cM long *qSB9b* region. Additional phenotyping to verify these preliminary results will be pursued in 2008. Because of the fixed recombination available between TILs for this region of chromosome 9, fine-mapping to the 2 to 5 cM precision level can be pursued within the present TILs, providing sufficient seed for multiple replications and evaluation methods.

Segregation for erect versus spreading culms in the above-mentioned plants being grown for dissection of the *qSB9b* region was noted. It was not known if this was due to a spreading culm gene residing nearby, or due to commonality among background introgressions between these TILs. Because increased airflow through an open canopy can inhibit *R.s* growth, increasing the plants' apparent resistance, it was important to map the spreading-culm locus (*Spr*). Three replications of these same TILs were planted in the greenhouse in Beaumont, TX, one plant per 10 x 10 cm pot. Plants were observed twice weekly for tiller number and tiller angle calculated as 2x the angle between the 1st tiller and the main culm, or measured between the two outermost tillers when two or more tillers existed. Correlation between tiller angles and marker data indicates that the *Spr* locus is in the upper half of the *qSB9b* region, in the 0.6 Mbp region between RM3808 and RM215. Marker-trait correlations were not perfect, however, in that the two most erect TILs contained the entire 37 end of chromosome 9. These TILs may contain another erectness gene over-riding the effect of this apparent *Spr* locus, being tested now in F_2 progeny. The other SB-QTL of high priority for fine-mapping was *qSB12a*, near the centromere on chromosome 12 where recombination during TIL development was limited. All the TIL introgressions in this region are relatively large (5+ Mbp). Additional recombination points will need to be generated before we can fine-map *qSB12a*. Selected TILs have been crossed. F_2 evaluations will be pursued in 2008.

Development and Characterization of Deletion and Mapping Populations for Functional Genomics and Rice Breeding

Jia, Y., Rutger, J.N., Moldenhauer, K., and Gibbons, J.

Traditionally, plant breeders improve rice crop utilizing visible mutants possessing agronomically important traits. Mutations that occur in a single gene but do not necessarily result in an altered and/or detectable phenotype are useful in discovering responsive genes. With accurate genome sequence, a large mutant population based on a single genetic background should facilitate the functional determination of predicted genes in a genome and should be useful to screen for traits that are influenced by environmental stimuli.

A large mutant population using U.S. adapted *Oryza sativa* cv. Katy was developed using a combination of chemicals, fast neutrons, and gamma irradiations. To date, 15,000 M4 have been recovered from fast neutron treatments. Additional 25,000 M2 recovered from EMS and gamma irradiations are being advanced to M4 using the single seed breeding method. Currently, we have screened the population with blast strains to identify lines that are more susceptible and/or more resistant for identification of useful mutants for genetics study and crop improvement.

In addition, several recombinant inbred line populations with parents containing different resistance genes are being developed using single seed descent method. These materials will be deposited at Genetic Stocks- Oryzae Collection (GSOR) (http://ars.usda.gov/Main/docs.htm?docid=8318) at Dale Bumpers National Rice Research Center.

Currently, 15,000 M4 of Katy and the recombinant inbred line (RIL) populations of the cross of Raminad strain #3 (highly resistant to blast) with an experimental line RU9101001 (highly susceptible to blast), the cross of Katy with RU91010001, and the cross of Lemont (susceptible to sheath blight) and Jasmine 85 (resistant to sheath blight) are available for distribution by writing to Yulin Jia or Lorie Bernhardt. Progress on additional mapping populations that capture resistance genes from different genetic backgrounds and other traits for crop improvement will be presented.

Molecular Characterization of the Recombinant Inbred Line Population of the Cross of Lemont with Jasmine 85

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

Recombinant inbred line (RIL) populations of rice are an essential genetic resource for the construction of molecular genetic linkage maps and map-based identification of quantitative trait loci (QTLs). The RIL F_5 population derived from a cross of the United States tropical Japonica rice cultivar Lemont (LMNT) and Jasmine 85 was used to tag QTLs for rice sheath blight (RSB) resistance, which is one of the most severe diseases of rice in the world. Jasmine, an aromatic indica cultivar co-developed by scientists at International Rice Research Institute and USDA, is known to possess significant resistance to RSB in greenhouse and field conditions.

The objective of this study, as part of USDA-NRI-funded RiceCAP project, was to characterize the 256 F_5 RIL population of LMNT/JSMN using 196 polymorphic simple sequence repeat (SSR) markers for QTL analysis. A genetic linkage map was constructed having markers every 10 cm across all rice chromosomes. One hundred ninety-three SSR markers were mapped on 12 rice chromosomes, representing a total of 1634.8 cM of the genetic distance. Seven markers (3.6%) on chromosomes 3, 4, and 12 favored LMNT allele; 19 markers (9.7%) on chromosomes 3, 7, 9, and 12 favored Jasmine allele. Twelve (4.7%) and 24 (9.2%) RILs were skewed towards Lemont and Jasmine, respectively. As expected from F_5 progeny, the average frequencies of overall genome heterozygous and non-parental alleles per RIL were 9.7 (0.0-45.4%) and 0.4% (0.0-2.6%), respectively. These results demonstrate that the LMNT/JSMN F_5 RIL population is an excellent mapping population with the low percentages of skewed markers and RILs, low frequencies of non-parental alleles, and the expected frequencies of heterozygosity. This will be useful for identifying QTLs for a wide diversity of traits in addition to RSB that are segregating in this population.

Field Evaluation of Rice (*Oryza sativa* L.) Agronomic Traits Important for Early Planting in Arkansas

Stivers, A.M., Gibbons, J.W., and Anders, M.M.

Rice (*Oryza sativa* L.) date of planting tests conducted by the Cooperative Extension Service show that the highest yields were reported from the earliest planting dates of mid-March to the first of April compared with mid-April and later. Planting rice early in the spring involves risk. However, it can result in higher yields and conservation of natural resources through efficient use of spring rain.

An early planting date (PD) study was conducted in 2005 and 2006, which included divergent rice cultivars in order to identify agronomic traits that might confer tolerance to stresses that are frequently encountered before optimum planting dates. Planting dates for both years began March 2 and were spaced approximately 2 weeks apart. The objective of this study was to determine the effects of early planting on 1) plant growth and development [days to first, 50%, and 100% emergence, plant stands, days to 1.25 cm internode elongation from planting (DAP) and emergence (DFE) and 50% heading DAP and DFE, plant height and lodging]; 2) rough rice yield and yield components [number filled grains (FG), effective tillers (ET), thousand kernel weight (TKW), and harvest index (HI)]; 3) milling quality (head rice yield (HRY)) and grain quality (length and width for rough rice and brown rice); and 4) irrigation usage per PD.

In 2005, PD 1 resulted in a 30-day delay in emergence (50% emergence used since correlation coefficients between all emergence observations were significant and high) compared with PD 4; however, in 2006, there was only a 14-day delay in emergence. Early planting resulted in reduced stand between PD 1 and PD 4, and there was a general trend toward higher stands at later PD. In 2005, the earliest PD resulted in a 33-day delay in 50% heading DFE (usage based on correlation coefficients) compared with PD 4; however, in 2006, there was only a 21-day delay from PD 1 to PD 4. Plant height and lodging, although not statistically significant, trended towards increased plant height at the later planting dates with no difference in lodging.

Yields were similar in the earliest PD of 2005 compared with PD 4; however, in 2006, in contrast to other reports, the earliest PD did result in reduced grain yield. PD 2, however, was no different than PD 4. In general, for both years, the earliest PD resulted in the highest number of FG, ET, TKW, and HI compared with PD 4. In 2005, average HRY ranged from 58% in PD 2 to 62% in PD 3. In 2006, HRY ranged from 56% in PD 1 to 59% in PD 4. Amylose % varied by less than 1% between PDs. The least amount of irrigation water was applied in PD 2 for 2005 and PD 1 for 2006. Also, PD 1 received 25 and 20 cm more rainfall in 2005 and 2006, respectively. Therefore, the most efficient use of spring rains occurred in the earliest PD.

Rice Breeding for Temperate Latin America

Corredor, E., Cruz, M., Jennings, P., and Zorrilla, G.

The Latin American Fund for Irrigated Rice (FLAR), with the headquarters at the International Center for Tropical Agriculture (CIAT) in Cali, Colombia, has conducted a breeding program since 1995 that is closely integrated with the different rice programs of its member countries. In 2001, a separate program was established specifically for partners in temperate South America. The program aims to develop elite materials to serve as a source of new varieties with cold tolerance, combined with high yield potential, acceptable quality, and disease resistance. Planned outputs of the program include (1) the complete characterization of parents for cold environments, (2) an average of 300 triple crosses per year, (3) evaluation and selection of parents and segregants for cold tolerance under controlled conditions, and (4) supply of segregating populations and lines to member countries. To date, FLAR has supplied 621 potential parents, 446 fixed lines from anther culture, 4,768 segregating populations, and tropical materials resistant to *Pyricularia*. The materials produced are tolerant to cold under controlled conditions and have long and slender grain with high amylose content. Future work will focus on improving plant height, maturity period, and white belly.

Evaluation of Cold Tolerance in Rice under Controlled Conditions

Cruz, M., Corredor, E., Jennings, P., and Zorrilla, G.

The Latin American Fund for Irrigated Rice (FLAR) conducts a rice breeding program, in association with its partners, at the headquarters of the International Center for Tropical Agriculture (CIAT) in Cali, Colombia. Although this tropical location is advantageous, especially because it reduces the time required to develop varieties, it also creates difficulties when breeding for temperate conditions. FLAR has accordingly studied different methodologies to select for cold tolerance and, since 2001, has released cold-tolerant breeding lines for programs conducted by its partners in Brazil, Uruguay, and Argentina. Methods were developed to evaluate rice in three stages: germination (dry seed), vegetative (seedlings), and reproductive (flowering). Priority is now being given to seedling tolerance as the evaluation method is simple and results are consistent. The method evaluates 21-day-old seedlings submitted to a temperature of 5°C for 32 hours. Seven days after cold treatment, plants are evaluated on a scale of 1 to 9, where scores of 1 and 3 are considered tolerant, 5 intermediate, and 7 and 9 susceptible. Tolerant seedlings are then transplanted to the field for subsequent selection. Seed of selected germplasm is sent to temperate countries for field screening under natural conditions of cold stress. FLAR's temperate breeding program then proceeds to makes crosses, F_1, F_2, and F_3 at CIAT, and the F_3 nurseries are distributed to partner countries to continue the selection process.

Each year FLAR's breeding program for cold tolerance evaluates approximately 3,000 lines in the germination stage and 6,000 in the seedling stage. Evaluation during the reproductive stage is not yet a routine procedure, and only a limited number of materials have been evaluated.

The methodologies of evaluation under control conditions permit a fast generational advance with germplasm selected for cold tolerance. This type of stress is difficult to predict under natural conditions because of the timing, duration, or intensity with which it occurs. Therefore, it would prove advantageous to use controlled conditions and subsequently verify reactions in the field. This process reduces an important number of populations that are transplanted to the field and selection can accordingly focus on the remaining number.

A Tall Mutant of M-206 – Description and Preliminary Results

Lage, J., Johnson, C.W., McKenzie, K.S., Andaya, V.C., Fischer, A.J., and Eckert, J.W.

In 2005, a tall mutant of the Californian medium grain variety M-206 was identified at the Rice Experiment Station (RES) in California. This mutant is approximately 20 cm taller than M-206. This increase in height is a result of an increase in length of all internodes. This is in contrast to variants on M-206 with the Elongated Upper Internode (*eui*) gene in which a similar increase in total plant height is primarily due to a drastic increase in the length of the upper internode. Furthermore, the brown rice kernel weight of the tall mutant is 9% heavier than that of M-206 despite the two having the same number of kernels per panicle.

In order to determine if the tall plant was indeed a mutant of M-206 and not a result of contamination or cross pollination, seed from both were submitted to OMIC USA Inc. for varietal identification. Ten selective SSR markers were used and results showed that the tall mutant could not be distinguished from M-206, strongly suggesting that the tall plant is a result of a single-gene mutation of M-206. To support this theory, the tall mutant was crossed and backcrossed to M-206 to determine the inheritance of this trait. Height of individual F_2 and BC_1F_2 plants were recorded, and the Chi-square tests did not reject the tall:short ratios of 1:3 or 1:7 for the simple and backcross populations, respectively, confirming our initial observations that the tall plant is due to a single recessive gene. Subsequently, this trait has been named "*plant height discovery*" (*phd*), and work is in progress to map the gene.

A moderate increase in plant height may provide rice growers an opportunity to control weeds by increasing the water depth, an option that could be of special interest to organic rice growers. In collaboration between UC Davis and RES, yields of *phd*-M-206, M-206, and M-202 were assessed under normal water depth (10 cm) and deep water (22 cm). Two basins for each water depth were used, with four replications of each line in each basin. *Phd*-M-206 and M-206 yielded 5005 and 5093 kg/ha (4,469 and 4,547 lb/A), respectively, under normal water depth, a difference which was not significantly different (P=0.61). At 22-cm depth the yield of the same two lines was reduced to 2251 and 1780 kg/ha (2,010 and 1,589 lb/A), respectively, a difference which was significant at P=0.06. M-202, which is well known for its ability to grow under deep water conditions, yielded 5686 and 2941 kg/ha (5,077 and 2,626 lb/A) under the two different water depths. These preliminary results indicate that the *phd*-trait can increase yield when grown in water 22 cm deep but also that a vigorous variety like M-202 is still superior under such conditions. Increasing plant height of any grain crop always increases the risk of lodging. However, data from RES and three off-station test sites did not show any difference in lodging between *phd*-M-206 and M-206.

We believe that the ever increasing public awareness of use of pesticides in agriculture warrants continuous research in ways to reduced pesticide use. This is primarily done by research in cultural management, but with a trait such as the *phd,* research in genotype by management interactions may gain increased focus to the benefit of both rice growers and the environment. Further testing of performance under different water scenarios is planned for 2008, and the *phd*-trait is being introgressed into different Calrose medium-grain backgrounds, including M-202.

The *PHD* Gene: Description and Genetic Characterization of a Spontaneous Mutant of Rice

Andaya, V.C., Johnson, C.W., Lage, J., Tai, T.H., and McKenzie, K.S.

Recently, the Rice Experiment Station in Biggs, CA, isolated a spontaneous tall mutant of the California medium-grain variety M-206 and initially named as DW-206. DW-206 has a mutation in a gene designated as *Plant Height Discovery* or *PHD* and believed to be different from the *EUI* genes previously characterized in rice. The inheritance pattern in the F_1 and F_2 generations has determined that *phd* allele is a single recessive mutation.

Initial phenotypic characterization has shown that the *phd* allele confers improved seedling emergence under flooded conditions and better stand establishment under water-seeded rice culture. Compared with M-206, the mutant has longer leaves and internodes and bigger kernels. Experiments comparing plant stands under varying water depths revealed that DW-206 showed faster seedling emergence under deep water compared with the wild-type M-206. The *phd* allele caused the elongation of the lower internodes, allowing the seedlings to emerge faster under submerged conditions. The allele has a potential to contribute to weed competitiveness of rice under direct seeding.

The rice microsatellite linkage map is well-developed and very robust in rice. With the sequencing of the rice genome completed, the development of markers that can be used to detect genes of interest is now routine. Two F_2 mapping populations were generated from the crosses DW-206/M-104 and DW-206/M-208 to map the location of the *PHD* gene using microsatellite markers. The rice varieties M-104 and M-208 are both medium-grain rice released for California. Based on the DNA fingerprinting of California rice varieties using genetic markers at the USDA-ARS in Davis, CA, microsatellite markers are initially selected based on their polymorphism within the medium-grain varieties. These markers were then screened for polymorphism using DW-206, M-208, and M-104.

Initial findings showed that the *phd* allele did not map to the location of *eui-1* in chromosome 5 or the *sd-1* in chromosome 1. However, the lack of useful markers in chromosome 10 did not exclude the possibility that the *phd* allele may be similar with *eui-2.* The medium-grain types have a relatively narrow genetic base making it difficult to find polymorphic markers to adequately map the *PHD* gene. There is a need to develop additional mapping populations using more diverse parents.

Status and Perspectives on Rice Germplasm in Guizhou, P.R. China

You, J., Prislovsky, S.E., Blocker, M.M., and Moldenhauer, K.A.K.

Guizhou province is one of the Chinese districts with high phenotypic and genetic diversity in cultivated rice (*Oryza sativa* L.). This abundant variation is an important rice resource, and preserving it in China will be essential for future rice improvement. There were 5,667 accessions of different rice cultivars in Guizhou by 2004. These accounted for 10% of the ex situ germplasm collection in China. Another 2,000 cultivars are introduced rice accessions from other Chinese regions and other countries. Some of the elite germplasm includes traits for semi-dwarfism, large panicles, large rice kernels, superior quality, cold and drought tolerance, and resistance to diseases and pests. Only some of these traits have been evaluated and utilized. Typical cultivars and speciality cultivars have been developed from this material, such as Guizhou He and upland rice. These cultivars have been attracting the attention of breeders and genetic researchers throughout China. Information is still lacking on the genetic diversity and genetic structure of these rice resources, and the percentage of utilization of the rice resources in the collection is low. In order to provide excellent rice germplasm for rice breeding in the future, research should be conducted on this germplasm to promote further utilization of the material. This research should involve evaluations at the phenotypic and genotypic level utilizing molecular technology.

Abstracts of Papers on Economics and Marketing
Panel Chair: D.A. Sumner

Economic Analysis of Water Conserving Irrigation Methods in Arkansas Rice Production

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

Contour levees account for the majority of rice hectares in Arkansas. Contour levee systems are extremely water intensive and can apply between 3,084 and 4,009 m^3 (30 and 39 A) of total water to maintain a flood during a growing season. Greater water savings may be achieved using multiple inlet irrigation, straight levee systems, or zero-grade systems. Multiple inlet (MI) irrigation allows water to be released into each individual paddy in a rice field at the same time via irrigation tubing. The field is flooded quicker and irrigation efficiency is increased through reduced pumping time during the season. Straight levee systems are often associated with precision leveled land. Precision leveling removes depressions in the field that hinder water movement and results in a reduction in the minimum depth of water required to cover the entire field. Zero-grade systems require the field to be leveled to a zero-slope. The zero-slope allows water to travel faster and the flood to be more uniform across the field. Water savings from MI and straight levees range from 11% (contour levees + MI) to 35% (straight levees + MI) when compared with contour levee fields, while water savings from zero-graded fields can be as high as 60% compared with contour levee fields.

This study evaluates the costs and returns of water conserving irrigation methods in rice production using water use data from the literature and enterprise budget analysis. Five different irrigation methods are evaluated: 1) contour levees, 2) contour levees + MI, 3) straight levees, 4) straight levees + MI, and 5) zero-grade. The Mississippi State Budget Generator (MSBG) is used to generate direct and fixed expenses for each irrigation method across three possible pump lift scenarios: 1) re-lift, 2) a standard well that is 36.6 m (120 ft) deep or less, and 3) a deep well that is between 36.6 and 73.2 m (120 and 240 ft) deep. The 2006 state average rice yield of 6,888 kg/ha (152 bu/A) is used for contour levee fields and is adjusted upward to reflect increased production area resulting from fewer levees under straight levee (5% of field in levees) and zero-grade management (0% of field in levees) relative to contour levee management (10% of field in levees). Returns and costs are calculated across irrigation methods and pump lift scenarios assuming a farm diesel price of $0.6156/L ($2.33/gal) and a rice price of $0.2244/kg ($4.57/bu).

Straight levee systems and zero-grade systems are more profitable than contour levee systems, regardless of the pump lift scenario analyzed due to water savings and reduced machinery and labor expenses associated with levee construction. Zero-grade systems result in the greatest net returns above total specified expenses. Multiple inlet irrigation produces greater monetary benefits on straight levee fields than on contour levee fields. Returns are greater for straight levees + MI than for straight levees without MI under every pump lift scenario except the re-lift scenario. Monetary returns to MI on contour levee fields are positive only for the deep well scenario. In the instances where inclusion of MI lowered net returns, the economic savings of applying less water are slightly outweighed by the cost of laying irrigation tubing on the field. The returns above total specified expenses across irrigation methods under the standard well scenario are: contour levees, $428/ha ($173/A); contour levees + MI, $420/ha ($170/A); straight levees, $535/ha ($216/A); straight levees + MI, $544/ha ($244/A); and zero-grade, $698/ha ($282/A).

Financial Characteristics of Rice Farms Relative to Other Selected Crop Farms, U.S., 2005

Chavez, E.C., Wailes, E.J., Ahrendsen, B.L., and Dixon, B.L.

The national average financial characteristics of rice farms are compared with those of five other selected crop farms in the United States for calendar year 2005. The other crop farms include corn, soybean, wheat, cotton, and sorghum. For rice farms, the mean area operated is 401 ha (991 A), while for the other crop farms the mean areas operated are 268 ha (662 A), 201 ha (498 A), 724 ha (1,790 A), 584 ha (1,442 A), and 703 ha (1,737 A), respectively. The bulk of the analysis focuses on the differences in selected average income statement and balance sheet variables at the farm business level. The per-hectare analysis covers only government payments, variable costs and income. This information provides a general indication of the comparative overall profitability of operating different types of crop farms.

Estimated means in this analysis are based on data from the 2005 Agricultural Resources Management Survey (ARMS) jointly conducted by USDA's Economic Research Service and National Agricultural Statistics Service. Non-family and retirement farms are excluded in the analysis. At the farm level, standard errors (computed using the delete-a-group jackknife procedure) are used for testing if the observed differences between means are statistically significant at the 5% significance level (two-tailed test) and 28 degrees of freedom with a critical t-value of 2.048. T-values for five 2-way comparisons with rice are computed. Overall results show that differences in both the mean net income and mean farm equity (net worth) between rice farms and those of the other five crop farms in 2005 are not statistically significant. However, there are a number of variables in rice farms' income statements, balance sheets, and financial ratios that are significantly different from those of the other five selected crop farms. These differences are discussed below.

The mean gross cash income of rice farms ($372,512) exceeds those of soybean and wheat farms by $230,350 and $228,877, respectively, and these differences are statistically significant. However, the differences between the mean gross cash income of rice farms and those of corn, cotton and sorghum farms are not statistically significant. Mean government payments for rice farms ($71,494) exceed those of soybean and wheat farms by $52,752 and $47,206, respectively; and the differences are statistically significant. The differences in mean government payments of rice farms and those of corn, cotton and sorghum farms, however, are not statistically significant. While the mean net cash farm income from rice farms ($67,643) is significantly lower than that of cotton farms by $136,560, the differences with those of corn, soybean, wheat, and sorghum farms are not statistically significant.

Mean variable expenses of rice farms ($234,976) are higher than those of corn, soybean, and wheat farms by $134,676, 172,742, and $159,435, respectively, and the differences are statistically significant but differences with those of cotton and sorghum farms are not statistically significant. Mean fixed expenses of rice farms ($69,893) are significantly higher than those of soybean and wheat farms by $38,681 and $40,007, while differences with corn, cotton, and sorghum farms are not statistically significant. Balance sheet variables on assets, liabilities, equity, debt-to-asset ratio, and current ratios for rice farms are compared with those of the other five crop farms. Only two significant differences for the means are found. Rice farms have mean current assets of $203,732, which is significantly higher than that of sorghum farms by $177,094. Rice farms' mean debt-to-asset ratio of 0.29 is significantly greater than soybean farms' 0.09, which indicates rice farms are more financially leveraged and, potentially, have more financial risk.

The lack of significant differences in the balance sheet variables indicates that rice farms' financial capital (assets), solvency (equity), financial risk (debt-to-asset ratio), and liquidity (current ratio) are similar in most cases to those of the other five crop farms on average. In terms of financial efficiency as measured by mean asset turnover ratio, rice farms (0.64) have a marked edge over corn (0.27), soybean (0.20), wheat (0.30), and sorghum (0.27) farms and the differences are statistically significant. The difference between rice farms' mean asset turnover ratio and that of cotton farms, however, is not statistically significant. On a per hectare basis, while mean government payments of $178 for rice exceed those of the five other crops, only the difference with wheat's $34 is statistically significant. Likewise, the mean variable expenses per ha of rice ($586) are higher than those of the other five crops, but only the differences with soybean, wheat, and sorghum of $277, $482, and $355, respectively, are statistically significant. The rice gross cash income per ha ($929) is significantly different only from those of wheat (by $731) and sorghum (by $575). However, both net cash farm income ($169) and net farm income ($301) per ha of rice are not significantly different from those of the other five crops.

Evaluation of Optimal Share Rental Arrangements for Rice Production in Louisiana

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

An equitable crop share arrangement identifies all contributions made separately and collectively by a landowner and a tenant. Income is then said to be shared in that same proportion. Production expenses may also be shared between the two parties. Equitable lease theory suggests that returns to land are similar to the returns to non-land inputs. The economic importance of a rental arrangement is dependent upon the terms and conditions that a producer enters into with a landlord or waterlord due to the fact that arrangements can vary across, as well as within, agricultural production regions. Agricultural land lease arrangements are generally of two basic types: cash rent or share rent.

In Louisiana, rental arrangements for rice production are predominately share rent with the landlord possibly sharing in some expenses. However, in recent years, rice producers have been renegotiating rental arrangements in response to declining net returns and increasing variable costs, most notably, increase in energy-related inputs, e.g. diesel, chemicals, and fertilizer. The allocation of capital and resources invested by the grower and landlord can serve as a management strategy when marketing, selling, and reinvesting in the crop.

In June 2007, a survey was mailed to 1,128 rice growers in the major rice producing parishes of the state to solicit the type of rental arrangement, rent mechanism, 2007 planted rice acreage, and the percentage of variable production costs paid by the landlord on a per tract basis. Possible variable production costs paid by the landlord or waterlord included: irrigation pumping, seed, fertilizer, chemicals, and drying. The purpose of this study was to identify predominant types of rice rental arrangements currently in the industry and to evaluate the impact of such factors as price level, yield level, production costs, source of irrigation water, and other factors that would favor one type of share rental arrangement over another. The top seven rental arrangements, representing 82.1% of the tracts survey, varied widely in terms of share of the crop paid to the landlord. General results from the study suggest optimal rice rental arrangements can vary widely within a relatively small localized area of production and are dependent on several factors that impact the net returns received by the grower and landlord.

Economic Factors Behind USDA's 2008 Domestic Baseline Analysis for Rice

Childs, N.W.

USDA's 2008 long-term annual supply and demand baseline results for the U.S. rice industry are presented, with the economic factors behind the results explained. Each year, USDA develops both a domestic and international long-term 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 farm policies remain in effect.

The 2008 baseline projects increasing U.S. rice acreage over the entire baseline period, with plantings reaching 1.3 million ha (3.2 million A) by 2017. The area expansion is primarily driven by increasing net returns. Despite the area expansion, U.S. plantings remain below the 2004 level, mostly due to strong prices for competing crops and rising production costs. The average U.S. yield is projected to increase almost 1% annually from 2009-2011. After 2011, the growth rate slowly declines. U.S. rice production is projected to increase each year of the baseline. Imports, already at record highs, are projected to continue to increase each year.

Domestic and residual use is projected to continue expanding each year at a rate slightly faster than population growth but slower than in the 1980s and 1990s. The share of the domestic market accounted for by imports is projected to increase over the next decade. Beginning in 2009, exports are projected to slowly increase each year due to increasing global demand, modest growth in U.S. domestic and residual use, and slightly more competitive U.S. prices. With total supplies growing slightly faster than total use, U.S. ending stocks are expected to increase after 2008. Despite a slight buildup in stocks, the stocks-to-use ratio is expected to slightly decline over the baseline period.

Global trading prices are projected to continue rising over the next decade, largely due to strong prices for competing crops, increasing global trade, and a tightening global stocks situation. Slow yield growth and little ability to expand area in most producing countries account for the tightening global stocks situation. This effect is partially offset by declining global per capita disappearance over the baseline, largely reflecting dietary shifts away from staple foods in Asia as incomes rise. The U.S. farm price increases each year of the baseline period, a result of rising world prices, high prices for other grains and oilseeds, and strong competition from other crops for U.S. acreage. U.S. prices are expected to rise at a slightly slower pace than international prices, causing the U.S. price difference to contract and support higher U.S. exports.

Long-Term Baseline Supply and Demand Projections of the U.S. and Global Rice Economies, 2007-2017

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

This paper focuses on projections of rice production, consumption, trade, and price estimates for key rice exporting and importing countries. These projections provide baseline estimates for evaluating and comparing alternative policy and market assumptions that affect the rice industry. Projections are generated from the Arkansas Global Rice Model (AGRM), a non-spatial econometric model of 30 countries, developed and maintained in the Department of Agricultural Economics and Agribusiness at the University of Arkansas in Fayetteville.

The average international long-grain rice price significantly strengthens further in 2007/08 as global stocks-to-use ratio remains below 19.0%. India's ban on exports of non-basmati rice will substantially reduce the country's estimated exports to 2.0 million metric tons from 4.2 million metric tons in the previous year. Thai 100B price rises as available supply in the world market tightens. U.S. rice export price increases also in 2007/08 as trade increases by 20%, and recovers from the previous year's decline as a result of GM contamination. Stocks decline by 32.0%. The price premium of U.S. long-grain rice over the Thai long-grain rice remains around $95/metric ton.

World rice harvested area in 2007/08 increases 0.5% to 153.7 million hectares as gains in China, Indonesia, Nigeria, and Thailand dominate declines in Japan, Pakistan, and Australia. Over 63% of the net area gain comes from China and Indonesia. World rice production is estimated to be 421.2 million metric tons, up 0.7 percent, as world average yield gains only 0.2% due to lower yields in a number of producing countries like Australia, South Korea, Taiwan, Uruguay, and Turkey--offsetting productivity gains in the U.S., Argentina, Japan, and Mexico. Nearly 55% of the net output increase in 2007/08 comes from China and 44.0% comes from Indonesia, Brazil, and Vietnam. While world population grows by 1.14%, global rice consumption increases by 0.4% to 419.6 million metric tons in 2007/08 as average per capita rice use declines by 0.7%. Declining per capita use is a result of the combined effects of urbanization, diet diversification, and diet changes toward more protein-based foods in countries with strong income growth like India, China, Indonesia, Taiwan, South Korea, Thailand, and the Philippines. Consumption increases in India and China account for virtually all of the net gain in global consumption in 2007/08.

Total global rice trade in 2007/08 is 28.2 million metric tons, down 1.7% from the previous year's level. Increases in exports from Thailand, U.S., Vietnam, and Egypt do not offset the big declines in shipments from India and Australia. Irrigation water constraints limit Australia's production area to 6.0 thousand hectares in 2007/08, down from 99 thousand in 2005/06 and 16 thousand in 2006/2007. Australia will become a net rice importer. Total world rice trade relative to total global rice consumption remains low at 6.7%. Net world rice trade in 2007/08 is 24.3 million metric tons, 2.4% below the previous year's level. World rice production is projected to gain 1.9% in 2008/09, as output from China, India, and Bangladesh increases, accounting for 73% of the net global increase. While world rice area is projected to decline slightly, average world rice yield is expected to improve by 2.0%. With average world population growth of 1.12% and a slight increase of 0.3% in per capita consumption, total global rice consumption is projected to increase by 1.4% to 425.5 million metric tons in 2008/09. Total rice trade is expected to expand by 4.9%, as India resumes normal export activity, causing international prices to decline by 7.0 to 8.0%.

Over the next decade, global rice area is projected to decline slightly below 153 million hectares, as average yield and total production grow in tandem at 0.7% annually. Substantial rice area contraction in China of 3.0 million hectares over the next decade overshadows the gains expected in other countries. Nearly 70% of the net volume growth in total rice production in the next 10 years will come from India, Bangladesh, Vietnam, Indonesia, Thailand, and Myanmar. Driven by 1.04% population growth, total rice consumption will grow at 0.8%, with average per capita use declining by 0.2%. Nearly 50% of the net gain in world rice consumption is accounted for by India, Bangladesh, Indonesia, Vietnam, Nigeria, Myanmar, and the Philippines. Driven by consumption and trade, international rice prices will grow modestly at 0.4% annually over the same period. India, Thailand, and Vietnam are projected to dominate trade and account for virtually all the growth in net exports over the next 10 years, as these countries continue to experience yield growth and declines in per capita consumption. Nearly 60% of growth in net imports by volume over the same period will come from the Middle East, Nigeria, South Africa, the European Union, and Mexico.

How Much Did We Miss? The Potential of Including Rice in the FTA with Korea

Lee, H. and Sumner, D.A.

Last year, the United States and Korea negotiated a free trade agreement KORUS-FTA that left rice completely off the table. This presentation asks how important this exclusion was to the U.S. rice industry in terms of narrow economic benefits foregone.

We use a fairly standard static log-linear equilibrium displacement model to measure the lost opportunity of a potential free trade agreements options with Korea that includes some liberalization of the rice trade. We do not consider the full free trade option because full free trade was probably never a realistic option. We allow for substantial trade diversion recognizing that U.S. exports of Japonica rice to Korea would mean smaller exports elsewhere so that the main economic impacts relate to market prices in all markets plus gain in quota rents for shipments into the Korean market.

The results suggest that the implications of opening the market for rice as a part of KORUS-FTA would have been moderate losses for Korean farmers (and gains for Korean consumers). The gains for U.S. producers would have also been moderate given the potential trade diversion. We show that these impacts would be smaller if the WTO deal still under negotiation would open the markets on a multilateral basis. The analysis uses a baseline before the recent jump in global rice prices, but we note the Korea domestic prices remain above even the highest of the recent spikes in world rice prices.

An Economic Analysis of the Impacts of House and Senate Farm Bill Proposals on U.S. Rice Producers

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

The current House and Senate farm bill proposals provide options for a continuation of the current direct payment, counter-cyclical payment, and loan deficiency payment/marketing loan gain programs; however, they also provide an option to enroll in a counter-cyclical revenue program. This program is called a revenue counter-cyclical payment under the House proposal and an Average Crop Revenue (ACR) payment in the Senate plan. Variability in state level prices and yields is expected to create winners and losers under both the House (national revenue trigger) and Senate (state revenue trigger) plans. This study evaluates the economic impact of each proposal on U.S. rice producers.

This study utilizes simulation modeling in a representative farm framework to determine the economic impact of implementing the House and Senate farm bill proposals. A focus interview process was used to obtain data necessary to develop four representative rice farms located in major rice production regions across the United States. Four model rice farms were developed by collecting fixed and variable costs, historical yields, prices received, and government program information from producers in Stuttgart, AR; Colusa, CA; Poplar Bluff, MO; and Eagle Lake, TX. Projected market prices, interest rates, and rates of change for input prices were obtained from the FAPRI December 2007 Baseline.

A multivariate empirical probability distribution for simulating stochastic yields and prices was estimated, thus incorporating yield and price risk into the analysis. Two measures of financial viability, average net cash farm income (defined as total cash receipts minus total cash expenses) over the 2008-2014 projection period and ending real net worth in 2014, were used to evaluate the impact of the new proposals on the model farms. The base situation assumed a continuation of provisions of the 2002 Farm Bill. Implementation of the House and Senate proposals (assuming enrollment in the revenue counter-cyclical and ACR options, respectively) were evaluated by comparing changes relative to the base scenario.

Preliminary results show that the House plan would yield a slight improvement in financial health of the farms compared with the base situation, while the Senate proposal negatively impacts the financial viability of the representative farms. With relatively strong price projections, traditional and revenue-based counter-cyclical payments are expected to be negligible, thus the reduction in fixed payments under the ACR plan is the primary reason for the negative impact on the representative farms under the Senate proposal.

Abstracts of Posters on Economics and Marketing
Panel Chair: D.A. Sumner

An Economic Comparison of the Alternative Farm Policies on Arkansas Rice Farms

Hignight, J.A., Wailes, E.J., Watkins, K.B., and Hogan, R.

Arkansas is the nation's largest producer of rice, second in cotton, and is the largest grower of soybeans in the southern region. A typical Arkansas rice farm will include soybeans and sometimes cotton, wheat, corn, and sorghum into its crop mix. The characteristics and crop enterprises are not only typical for the state but for the Delta region as well. Although there are differences within the region, all face the same challenges of capital investment and input cost, determining optimal crop mixes, adoption of new technologies, and trying to attain profitability. Access to the safety net provided by government price and income support programs is generally an important dimension of all of these farms.

To help set the stage for the new legislation, the USDA released its proposal for the 2007 Farm Bill in January 2007. It is the first time in history that the Department put forth such a comprehensive proposal for farm legislation. The House Agriculture Committee drafted farm legislation over the summer of 2007. On July 27, 2007, the House of Representatives voted and approved its farm legislation H.R. 2419 by a vote of 231-191.

The objectives of this study are to measure and compare the impacts of the USDA 2007 Farm Bill proposal, each major program component within the USDA proposal, and the House 2007 Farm Bill legislation relative to an extension of the current 2002 Farm Bill on the Arkansas representative panel farms economic well-being. Five representative panel farms are created with a panel of producers in a specific area based upon their characteristics and crop enterprises. Using historical data, empirical distributions are developed for each variable by means of multivariate empirical distributions. Policy parameters are adjusted according to each scenario as described in the 2002 Farm Bill, the USDA 2007 Farm Bill proposal, and the House legislation H.R. 2419. The analysis assumes the policies would be implemented from 2008-2012. The results are generated by stochastically simulating farm performance 500 times for each scenario and are average results over the 5 simulated years.

The results indicate that the 2007 USDA Farm Bill proposal would have a severe negative impact on all but one of the five Arkansas rice farms primarily due to the stricter payment limits. The smallest representative farm is financially better off than its baseline due to increases in direct payments and no impact from payment limits. H.R. 2419 would also have a negative impact on some Arkansas rice farms, depending on their crop mix and base acreage due to stricter payment limits. A unique finding was that the majority of farms averaged a higher net income with the revenue-based counter-cyclical program proposed by the USDA and incorporated into H.R. 2419 as an alternative to the current price-based counter-cyclical program.

Evaluating the Impact of Crawfish Production on Rice Production Costs in a Rice/Crawfish/Rice Rotation

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

Rice in southwest Louisiana is produced in a crop rotation system. However, the number of viable rotational crops agronomically and economically suitable for rotation with rice in this area of the state is rather limited. Common rotation options include leaving the land fallow, producing soybeans, or producing crawfish. The production situation evaluated in this paper is a 3-year rotational production system with rice production in Year 1 and Year 3 and crawfish production in Year 2. Production of crawfish in rotation with rice imposes costs on the rice enterprise both in the year prior to crawfish production and in the year following crawfish production. Three primary costs imposed on the rice enterprise from crawfish production include the loss of rice ratoon crop revenue in Year 1, additional field operations to prepare the field for rice planting following the crawfish crop in Year 2, and additional rice herbicide costs in Year 3. These costs were estimated to be in the range of \$346 to \$396/ha of rice planted over two rice crops or \$173 to \$198/ha of rice planted per year. From a farm economic accounting perspective, these costs should be charged to the crawfish operation. In situations where the rice grower is also producing crawfish, revenue from the crawfish operation is available to offset these added costs imposed on the rice enterprise. However, in situations where crawfish production in Year 2 is being produced by a third party, this rental arrangement inequitably imposes costs on the rice producer.

Abstracts of Papers on Plant Protection
Panel Chair: L.D. Godfrey

Rice Water Weevil Populations, Damage, and Insecticidal Efficacy Relative to Planting Date

Way, M.O., Nunez, M.S., Pearson, R.A., Espino, L., and Jiang, M.

Experiments were conducted at the Beaumont Center from 2005-2007 and were designed as a randomized complete block with four replications. Treatments were registered insecticides applied at recommended rates and times. Planting dates extended from early March through early June. All experiments were planted with Cocodrie. Rice water weevil populations were monitored about 3 weeks after flood and 10 days later on the main crop and yields recorded. March through mid-April plantings were ratooned if the main crop was harvested before or about mid-August. Ratoon crop yields also were recorded, but rice water weevil populations were not treated or monitored on the ratoon crop.

In general, rice water weevil populations were higher on the second sample date compared with the first sample date on earliest (mid-late March) planted rice. Highest populations of rice water weevil in untreated plots coincided with earliest planting dates. Highest yields were produced by mid-March to mid-April plantings. All treatment insecticides provided good control of rice water weevil, regardless of planting date. Averaged across all experiments over all 3 years, rice water weevil control resulted in the greatest yield gain [642 kg/ha (572 lb/A)] for late-March to mid-April plantings, which coincides with the recommended optimum planting window in Texas.

Evaluation of Insecticides for Management of the Rice Water Weevil in Louisiana

Stout, M.J., Lanka, S., McClain, R., Barbee, G., and Riggio, M.R.

The rice water weevil, *Lissorhoptrus oryzophilus*, is the most destructive insect pest of rice in Louisiana, causing yield losses in excess of 20% in some fields. The current management program for this insect relies heavily on applications of liquid formulations of pyrethroid insecticides to kill adult weevils before they oviposit. There are numerous problems associated with the use of pyrethroids. Foremost among these problems is the fact that pyrethroids are extremely toxic to crawfish. Crawfish is Louisiana's most valuable aquaculture commodity and crawfish are co-cultivated with rice in many areas of Louisiana. Four insecticides are being seriously considered as alternative to the pyrethroids. Of these potential alternatives, three [thiomethoxam (Cruiser, Syngenta Crop Protection U.S.), dinotefuran (Mitsui Chemicals), and clothianidin (Valent U.S.A. Corp.)] are neonicotinoids, and the fourth (chlorantraniliprole [Dermacor, DuPont Crop Protection]) is a member of a novel insecticide class (anthranilic diamides). Thiomethoxam, clothianidin, and chlorantraniliprole were tested as seed treatments, whereas dinotefuran is formulated as a granule. All four insecticides have been evaluated over multiple years. The effectiveness of the seed treatments against the rice water weevil in small-plot field studies has ranged from good to excellent. Greenhouse studies suggest that the neonicotinoid seed treatments reduce weevil populations at least in part by killing adult weevils (i.e., the insecticide is translocated to leaves and kills adults when they feed). Split applications of granular dinotefuran (one preflood application + one postflood application) have also provided excellent control of weevils. Interestingly, late postflood applications (ca. 20 d after flooding) have also proven moderately effective. Greenhouse studies with dinotefuran confirmed the larvacidal activity of granular dinotefuran. Preliminary data strongly indicate that all four potential alternatives to pyrethroids are much safer against crawfish than pyrethroids. The potential for improving the integration of pest management and crawfish production in rice fields will be discussed.

Induced Resistance in Rice to the Rice Water Weevil (*Lissorhoptrus oryzophilus*) Using Jasmonic Acid

Hamm, J.C., Stout, M.J., Riggio, R.M., and Pourian, S.

The rice water weevil, *Lissorhoptrus oryzophilus* (Kuschel), is the most destructive early-season insect pest of rice in Louisiana. On average, yield losses of 10% are encountered, and losses exceeding 30% are not uncommon. In addition, this insect has been accidentally introduced into some of the major rice-producing regions of Asia and poses a global threat to rice production. Jasmonic acid (JA) is a plant hormone that mediates plant responses to insect herbivory in many plants, and exogenous applications of JA have been used to induce resistance in several plant species. Treating greenhouse-grown rice plants at the two-three leaf stage with exogenous applications of JA reduced the number of eggs oviposited by rice water weevil females, as well as densities of first and late instar larvae. Similar experiments were undertaken in field plots using two different varieties. Our field data did not show any significant effect of JA on *L. oryzophilus* larval densities, but the effect of variety was significant.

Response of Water-Seeded Rice to Insecticidal Control of Target and Non-Target Aquatic Insects

Pearson, R.A., Way, M.O., Nunez, M.S., Espino, L., and Weiss, M.S.

The objectives of this research were: 1) to determine if selected non-target, aquatic insects are responsible for uprooting rice seedlings; 2) determine if these insects are affected by the insecticides fipronil (Icon 6.2FS) and lambda-cyhalothrin (Karate Z) applied in different planting regimes to control rice water weevil (RWW), *Lissorhoptrus oryzophilus* Kuschel; and 3) evaluate the effectiveness of these insecticides against the RWW. Based on personal observations in the field, adult *Tropisternus lateralis* (Say) bring rice seedlings to the water surface. Greenhouse experiments were conducted with varying densities of adult *T. lateralis* and another abundant hydrophilid beetle, *Berosus infuscatus* LeConte. Results showed that *T. lateralis* uprooted seedlings but *B. infuscatus* did not. In field experiments, applications of the insecticides Icon 6.2FS and Karate Z (when applied before flood) resulted in large numbers of dead insects associated with reductions in numbers of uprooted seedlings. Icon 6.2FS appeared to be less effective than Karate Z in controlling RWW.

Impact of Management Strategies for Rice Water Weevil on Populations of Non-Target Invertebrates in California Rice

Godfrey, L.D., Lewis, R., Pinkston, W., and Windbiel-Rojas, K.

Registered and experimental insecticides were evaluated for their efficacy against rice water weevil (RWW), *Lissorhoptrus oryzophilus* Kuschel, as well as their effects on populations of non-target invertebrate organisms in rice fields. Both preplant applications and postflood treatments were utilized and compared. The effect on non-target invertebrates has become more significant with the increased importance of mosquito-vectored West Nile Virus in California. Many of these non-target invertebrates are potential predators of mosquito immatures in the rice system and may help to keep mosquito populations in check. Efficacy against rice water weevil was evaluated in plots comprised of aluminum rings 3 m^2 (~10 ft^2) placed in the flooded fields with M-202 rice. Treatments were applied per use directions and were replicated four times. RWW adults were collected from nearby infested, untreated fields and placed in each ring to guarantee a consistent population. Larval populations were sampled at 5 and 7 weeks after seeding using 10-cm (4-in.) diam. cores (five samples per plot per date). RWW immatures were recovered using a washing-flotation technique. Separate plots were used to assess the impact of treatments on populations of non-target invertebrates. Treatments were applied to individually leveed rice plots 4.6 x 15 m (~15 x 50 ft) with four replications. Treatments were applied according to the accepted use pattern either preflood, postflood at the 3-leaf stage, or midseason (timing for armyworm control). Populations of aquatic invertebrates were assessed weekly from seeding (late May to early June) until the time of field draining (late August to September). Three sampling methods were used 1) floating barrier traps for the first 4 weeks after seeding, 2) quadrant samples of 0.08 m^2 (0.9 ft^2) where all invertebrate organisms were removed with an aquatic net (six samples per plot), and 3) mosquito dip samples (25 samples per plot). In summary, etofenprox, indoxacarb, and clothianidan all appear to have significant potential for RWW management. Indoxacarb is active via a postflood application whereas clothianidan has the most flexibility in terms of application timing. Given the re-evaluation of pyrethroid registrations due to possible off-site movement, it is important to continue to develop alternative active ingredients and classes of chemistry. The Trebon 3G preflood applications were not effective, thus, it appears that the 3-leaf stage application is going to be the preferred application method for this product. The Clorox seed soak (used for Bakanae control) greatly affected the activity of V10170 seed treatment; the soaked treatment was largely ineffective, whereas without the Clorox soak, the activity was good. The E2Y45 (rynaxypyr) seed treatment was largely ineffective, although these seeds were similarly soaked in Clorox. For the effects of insecticide treatments in rice on populations of non-target invertebrates, a preflood Warrior application reduced populations of aquatic insects compared with the untreated for the first week after application but not thereafter. Seven treatments applied at the 3-leaf stage were compared and V10170 and Mustang reduced aquatic insect populations at 2 and 3 weeks after application. Averaged over the 5-week period following application, all the treated plots had levels of aquatic insects equal to or greater than in the untreated. Warrior was evaluated as a representative material that could be applied against armyworms in July and this treatment was very damaging to populations of aquatic insects at 1 and 2 weeks after treatment.

The Panicle Rice Mite, a New Pest of Rice in the United States

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

The panicle rice mite (PRM), *Steneotarsonemus spinki* Smiley (Acari: Tarsonemidae), was found in breeding greenhouses and a few rice fields in Arkansas, Louisiana, Texas, and New York in the summer of 2007. This included five commercial fields in Louisiana. This talk will summarize the areas infested, regulatory action initiated, educational programs, and survey efforts underway.

The panicle rice mite is a pest of commercial rice, *Oryza sativa* L., and also completes its development on the invasive plant *Oryza latifolia* Desv. It may survive and reproduce on other grass host plants. Currently, the PRM is listed as a reportable and actionable pest by the USDA-APHIS. The reason for this status is that it has been reported to cause from 5 to 90% crop losses in the Caribbean region. The mite is thought to have originated in Asia or India, first being reported in the 1930s. It then spread to Africa, Central America, the Caribbean, and Mexico. Currently, PRM is found in all rice producing regions of the world, with the exception of Brazil. In the tropical climate of the Caribbean, it has caused the most significant crop losses. Fortunately, the damage from this mite can be minimized by breeding and proper cultural management practices.

The PRM is not thought to have the ability to thrive in the temperate climate of the United States. Yet, southwest Louisiana has a sub-tropical climate with high temperature and high humidity. The PRM thrives under both of these conditions. Furthermore, the PRM has been reported to cause economically significant losses when found in association with *Burkholderia glumae* (bacterial panicle blight) and *Sarocladium oryzae* (sheath rot) pathogens. Both of these pathogens are present in southwest Louisiana. For these reasons, we are launching a survey of the state to determine the distribution of PRM in rice producing parishes of Louisiana.

The Louisiana State University Agricultural Center has launched an extensive extension educational program with the goal of quickly educating field scouts and county agents to identify this mite in commercial production fields. This educational program has included multiple components. The first activity was a "Mite School" at an infested commercial field. This was conducted in cooperation with USDA-APHIS and Louisiana Department of Agriculture and Forestry officials. We provided an overview of the current regulatory response, biology of the pest, and trained in identification of infested plants. A pest note has been published. A website detailing identification, biology and scouting information has been launched. We have also posted radio clips and film interviews that explain damage symptoms and possible impact on crop yield and quality.

A nationwide survey is being planned by the USDA-APHIS in cooperation with state regulatory and university officials. The purpose of this survey is to delineate the extent of the infestation of PRM in commercial rice fields in the United States. Survey designs are evolving and the details of the sampling protocol are still in preparation.

Relative Susceptibility of Stages of Rice Panicle Development to the Rice Stink Bug: Implications for Management

Espino, L. and Way, M.O.

The rice stink bug (RSB) is one of the most important pests of rice in Texas. Economic thresholds were developed in the early 1990s and are still in use today. However, as a result of changes in cultural practices and cultivar selection in recent years, economic thresholds need to be revised. The objective of the present study was to determine the effect of RSB on rice grain production during different stages of panicle development and to generate information to update thresholds and improve management.

Field experiments were conducted during 2005 and 2006 in research plots at the Texas A&M University Agricultural Research and Extension Center in Beaumont, Texas. Rice panicles were caged from heading to harvest and infested for 48 h with one male or female RSB at heading, milk, soft, and hard dough stages of development. To determine if cages had an effect on grain production or other variables measured, additional panicles were not caged but protected from natural RSB infestation with an insecticide. For both years, significant differences were not found for any of the response variables measured between the uninfested caged and non-caged control panicles; therefore, data from these two treatments were pooled and considered as a single uninfested control treatment. Number and weight of filled grains, number and weight of empty grains, and percentage whole kernels per panicle were not significantly affected by infestation at any stage of panicle development nor were any significant differences found in percentage peck caused by male or female RSBs. In 2005, percentage peck was significantly lower in uninfested panicles and panicles infested during hard dough than in panicles infested during heading, milk, or soft dough. No differences were found in percentage peck caused by RSB during heading, milk, or soft dough. In 2006, no significant differences were found in percentage peck produced by RSB in panicles infested during heading, milk, soft dough, or hard dough. Higher percentage peck in hard dough may have been the result of late drainage of the field.

Using the injury information generated from the field experiments, treatment thresholds were calculated for each stage of panicle development. If percentage peck exceeds 2%, the price of rice is discounted resulting in a loss for the grower. Percentage peck per day per acre was estimated using the formula $\%peck = (I * (SN / (A_{SN} * E_{SN}))) / Y * 100$, where I is injury expressed as weight in grams of pecky grains produced by one RSB for a period of 24 h, in grams. SN is the number of adult RSBs caught after 10 consecutive sweeps of a 38-cm (15-inch) diameter sweep net. A_{SN} is the area in ha covered by 10 consecutive sweeps of the sweep net. E_{SN} is RSB catch-efficiency for the sweep net. Y is brown rice yield in grams/A. Estimates were made for four different yield levels: 5,000, 6,700, 8,400, and 10,000 kg/ha (4,500, 6,000, 7,500, and 9,000 lb/A).

Results indicate that treatment thresholds increase as rice panicles mature. Longer periods of panicle exposure to RSB (infestations starting at heading and milk) are likely to develop more peck. Thus, in general, controlling infestations during heading and milk is very crucial to managing peck. Also, treatment thresholds increase with yield. Higher yields mean more grain is available for RSB feeding, which implies that RSB damage actually can be diluted by higher yields.

Influence on Germination and Growth of Rice Seedlings from Seed Damaged by Rice Stink Bugs

Bernhardt, J.L. and Moss, T.L.

The rice stink bug*, Oebalus pugn*ax (F.), is a common insect pest of rice in the mid-South. Adults and nymphs feed on kernels by piercing the hulls of grain. Often, pathogens are vectored inside the hulls or gain entry once the hulls have been breeched. Feeding by rice stink bugs very slightly discolors kernels, but infection by assorted pathogens consumes and discolors variable amounts of the kernel. Our objective was to select kernels with different levels of damage from rice stink bugs and pathogens and assess the impact on seed germination and seedling growth.

Discolored seed from the rice cultivars Bengal, Cocodrie, and Wells were selected with a light-box. Seed was then categorized by proportion of seed damaged. The categories were 0, 5 to 10, 25, 50, and 75% of the kernel discolored and kernels with any amount of discoloration at the germ. Seed from each category was placed on moistened filter paper in Petri dishes and incubated at 29.4°C. In addition to the damaged and check seed, undamaged seed was cut to remove 25, 50, or 75% of the endosperm after germination. The cut-end was dipped in wax. All germinated seeds were placed in potting soil, monitored for seedling emergence and held in a greenhouse for 10 days after emergence. After 10 days, plants were removed from pots and the roots gently washed to remove soil. Plants were measured and the roots scanned and measured with WinRhizo software (Regent Instruments).

Germination was not statistically different between cultivars, but seed with 50 and 75% damage had significantly lower germination than seed with other amounts of damage. No seed with damage at the germ germinated. Also, seed of the Wells cultivar needed significantly more hours to germinate than the other two cultivars. The overall trend among all cultivars was for more hours to germinate as the amount of damage on the seed increased.

Growth responses of surviving plants from damaged seed were highly variable and statistically similar for each category. Plants from seed of the four categories of damage, combined, had a decrease in height by 14, 17, and 17%, a decrease in the dry weight of leaves and stems by 30, 32, and 42, and a decrease in the total length of roots of all sizes by 29, 24, and 40% for Bengal, Cocodrie, and Wells, respectively, when compared with plants from undamaged seed.

Undamaged seed with a percentage of the endosperm manually removed had a significant linear reduction in measured plant characters when compared with plants from undamaged seed. Seed with endosperm reductions of 25, 50, and 75% had: 15, 62, and 67%, 36, 50, and 73%, and 34, 54, and 81% decrease in the dry weight of leaves and stems; 4, 20, and 39%, 21, 43, and 45%, and 5, 21, and 39% decrease in height of plants; and 24, 59, and 71%, 23, 48, and 72%, and 33, 50, and 80% decrease in total length of roots of all sizes for Bengal, Cocodrie, and Wells, respectively, when compared with plants from undamaged seed. These data demonstrate that manual removal of the endosperm had a more predictable reduction of seedling growth than did seed that had different amounts of damage from rice stink bug feeding and pathogen infection.

Rice Entomology Research, Delta Research and Extension Center, 2007

Robbins, J.

Field and laboratory tests were conducted this year to determine the effectiveness of rice seed treatments produced by Syngenta, Trebon a granular insecticide from Mitsui Corporation, and Dinotefuran the EC formulation from Mitsui. Test results show good control of rice water weevil by application of the seed treatment and the granular formulation of Trebon. Rice stink bugs were controlled with Dinotefuran in tests conducted in small plots. Yields from these tests were significantly higher from the test plots compared with the untreated control plots and compared favorably with test plots treated with Karate Z and Mustang Max. Additional tests of the granular formulation of Trebon and the seed treatments from Syngenta are planned to determine efficacy against other early-season insects of rice, such as the colaspis beetle and chinch bug.

Oviposition Preference of the Sugarcane Borer, *Diatraea saccharalis* (F.), among Previously Infested Plants and Different Rice Varieties

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

In Lepidoptera, oviposition choice is crucial because hatching larvae has limited dispersal capacities and, therefore, are dependent on the judicious choice of host plants by adult females. There are many factors that can influence oviposition site selection, including host quality and quantity, as well as the presence of conspecifics. The oviposition preference of the sugarcane borer, *Diatraea saccharalis* (F.), was investigated in a series of experiments. Several experiments were conducted to evaluate the effects of rice variety and phenological stage on oviposition preference of sugarcane borers. *D. saccharalis* preferred to oviposit on rice in reproductive stages of development. No significant varietal preferences were observed, although twice as many eggs were laid on a hybrid variety XP744 than the variety Priscilla. In addition, we tested the hypothesis that *D. saccharalis* females discriminate between infested and uninfested plants when ovipositing. To test this, plants that were previously infested with second instar *D. saccharalis* larvae were caged with control (uninfested) plants and newly enclosed *D. saccharalis* adults were introduced into the cages. Results indicate that females prefer to oviposit on uninfested plants.

Tolerance and Compensatory Response of Rice to Sugarcane Borer (Lepidoptera: Crambidae) Injury

Lv, J. and Wilson, L.T.

A 3-year field experiment was conducted to evaluate the sugarcane borer (*Diatraea saccharalis* F.) injury to rice (*Oryza sativa* L.), as affected by cultivar (Cocodrie, Francis, and Jefferson), stage of crop growth stage during which the injury occurred (3-tiller stage, panicle differentiation stage, and heading stage), and sugarcane borer density. The mean proportion of rice tillers with sugarcane borer injury (leaf and leaf sheath injury and/or stem injury) was lower when it occurred at the 3-tiller stage (0.05) than at panicle differentiation (0.19) and heading (0.18). When injury occurred at the two latter stages, both the proportion of tillers with injury and the proportion of tillers with stem injury were negatively correlated with rainfall. Rainfall resulted in dislodgement and mortality of sugarcane borer eggs and larvae before entering the stems.

This study also evaluated the compensatory response of rice to sugarcane borer injury in the U.S. rice system. Rice plant density in this study (20 plants/m-row) was higher than recorded for previous research on rice compensation using potted rice or conducted in low density hill production systems. Two mechanisms of within plant compensation were observed. Stem injured plants produced ca. 0.69 more tillers than uninjured plants, while tillers with leaf and leaf sheath injury produced larger panicles, up to 39.5 and 21.0% heavier than uninjured tillers, when injury occurred at 3-tiller stage and at panicle differentiation, respectively. Significance between plant compensation was not detected in this study, which suggested competition between adjacent plants was not significantly reduced by injury. Yield/m^2 integrates the effect of injury on both tiller density and yield per tiller. Rice compensated for up to 42% of tiller injury and up to 17% of stem injury.

DuPont Dermacor X-100: A New Rice Seed Treatment Insecticide

Grymes, C.F., Smith, J.D., Kirk, D.J., Sherrod, D.W., Fuesler, T.P., and Marçon, P.C.

DuPont Dermacor X-100 seed treatment for rice is a new insecticide from DuPont, in a new chemical class, the Anthranilic diamides. Results from a 3-year research program indicate that Dermacor X-100 is very effective in protecting the roots from rice water weevil (*Lissorhoptrus oryzophilus*) larval damage, providing increased yield. Recent data indicate Dermacor X-100 can control other important insect pests of rice, including the Mexican rice borer (*Eoreuma loftini*), the sugarcane borer (*Diatraea saccharalis)*, and the South American rice miner (*Hydrellia wirthi*).

An Epidemic of Narrow Brown Leaf Spot on Rice in 2006 in Louisiana and Its Control

Groth, D.E.

Narrow brown leaf spot, caused by the fungus *Cercospora janseana*, is normally a minor rice disease causing little damage. The disease is more severe as rice approaches maturity. Spots are linear and reddish-brown. On susceptible cultivars, the lesions are wider, more numerous, and are lighter brown with gray necrotic centers. They tend to be narrower, shorter, and darker on resistant cultivars. Spots usually appear near heading and are slow to develop, taking up to 30 days from infection. Both young and old leaves are susceptible. Seedheads can become infected, causing premature ripening and unfilled grain. Symptoms can be confused with rotten neck and panicle blast lesions. Narrow brown disease lesion symptoms usually are darker brown and develop in the internodal area of the neck. Sheaths and glumes can be infected, causing significant discoloration and necrosis. On sheaths, the disease is referred to as "net blotch" because of the brown sheath cell walls and the tan to yellow intracellular areas that form a net-like pattern. Grain infection appears as a defuse brown discoloration. The disease also can be severe on the second crop. In 2006, this complex of disease symptoms developed to epidemic levels, causing significant yield and quality losses and reduced second crop yield. The increase in severity was apparently due to a combination of factors, including over-wintering of the fungus on surviving rice in untilled fields and crawfish ponds, over 50% of the acreage being planted to susceptible varieties, a very wet period during the growing season, and the most widely used fungicide, Quadris, having little activity against this disease. Fungicides and varietal resistance were evaluated late in 2006 and again in 2007 for effectiveness in controlling this Cercospora complex.

Fungicide timing and rate trials were conducted at the LSU AgCenter's Rice Research Station. Fungicides were applied using CO_2 pressurized sprayers. Fungicides were applied at either the 10-cm (4-inch) boot or 50% heading growth stages. The variety used was the susceptible CL161 planted late in the 2006 season and CL131 in 2007. Various fungicide, rate, and timing combinations were included. Disease severity was evaluated 1 week before harvest using a 0-9 rating scale where 0 indicated no disease development and 9 indicating leaves dead. Existing rotten neck blast disease nurseries were used to evaluate resistance levels to naturally occurring Cercospora infections.

Propiconazole (Tilt, PropiMax, Bumper, Stratego, and Quilt) had the best activity of the labeled fungicides. Quadris had little activity. A limited number of tests have been conducted to determine the best activity against all stages of this disease, but disease control and yield increases appear best when fungicides were applied at the boot growth stage when disease pressure is high. When disease pressure is lower, heading applications appear as effective as boot applications. The rate of propiconazole needed to control the disease was approximately equivalent to 0.19 kg propiconazole ai/ha (6 oz/A) Tilt, PropiMax, Bumper, Stratego (19 oz/A), or Quilt (21 oz/A). This rate for Tilt, PropiMax, and Bumper is very weak against sheath blight, and Quilt does not have enough azoxystrobin to be effective against sheath blight. These fungicides will need additional fungicides to control sheath blight.

In host resistance evaluations, CL131 was found to be most susceptible, followed by Cheniere, Cybonnet, and Trenasse. CL161 and Cocodrie were intermediate in susceptibility. All of the medium and the remaining long grains were resistant to Cercospora. Rice breeders have found resistance to narrow brown leaf spot, but new races of the pathogen develop rapidly, therefore, varietal resistance will need to be evaluated every year.

At present, there is no recommended scouting method for Cercospora except to look at the lower leaves for the narrow brown leaf spot lesions. If the disease is present, there is no treatment threshold for spraying so fungicides will have to be applied preventatively. There is also no guarantee that the disease will develop to the same levels as 2006, which was unusually wet and the pathogen had extensively over-wintered on rice in crawfish fields providing early inoculum. Pressure was lower in 2007 because the two most susceptible varieties Cheniere and CL131 were not grown, and little rice over-wintered from 2006 to 2007, which contributed less inoculum to the epidemic. Also, it is estimated that 70 to 80% of the rice in south Louisiana was treated with propiconazole-containing fungicides. The combination of effective fungicides and varietal resistance provided good control in 2007, and the disease did not cause any significant damage.

Breeding for Stem Rot Resistance from *Oryza rufipogon* and *O. nivara*

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

This paper summarizes our experience in breeding for stem rot resistance derived from wild species of rice. Breeding for stem rot resistance is difficult because no highly resistant sources are available. Other environmental factors influence expression of resistance, such as maturity and plant type. Sources of moderate resistance often are poorly adapted. Deficiencies include photoperiod sensitivity, low tillering, poor seedling vigor, blanking sensitivity at microsporogenesis, and poor grain symmetry and quality.

Breeding for stem rot resistance derived from *O. rufipogon* started in 1980. The resistance is quantitative, semi-dominant, and only moderately heritable. Markers have been reported for this resistance, accounting for 49% of resistance variation. High-yielding, adapted long- and short-grain lines have been obtained with yield exceeding current varieties in an inoculated stem rot nursery. Adapted medium-grain lines have not been obtained. An immediate backcross program has been adopted to introduce this resistance into a medium-grain background.

Resistance to *O. nivara* was discovered in 1995 and incorporated into M-202 by 1999. A study of this resistance when crossed into M-206 was started in 2005. Resistance appears to be quantitative and additive and probably different from that of *O. rufipogon*. Marker development is planned.

Resistance derived from either wild species is sufficient to minimize yield loss and suppress sclerotium formation. The effect of flowering time and correlation of stem rot score with sclerotium formation will be presented. Data on the influence of pathogen variability on resistant lines will also be presented. Resistant lines also appear to have significant resistance to aggregate sheath spot.

Sheath Blight Control Using a Fungicide With and Without a Spray Adjuvant

Allen, T.W. and Walker, T.W.

Previous research has indicated that applying a fungicide with a spray adjuvant can enhance fungicide performance. Adjuvants are also applied to improve fungicide coverage, spray performance, and overall plant absorption. Spray adjuvants are particularly important in the Mississippi Delta where fungicides are applied to a large number of acres by aerial application. However, little work has been conducted on those spray adjuvant formulations that include fertility.

Rice sheath blight (*Rhizoctonia solani*) is the most costly, yield reducing disease in Mississippi and rice production areas throughout the world. Sheath blight is favored by high humidity, planting susceptible varieties, excessive seeding rates, overcast skies, improper rotation, and excessive nitrogen rates. Foliar fungicides are an effective means of controlling the disease. In 2003, and again in 2004, experiments were conducted in on-station, small plot trials, and off-station, large, replicated strip trials in existing rice production fields. Experiments were outlined to consider the role of an experimental adjuvant containing nitrogen, mixed with available fungicide chemistries at controlling rice sheath blight and their effect on yield and milling quality.

On-station trials in Stoneville, MS, were conducted in 1.6-m wide by 4.6-m long plots planted with CL161, a sheath blight susceptible variety. Plots were inoculated with *R. solani*, grown on oat kernels to provide adequate disease levels. Each plot received approximately 500 ml of infested oat kernels. Treatments for on-station experiments were applied using a backpack sprayer in 93 l/ha (10 gal/A). Experiments were conducted as a randomized complete block design with four replications. The center three rows within each plot were harvested with a small plot combine.

In 2003, off-station experiments were conducted on two 29.5-ha Cocodrie fields near Cleveland, MS, separated by a turn-row. The two fields served as replications. In 2004, a 36.4-ha CL161 field, near Clarksdale, MS, was used for trials. Prior to treatment, fields were scouted for sheath blight incidence. Treatments were aerially applied at a rate of 93 l/ha (10 gal/A) to four 18.3-m wide strips flown perpendicular to the outer levees in 2003, and eight strips in 2004. Milling samples were collected by harvesting a 0.6-m wide by 4.6-m long strip from the center of each treatment with a plot combine. Rice was harvested using a combine with a GPS-equipped yield monitor. Following harvest, yield data were overlayed on a georectified field map, and yield data points were selected from the center 18.3 m from within each treatment and averaged.

Fungicide treatments included Quadris [112.4 ml/ha (9.5 oz/A)], Stratego [186.3 ml/ha (15.5 oz/A)], and an untreated control. Fungicides were tested with and without HM9310, an experimental adjuvant containing nitrogen, at a rate of 3.1 l/ha (2 gal/A) for off-station trials. Off-station research in 2004 only included a Quadris + HM9310 treatment. On-station trials included a second adjuvant, HM0108, an experimental formulation containing nitrogen, potassium, and boron. All treatments were applied at approximately PD + 15 days. All data were analyzed in SAS using PROC GLM and means separation was conducted using Fisher's LSD to determine treatment effects on yield.

At both off-station locations in 2003 and 2004, HM9310 alone and tank mixed with Quadris did not increase yields compared with the untreated control or with the fungicide alone. Results from the off-station trials in 2003 with the additional Stratego + HM9310 were similar. In on-station, small plot trials, there were no significant differences between the experimental adjuvants, either HM0108 or HM9310, and tank-mixed fungicides or the fungicides without adjuvant. Fungicides alone significantly increased yield when compared with untreated controls, however, a spray adjuvant did not enhance the increase.

Effects of Rice Cultivar Resistance Level and Fungicide Applications on Rice Sheath Blight, Yield, and Quality and Its Implications on Varietal Screening

Groth, D.E. and Linscombe, S.D.

The development of sheath blight (*Rhizoctonia solani*)-resistant rice cultivars will allow producers to use less fungicide and 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 in the level of loss within the same susceptibility rating. Disease nurseries and yield loss studies are needed to accurately characterize varietal response to sheath blight. Two studies were conducted to determine the response of cultivars, with different levels of susceptibility, to sheath blight inoculations and fungicide applications and to determine the impact of sheath blight disease development on rice yield and quality.

Sheath blight epidemics in field plots were initiated by inoculation at the panicle differentiation growth stage from 2003 through 2007. Azoxystrobin at 0.17 kg ai/ha and flutolanil at 0.56 kg ai/ha were applied in sequential applications at mid-boot and 50 to 70% heading. In a second study, a single boot application of Azoxystrobin at 0.17 kg ai/ha was used.

In the first study, inoculation significantly increased sheath blight severity and incidence and caused yield losses of 4% in moderately susceptible tall Francis to 21% in very susceptible semidwarf Cocodrie in the first study. Milling yield was affected to a lesser extent. Two fungicide treatments effectively reduced sheath blight incidence and severity, regardless of cultivar, and returned both grain and milling yields to uninoculated lightly diseased levels. In the second study, inoculation again significantly increased sheath blight severity and incidence and caused yield losses of 8% in moderately resistant Jupiter, 25% in the very susceptible CL131, and 40% in very susceptible Trenasse. A single fungicide application effectively reduced sheath blight incidence and severity, restoring yield and milling to uninoculated levels in all cultivars.

In previous studies, sheath blight reduced yields up to 50 to 60% in older cultivars. In current cultivars, yield losses were in the 20 to 25% range for susceptible cultivars. This tolerance to sheath blight damage appears to be due to the lack of fungal penetration into the culm and subsequent lodging. The exception was Trenasse, which had a 40% reduction. Trenasse has more culm damage than other modern cultivars but does not lodge as severely as older cultivars. Due to these differences in yield loss, evaluations need to be conducted to effectively evaluate susceptibility to sheath blight in different cultivars in the same susceptibility group. Fortunately, fungicides applied sequentially and as single applications were effective in controlling sheath blight and maintaining grain yield and quality on all cultivars.

Global Gene Expression of Rice after Infections with Rice Blast and Sheath Blight Pathogens

Jia, Y., Wang, G.L., and Valent, B.

Rice (*Oryza sativa*) production worldwide has been challenged by increased new virulent pathogens. Over years, genetic diversity needed for fighting diseases has been decreasing in cultivated rice around the globe. This presents a real challenge for rice crop protection. In an effort to develop effective methods to control rice diseases, phenotypical, molecular, and biochemical analysis of rice plants after infected with rice blast (*Magnaporthe oryzae*) and sheath blight (*Rhizoctonia solani*) fungi were examined by global gene expression using DNA microarray and Serial Analysis of Gene Expression (SAGE).

It was observed that the infection of rice by *M. oryzae* is a biotrophic process where nutrients from live cells are taken up by the pathogen at the early stage of infection within 24 hrs. In contrast, the infection of rice by *R. solani* is a necrotrophic process where the pathogen produces enzymes and toxins to kill the cells for its infection. Using total RNA prepared from leaves at the 3- to 4-leaf stage at 6, 16, 24 hr after inoculation, gene expression profiles were analyzed and compared. Most of defense responsive genes are reduced to a normal level 3 days earlier in the interactions of *O. sativa*/*R. solani* than in the interactions of *O. sativa/M. oryzae*. Most of the differentially expressed genes identified by DNA microarray were confirmed by SAGE except that the fold induction varied significantly between the two platforms. To date, uniquely expressed genes specific to interaction of *O. sativa*/*M. oryzae*, and to *O. sativa*/*R. solani* were identified and confirmed using real time polymorphism chain reaction (PCR). Additional critical genes were also identified in a suppression subtractive hybridization cDNA library after the sheath blight pathogen infection and verified by real time PCR using RNA prepared after blast infection. Overall, our results suggest that several common signaling pathways were activated at different time points after pathogen infection. These molecular responses concur with differential phenotypical reactions observed under light microscopes. The cause and effect of expressions of these differentially and highly expressed genes in relation to the invasive growth of the pathogen and to the defense responses of rice are being analyzed and the implication for crop protection will be presented.

Field Resistance as a Primary Rice Blast Control Strategy

Lee, F.N.

Historically, newly released blast-resistant rice (*Oryza sativa* L.) cultivars typically are overwhelmed, usually within 1 to 3 years, by either previously minor races or new races of the rice blast pathogen (*Magnaporthe grisea* Cav.). Subsequently, cultivar utility is then determined by residual field resistance. Modern and historical data identify field resistance as a primary blast control mechanism.

Record per-hectare rough rice yields achieved in Arkansas from 2001 to 2007 demonstrates the role of field resistance as a rice blast control strategy. Cultivars grown during this period possess a very high yield potential packaged with advantageous agronomic characteristics and production techniques. Rice blast control with flood-induced field resistance was a key component of that package. On the whole, the cultivars utilized to establish the yield records were susceptible when moisture stressed and were rated as being moderately susceptible to very susceptible under conditions favorable for blast disease development. While susceptible to several contemporary races of the blast pathogen, preferred cultivars typically exhibit a high degree of field resistance in disease test plots and production fields, especially when growers were careful about field selection, irrigation schedules, and other cultural practices. However, field resistance may have been supplemented with fungicides when cultivars were adversely impacted by improper cultural practices.

Although well established cultivars with efficacious R-genes were available, growers knowingly planted blast susceptible cultivars on more than 80% of Arkansas rice production hectarage from 2001 to 2007. It is particularly noteworthy that rice cultivars with the *Pi-ta* gene that were planted to 30 to 40% of the production hectarage from 1996 to 2000 were quickly discarded as growers planted higher yielding but blast-susceptible Wells cultivar on 30 to 47% of the state production hectarage from 2001 to 2007. Currently, less than 5% of the state hectarage is planted to *Pi-ta* cultivars.

Historically, field-resistant cultivars such as Starbonnet and Cypress have performed exceptionally well in Arkansas. Starbonnet was planted on 42 to 65% of hectarage from 1969 to 1984. Cypress was planted on 15 to 39% of Arkansas rice production from 1994 to 2000. Starbonnet, Cypress, and all other rice cultivars planted on any significant hectarage in Arkansas have been rated susceptible to one or more common races of the blast pathogen in greenhouse screening trials.

Flood-induced field resistance to blast disease is expressed when saturated moisture in the root zone soil facilitates depletion of dissolved oxygen. The ensuing anaerobic condition defines availability and form of nutrients associated with blast susceptibility, influences production of hormones mediating disease resistance mechanisms, and induces morphological modifications that enables oxygen transport to the roots and restricts pathogen growth. Research and field observations show flood-induced blast field resistance to be cumulative with duration and depth of flood and comparable to R-genes in certain cultivars. Although response varies with cultivar, some degree of flood-induced field resistance has been observed in all rice cultivars inoculated with a virulent race of *M. grisea*.

Traditionally defined as the residual resistance after R genes are compromised, genetic relationships of field resistance induced by anaerobic-root-zone conditions are unknown. Exemplified by classic reduction in lesion size, lesion number, and sporulation, anaerobic resistance is difficult to induce under laboratory conditions and is best quantified in a homozygous population. The interaction of individual blast races and resistance genes is unclear. The Wells cultivar, with the *Pi-ks* gene, is tolerant to race IG-1 but very susceptible to other U.S. races, including the *Pi-ta* virulent race IE-1k but becomes highly resistant to all races when continuously flooded. Conversely, *Pi-ta* cultivars Drew and Banks are resistant to common U.S. races in greenhouse and field tests, but both cultivars are quite susceptible to race IE-1k in upland greenhouse tests. Even if drought-stressed, Drew is highly resistant to rice blast in field tests and production fields. Banks resistance compares with Drew except for being susceptible to race IE-1k when under drought-stress conditions. Developed from different genetic backgrounds, both cultivars have the *Pi-ta* gene but Banks lacks the *Pi-ks* gene and other possible modifying genes present in Drew.

Abstracts of Posters on Plant Protection
Panel Chair: L.D. Godfrey
Poster Session Chair: C.A. Greer

Identification of Semiochemicals from Defensive Glands of the Rice Stink Bug, *Oebalus pugnax* (F.).

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

Stink bugs are characterized by the production of large quantities of strong smelling and irritating defensive chemicals, which are released when the bugs are disturbed. Numerous studies have attested to their efficacy as a defensive response towards predators, and other studies have shown that male-produced pheromones are exploited by natural enemies.

In order to identify the chemical constituents of *Oebalus pugnax* (F.) metathoracic glands, individual adults were placed in glass vials and briefly agitated. The headspace was sampled using solid-phase microextraction (SPME) fibers coated with 100µm polydimethlysiloxane (PDMS) for 2 minutes. Following sampling, compounds were separated using gas chromatography (GC) and identified with a mass spectrometer (MS). Compounds were tentatively identified using a spectral database and confirmed by comparing retention times and spectra to authentic standards. Relative abundances were determined by dividing the area under each peak by the area of the most abundant compound, tridecane.

Our data indicate that tridecane, (E)-2-octenyl acetate, (E)-2-heptenal, (E)-2-octenal, and (E)-2-decenal are major components of defensive chemicals. Tridecane was the most abundant compound in headspace samples; other *n*-alkanes were detected, although at lower concentrations. Several *trans*-alkenals were present, along with the ester (E)-2-octenyl acetate. Previous research has identified two major components of scent glands from *O. pugnax*, and coupled with our results, data suggests that the defensive chemicals found in *O. pugnax* are shared with other stink bug species, which suggests a conserved defensive strategy among Pentatomids.

Influence of Rice Seeding and Establishment Methods on the Populations of Rice Water Weevil and Larval Mosquitoes

Pinkston, W., Lewis, R., Windbiel-Rojas, K., and Godfrey, L.D.

A study has been ongoing at the Rice Experiment Station (RES) for the last 4 years with the primary goal of investigating alternative rice seeding and establishment methods in order to open up new opportunities for weed management. A continuously flooded, water-seeded establishment has been the standard for California rice production for many years but weed management concerns are challenging the viability of this method. These changes in rice production need to be done without disrupting other aspects of rice agronomy and pest management. In terms of invertebrates, these techniques may affect insect pest populations and mosquitoes.

Studies were conducted in plots set-up for the Rice Systems Project which involves ~12 UC-Davis and county-based CE researchers. Five seeding establishment treatments are being studied, 1) conventional water-seeded; 2) conventional drill-seeded; 3) delayed stale seedbed, water-seeded; 4) delayed stale seedbed, no spring till, water-seeded; and 5) delayed stale seedbed, no spring till, drill-seeded.

Populations and/or damage from rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, armyworms (*Spodoptera* spp.), and mosquito immatures were monitored. Rice water weevil (RWW) adult leaf scarring was determined by examining 100 seedlings per plot and recording the number with feeding scars on either of the two newest leaves. Rice water weevil larval samples were collected using five 11.4-cm diameter core samples taken from two sides of the treatment plots. The samples were processed with a washing-flotation technique to recover the larvae. Sampling for mosquito larvae was accomplished using standard mosquito dippers. Three sets of 50 dips, for a total of 150 dips, were collected for each treatment replicate. The dips were then strained through aquarium nets and then placed into collecting cups half filled with 80% ethyl alcohol. Mosquito larvae were then counted in each sub sample with no regard for identification of the mosquito species.

Leaf feeding by RWW adults (indicative of population magnitude) was lower (about 1/3 the level) in the conventional water-seeded than the other treatments. The highest numbers of RWW larvae were found in the stale no till drill-seeded plots. These results are contradictory to previously conducted studies that show reduced larval numbers in drill-seeded plots. The mosquito dip results showed that there was a reduced number of mosquito larvae collected from the conventional drill-seeded and the stale no-till drill-seeded plots while the three water-seeded plots show higher numbers of mosquito larva. The mosquito data warrant further investigation to determine if the pattern of larval reduction holds over an extended number of years.

Susceptibility of Nine Indica Germplasm Lines to Three Rice Insect Pests

Bernhardt, J.L.

Nine indica germplasm lines evaluated for insect susceptibility were selections from crosses between Zhe 733 from China and the indica cultivar IR64 and six indica experimentals from IRRI. The crosses were first evaluated in 2003, and these data give results from a second year of tests.

In 2007, a split-plot design was chosen with and without insecticide as main plots and with indica lines and japonica checks as subplots. Seed was treated with Icon 6.2FS at 0.056 kg ai/ha. Icon controlled rice water weevil (RWW) larvae and suppressed damage by the rice stalk borer, *Chilo plejadellus* Zincken. Rice was drill seeded at 100 kg/ha on 12 June and emerged to a stand by 20 June. Plots were nine rows with 17.8-cm (7-inch) spacing by 2.4 m (8 ft). Indica lines received 45.4 kg (100 lb) of urea preflood. The checks were Jupiter, Cocodrie, and Wells and were fertilized at 47.7 kg/ha of urea preflood and 20.4 kg/ha at midseason. The plots were flooded on 16 July to take advantage of high population densities of the RWW, rice stalk borer, and rice stink bug, *Oebalus pugnax* (F.). Two standard core samples/plot were taken on 6 August and 13 August and evaluated for RWW immatures. The density of whiteheads/plot was taken on 10 September as an indicator of susceptibility to rice stalk borer. Rough rice subsamples of 200 g each were taken from each plot and evaluated for discolored kernels and used as an indicator for susceptibility to the rice stink bug and pathogens.

In 2007, the indica and Japonica lines had average densities of rice water weevil larvae that by line corresponded to those in 2003 but were 10 to 15% higher than the 22 to 37 larvae per core found in 2003. Daily temperatures during flowering were extreme in 2007, often exceeding 36°C, and contributed to many blank florets. Lower grain yields in 2007 could be attributed to weather conditions and higher rice water weevil densities. Three indica lines (8008-5, 8011, and 8014) in 2007 were added to the two (8008-3 and Zhe733/IR64) identified in 2003 to positively benefit from the insecticide protection from RWW damage. Perhaps weevil densities were high enough in the three indica lines in 2007 to overcome the tolerance to weevils exhibited by most lines in 2003. Each year, all Japonica cultivars treated with insecticide had significant yield increases over the untreated plots.

Rice stalk borer infestations were practically non-existent in 2007. In 2003, three indica lines (Zhe733/IR64, 8008-3, and 8008-5) were found to be moderately susceptible to the rice stalk borer. The other indica lines appeared resistant to whiteheads caused by rice stalk borers.

Blast Field-Resistant Cultivars Utilized in Arkansas for Record Rice Yields

Lee, F.N., Cartwright, R.D., and Wilson, Jr., C.E.

Rice (*Oryza sativa* L.) is a critical commodity in the Arkansas agricultural economy. A sustained period of historic per-hectare rice production occurred in Arkansas from 2001 to 2007. Modern cultivars grown during this period possessed a very high yield potential packaged with multiple desirable agronomic characteristics. Control of rice blast, incited by *Magnaporthe grisea* Cav., using flood-induced field resistance was a key component of the agronomic package.

Although cultivars with the efficacious *Pi-ta* gene and other R-genes were available, blast susceptible cultivars were planted to more than 80% of Arkansas production hectarage from 2001 to 2007. In the absence of effective R-genes, producers depended upon cultivar field resistance for blast control. On the whole, cultivars utilized from 2001 to 2007 were susceptible to panicle blast when growing in drought-stressed blast field nurseries and were rated as being moderately susceptible (MS) to very susceptible (VS) to rice blast. These susceptible cultivars typically exhibited a high degree of flood-induced blast field resistance in disease test plots and in production fields, especially when growers were careful about field selection and irrigation schedules. Field resistance was impacted by cultural practices, primarily fertility and irrigation, and was supplemented with fungicides when cultivars were mismanaged.

Flood-induced blast field resistance occurs with depletion of dissolved oxygen in the root zone to establish anaerobic conditions. The anaerobic environment defines availability and form of nutrients associated with blast susceptibility, influences production of hormones mediating disease resistance mechanisms, and induces morphological modifications that facilitate oxygen transport to the roots and restrict pathogen growth. Flood-induced blast resistance is cumulative with duration and depth of flood and in many susceptible cultivars is comparable with that expressed by major R-genes. To date, some degree of flood-induced field resistance has been detected in all flooded rice cultivars inoculated with a virulent race.

Historically, field-resistant cultivars such as Starbonnet and Cypress have performed exceptionally well in Arkansas. Starbonnet was planted on 42 to 65% of hectarage from 1969 to 1984. Cypress was planted on 15 to 39% of Arkansas rice production from 1994 to 2000. Starbonnet, Cypress, and all other rice cultivars planted on any significant hectarage in Arkansas have been rated susceptible to one or more common races of the blast pathogen in greenhouse screening trials.

In 2003, evaluation of brown rice samples for discolored kernels indicated that none of the indica lines were as susceptible to kernel smut as Cocodrie and LaGrue. Weather conditions during grain-fill apparently did not favor kernel smut in 2007 because all lines had very low incidence of kernel smut. In 2003, all lines and check cultivars had small amounts of false smut, but in 2007, levels were observed to be higher. Indica lines 8002, 8017, and Wells were clearly more susceptible to false smut than the other lines. Rice stink bug incidence in 2007 was lower than that of 2003. Levels of peck damage in 2007 did not correspond to that of 2003; but similar to 2003, all indica lines had higher peck than the Japonica check lines.

Genotype x Management Interactions Influencing Susceptibility to Rice Grain Smuts

Brooks, S.A. and Anders, M.

Grain smuts have historically been considered minor diseases of rice in the United States. In recent years, localized infestations of kernel smut and increased prevalence of false smut have raised interest in these diseases. Although major gene resistance has not been described for either disease, variation in levels of susceptibility exists among rice cultivars. Susceptibility is confounded by genotype x fertility interactions, where increased levels of nitrogen fertilizer promote disease, making assessments of resistance among germplasm accessions difficult. Our goals were to identify genetic sources of resistance to these diseases, and connect germplasm to agronomic practices that promote cultivar performance and minimize disease incidence.

False smut and kernel smut have been persistent diseases in experimental plots at the University of Arkansas Rice Research and Extension Center in Stuttgart, Arkansas. By exploiting natural occurrence and promoting disease incidence, cultivar performance and disease resistance were evaluated under a variety of management practices. The effects of fertilizer rate, crop rotation, tillage, and irrigation practices on disease incidence and yield were evaluated. All treatments had significant effects on one or both diseases, but each disease responded independently to the treatments. Differences in kernel smut susceptibility were observed among cultivars, and fertility treatments were also significant for this disease. Fertility was also significant for false smut but cultivar differences were not observed. Tillage, rotation, and irrigation were all significant treatments influencing cultivar susceptibility to false smut.

Effect of Azoxystrobin Fungicide on Sheath Blight and Yield of Different Rice Cultivars

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

Sheath blight remains the most important disease in Arkansas rice production, and accounts for most of the fungicide use in the state. Since the introduction of azoxystrobin in 1997, total usage of fungicides in rice has increased from 10% of planted rice area treated to more than 70%. Usage pattern has also shifted, from scouting and decision making systems based on disease intensity to preventative applications. While strong monogenic resistance in rice to sheath blight is not known, current cultivars vary greatly in reaction to the disease. There are many new rice cultivars available to Arkansas producers, including hybrids, but the yield response of individual cultivars to preventative fungicide applications is not well documented, and would be helpful in understanding their value to rice growers considering this approach.

Cultivars included in the study for the first year included 4484, Bengal, Cheniere, CL131, CL171AR, CLXL730, CLXL729, Cybonnet, Francis, Jupiter, Sierra, Trenasse, Wells, and XL723. For the second year, Cocodrie replaced Cheniere, and CL161 replaced CL131 due to concern over the ongoing LL 601 issue. Seed was planted 1 cm deep in a conventional Dewitt silt loam seedbed on 12 Apr 2006 and 23 Apr 2007 in plots 1.25 x 7.6 m. Study sites were on the same farm but in different fields each year. The study was arranged in a split plot design with cultivar as the main plot and preventative fungicide treatment as subplots, using four replications. Fertilization, weed control, insect control, and irrigation were according to University of Arkansas Cooperative Extension Service guidelines, with the exception that total nitrogen rate was higher than recommended – 196 kg N/ha (as urea) in 2006 and 165 kg N/ha (as urea) in 2007. All plots were inoculated with 100 mls 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 on 22 June in both years. Preventative fungicide treatments were applied just prior to disease development on 29 June 2006 (27 June 2007) with a compressed air, self-propelled plot sprayer calibrated to deliver 93.5 l/ha volume using flat fan tips. Plots were visually evaluated for disease 28 days after fungicide application in both years and harvested with a small plot combine on 9 Sep 2006 and 12 Sep 2007, respectively. Stem rot was present at the 2006 site and likely affected yield, although lodging was not a problem at harvest. Stem rot was evaluated but data have not been analyzed. Harvested grain was weighed and converted to standard weight at 12% grain moisture. Subsamples were processed to obtain head and total milled rice using GIPSA procedures. Yield and quality loss was determined by comparing untreated and treated plots within cultivar.

In 2006, nine of 14 cultivars had significantly higher yield in treated plots while seven of 14 cultivars did in 2007. Sheath blight severity reached 7.5 on a 0-9 scale for the most susceptible untreated cultivar, CL131 in 2006, but only 6.5 on CL161 during 2007. Yield loss was 37% for CL131, 35% for Sierra, 30% for Cybonnet, 29% for CL171AR, 21% for CLXL730, 20% for Wells, 17% for Cheniere, 15% for Trenasse, 12% for Francis, 9% for Jupiter, 6% for CLXL729, 3.6% for 4484 and XL723, and 1.9% for Bengal during 2006. In 2007, yield loss was 14% for CL161, 8% for Sierra, 14% for Cybonnet, 14% for CL171AR, 3% for CLXL730, 8% for Wells, 6% for Cocodrie, 19% for Trenasse, 14% for Francis, 4% for Jupiter, 0% for CLXL729, 4% for 4484, 2% for XL723, and 11% for Bengal. Yield loss varied greatly between the two years, with an average loss of 17% in 2006 compared with only 8.5% for 2007. The most likely factors include differences in the locations, weather patterns in July and August, planting date, stem rot, and fertilizer management. In 2006, rainfall and temperature were normal for the area, while in 2007, July was wetter and cooler than normal during the first 2 weeks followed by above normal temperatures and extreme drought through August.

Grain quality differences were also evident for certain cultivars between treated and untreated plots. Head rice loss in 2006 was significant for Cheniere (6.3%), CL 131 (10%), CL171AR (6.3%), Cybonnet (6.3%), and Sierra (9.5%). For 2007, head rice loss was significant for 4484 (7.5%), Cocodrie (2%), Cybonnet (2.8%), and Francis (2.5%). Total milled rice loss in 2006 was significant for Cheniere (5.2%), CL131 (8.7%), CL171AR (5.3%), Cybonnet (4.8%), Sierra (5.5%), and Wells (2.7%). For 2007, total milled rice loss was significant for 4484 (2.5%), Cocodrie (2%), CL171AR (2.2%), Cybonnet (2.8%), Trenasse (3.3%), and Francis (1.8%). Further research is needed to determine the interaction of stem rot and sheath blight on rice yield and milling quality.

Effect of Novel Fungicides on Sheath Blight and Yield of Rice

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

Sheath blight is the most important disease in Arkansas rice production, and fungicide use to control it has increased from 10% to more than 70% since 1997, when azoxystrobin was introduced. Currently, growers rely on azoxystrobin and trifloxystrobin to help manage sheath blight but also apply these fungicides with propiconazole to minimize kernel smut in Arkansas. Strobilurin fungicides have changed rice production in Arkansas over the past decade and contributed to record production in recent years. Crop protection companies are more mindful of fungicides in the southern U.S. rice production, and the industry is always interested in novel products of equal or superior efficacy to existing fungicides. University plant pathology programs maintain a strong interest in novel compounds as well, providing objective testing in variable environmental settings that provide data that can be used later to assist growers if the products become registered.

Novel fungicides were assessed during 2006 and 2007. In 2006 and 2007, a mixture containing trifloxystrobin and a new triazole (EXP 1) was compared to Quadris (azoxystrobin) at labeled rates in a randomized complete block field study with four replications. In 2007, a new formulation of azoxystrobin + propiconazole (similar to Quilt but with a higher concentration of azoxystrobin) was compared with Quadris (azoxystrobin) at labeled rates as above. The rice cultivar CL131 was used in 2006 while CL161 was used in 2007. Both cultivars were considered highly susceptible to sheath blight. Seed was planted 1 cm deep in a conventional Dewitt silt loam seedbed on 12 Apr 2006 and 23 Apr 2007 in plots 1.25 x 7.6 m. Study sites were on the same farm but in different fields each year. Fertilization, weed control, insect control, and irrigation were according to the University of Arkansas Cooperative Extension Service guidelines, with the exception that total nitrogen rate was higher than recommended – 196 kg N/ha (as urea) in 2006 and 165 kg N/ha (as urea) in 2007. All plots were inoculated with 100 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 on 22 June in both years. Fungicide treatments were applied just prior to disease development on 29 June 2006 and 27 June 2007 with a compressed air, self-propelled plot sprayer calibrated to deliver 93.5 l/ha volume using flat fan tips. Plots were visually evaluated for disease development periodically after fungicide application in both years and harvested with a small plot combine on 9 Sep 2006 and 12 Sep 2007, respectively. Harvested grain was weighed and converted to standard weight at 12% grain moisture. Subsamples were processed to obtain head and total milled rice using GIPSA procedures.

In 2006, EXP 1 at the highest rate tested significantly reduced final sheath blight severity 35% compared with untreated plots and resulted in a significant yield increase of 32% over the untreated control. Azoxystrobin alone at 223 g ai/ha of azoxystrobin reduced sheath blight severity 36% and resulted in a 30% higher yield than the untreated control in the same study.

In 2007, EXP 1 at the highest rate reduced sheath blight severity by 30% and resulted in a 10.2% yield increase over the untreated control. The impact of sheath blight on CL161 yield in 2007 may have been influenced by extremely hot, dry weather during late July and August. Azoxystrobin at 223 g ai/ha reduced sheath blight severity 41% and resulted in a higher yield of 12% in the same study. There was no significant treatment effect on milling quality in either year.

Also, in 2007, the new formulation of azoxystrobin + propiconazole reduced sheath blight severity 40% at the 181 g ai/ha rate and 45% at the 217 g ai/ha rate. This resulted in a significant yield increase of 10 and 11.5%, respectively. Azoxystrobin alone at 223 g ai/ha reduced sheath blight severity 35% and resulted in a higher yield of 11% in the same study. There was no significant treatment effect on milling quality.

Based on these results, both EXP 1 and the new formulation of azoxystrobin + propiconazole appear to have similar efficacy to the best commercial fungicide treatment for control of sheath blight of rice used in the southern United States.

Development and Field Testing of Toxoflavin Deficient Mutants of *Burkholderia glumae*, the Rice Bacterial Panicle Blight Pathogen

Nandakumar, R., Groth, D.E., and Rush, M.C.

Burkholderia glumae is a major causal agent of bacterial panicle blight (BPB), grain rot, and seedling rot in rice. In the southern United States, including Louisiana, BPB is a devastating problem in rice production because of its endemic, and occasionally epidemic, development each year and the significant yield loss that it causes. Pathogenic *B. glumae* strains produce a yellow colored toxin, toxoflavin, which is considered the major pathogenicity factor for this bacterium. The high temperatures and humidity normally occurring in Louisiana during the growing season are highly favorable for disease development because the maximum toxoflavin production occurs at 37°C. The genes responsible for toxoflavin production have been characterized. Non-toxigenic strains obtained from spontaneous mutation, repeated sub-culturing, or gene knockout studies with toxin producing genes failed to cause disease. This has been demonstrated under greenhouse conditions but had not yet been studied under field conditions. The main objective of this study was to develop toxoflavin-deficient mutants (TDMs) using gene knock out procedures and test them under field conditions in comparison with a wild-type strain.

TDMs were generated by introducing single allelic exchanges of *toxA* gene with a 432-bp internal DNA fragment of the gene. *ToxA* encodes the methyl transferase that confers the final step of the toxoflavin biosynthesis pathway. The TDMs of the *toxA*$^{-}$ strains were identified by their failure to produce yellow-colored toxoflavin on King's B agar medium. Two *toxA*$^{-}$ strains and a naturally avirulent strain were compared with the virulent wild-type strain, from which the two *toxA*$^{-}$ strains were developed, for their virulence on rice under field conditions. The test was conducted at the LSU AgCenter Central Research Station, Ben Hur, Baton Rouge from June to September 2007 on two susceptible rice varieties Trenasse and Cocodrie. Bacterial inoculum in sterile water (10^{8}cfu/ml) was sprayed onto the plots at the 30% of panicles emerging stage. Disease development was recorded 2 weeks after inoculation using a 0-9 scale with 0 equal to no disease and 9 equal to severe disease with most florets sterile or aborted.

Four toxin deficient mutants of wild-type *B. glumae* were developed and the mutants did not produce toxoflavin in culture medium, which was confirmed by mass spectrometry. Field results indicated that the toxin deficient mutants were still capable of causing panicle blight symptoms (disease ratings of 2 to 4 on a 0-9 scale) under field conditions and caused considerable yield loss. However, the mutants were less virulent than the wild-type strain (ratings 8-9) in causing BPB symptoms and caused substantualy less loss than the wild-type strain. The toxin mutants were reisolated from the diseased rice seed and their identity and toxin-deficient nature were further confirmed. Preliminary results indicate that toxoflavin-deficient *B. glumae* isolates induced a typical hypersensitive reaction on tobacco plants, indicating the possible role of the type III secretion system (TTSS) in disease development, and these cultures also produced lipase in culture medium. Based on our results, we hypothesize that all three virulence components toxoflavin, TTSS, and lipase are involved in pathogenicity of *B. glumae* on rice.

A Comparison of Rice Fungicide Testing in Artificially Inoculated and Naturally Infested Conditions

Groth, D.E.

The lack of sheath blight-resistant cultivars requires rice farmers to often use fungicides to control the disease and avoid significant reductions in grain and milling yields. Sheath blight fungicide evaluations have traditionally been conducted in artificially inoculated small plot trials. It has been suggested that artificial inoculation causes excessive disease and does not represent conditions in growers' fields. In order to provide the most accurate fungicide performance evaluations, methods that mimic commercial conditions must be used. A comparison of fungicide trials with artificially inoculated and naturally infested plots were conducted to compare fungicide trial methodologies.

Artificially inoculated, at panicle differentiation (PD), field tests were conducted at the Rice Research Station, Crowley, LA. Natural sheath blight populations were allowed to develop from soilborne inoculum in commercial fields at Lake Arthur and Fenton, LA. Various commercially available fungicides at recommended rates were applied to the foliage at mid-boot using a CO_2 pressurized sprayer. Plots were evaluated for sheath blight severity and infestation at maturity. Yield and milling were determined. Experiments were arranged in a randomized complete block design with four replications. Trials were conducted over 3 years (2005-2007).

Sheath blight significantly reduced rice grain and milling yields. There were no significant differences in sheath blight severity and incidence between artificially inoculated and naturally infested plots. Most fungicides significantly reduced sheath blight development and increased rice yields in artificially and naturally infested plots. Yields tended to be higher in on-station trials. Artificially inoculated trials tended to overestimate fungicide disease control and yield increases. This was probably due to sheath blight developing earlier in commercial fields, resulting in the fungus being better established in the plant tissues making control more difficult.

Characterizing *Pythium* Species Associated with Rice Stand Establishment Problems in Arkansas

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

Stand establishment problems consistently cause significant production losses and management problems in Arkansas rice fields. To determine the role of the environment and seedling disease pathogens on stand establishment, field and controlled environmental studies were conducted using selective fungicides, and pathogens were isolated from seedlings. In addition, pathogenicity studies using artificially infested potting media were conducted on isolates. This poster presents the *Pythium* spp. that were recovered from over 20 producers' fields in Arkansas in 2006 and 2007. In field experiments, the rice cultivar Wells was planted with six different seed treatments in six producers' fields in 2006 and 2007. Stand response for the fungicide treatments should help separate stand problems associated with different seedling disease pathogens from other factors and aid in identifying important pathogen groups. Also, approximately 25 arbitrary seedlings in each of the nontreated plots were extracted for disease assessment and isolation of pathogens. In the controlled environmental experiments, soils from six producers' fields with a history of stand establishment problems were selected in 2006 and 2007. Two environments (cool/wet and warm/dry), three cultivars (Francis, Wells, and Cheniere), and four different seed treatments were used. Seedlings were sampled from the nontreated containers for pathogen isolation and identification. In controlled environmental studies, stand response was similar across soils for the fungicides, indicating environment was a more important factor than field history or soil characteristics for seedling diseases. Plant stands were greater in warmer environments and response to seed treatment fungicides was less. In both field and controlled environmental studies, metalaxyl seed treatment significantly improved stands under cool/wet conditions, indicating that *Pythium* species were important pathogens in stand establishment under these conditions. *Pythium* isolates collected from the producers' soils during the field and controlled studies were evaluated for pathogenicity in artificially infested vermiculite under a controlled environment by examining stand establishment. After pathogenicity of each isolate had been characterized, selected virulent isolates (little or no stand) and non-/or less virulent isolates (no stand loss or little stand loss) were taken for molecular identification of the *Pythium* isolates to species. Mitochondrial DNA was extracted and the mitochondrially encoded cytochrome oxidase II gene (mtDNA *cox* II) was amplified by using primers specific for *Pythium*, PyRFLP-1 and PyRFLP-2, developed by Dr. Frank Martin (USDA-ARS, Salinas, CA). RFLPs were done for each selected isolate's PCR product by digesting the mtDNA *cox* II gene using three restriction enzymes: *Alu*I, *Nla*III, and *Rsa*I. Each enzyme was kept separate. Restriction fragments were separated in a 3% Amresco 3:1 agarose gel amended with Ethidium Bromide. A 100-bp ladder was used as a size marker and mtDNA restriction fragments were visualized with an ultraviolet light. Fragment bands for the three enzymes were used for identification. ITS sequences were also run on selected isolates that had different RFLP banding patterns to assist in identification. Isolates of *Pythium* spp. that were pathogenic were found to be *P. arrhenomanes* and *P. irregulare.* Isolates that did not produce significant stand loss (non-/or less virulent) included *P. arrhenomanes*, *P. catenulatum*, *P. torulosum,* and *P. diclinum*. *P. arrhenomanes* was the most frequently isolated and virulent of the *Pythium* species in producers' rice fields in Arkansas. *P. arrhenomanes* has also been reported to be an important seedling rice pathogen in other states and countries.

Abstracts of Papers on Processing, Storage, and Quality
Panel Chair: J.F. Thompson

Effect of Pre-Soaking on the Flavor of Cooked Rice

Champagne, E.T., Bett-Garber, K.L., Thomson, J.L., and Shih, F.F.

Water soaking rice for 30 minutes or longer prior to cooking is traditionally practiced in Japan, Korea, and other Asian countries. When soaked, rice grains hydrate, develop cracks, and water is absorbed. Soaking facilitates uniform cooking and shortens cooking time. The cooked kernel is usually less firm. The present study was undertaken to determine the effects of pre-soaking on the flavor of cooked rice and whether flavor differences are associated with textural changes that could influence retention of the aroma compounds.

Eleven samples of short-, medium-, and long-grain milled rice, representing scented and non-scented rice, and a wide range of amylose contents were used. Portions of white rice (600 g) were transferred to pre-weighed rice cooker insert bowls and water was added to give a rice-to-water weight ratio of 1:1.7, with the exception of the waxy rice which was cooked with a 1:1 rice-to-water weight ratio. The rice was either not soaked or soaked for 30 min. and then cooked in a 5-cup rice cooker-steamer (Panasonic SR-W10G HP) to completion. Upon completion, as determined by the cooker switching to the warm holding position, the samples were held 10 min. prior to presentation to the panelists. Six panelists trained in descriptive analysis participated in the study. The rice flavor lexicon included 13 unique flavor attributes (sewer/animal, floral, grain/starchy, hay-like/musty, popcorn, corn, alfalfa/grassy/green beans, dairy, aromatic/sweet, water-like/metallic, sweet taste, sour/silage, and astringent) which were determined by smelling and evaluation in the mouth. The intensities were scored based on a universal scale for all foods. Each sample was presented to the panelists at least twice, in separate sessions, following a randomized design. Texture Profile Analyses (TPA) were conducted using a QTS-25 Texture Analyzer (Brookfield Engineering Labs, Middleboro, MA). The rice was cooked following the procedure used for the sensory analyses. Upon completion, each sample was held 10 minutes prior to sampling. The upper layer of the rice was skimmed off and representative kernels were arranged in nine groups of three on the stainless steel plate of the Analyzer. A 25.4-mm diameter acrylic cylinder was set at 55 mm above the base. In the TPA, the probe traveled at 30 mm/min compressing the sample 45 mm after encountering the 3 g trigger point in the 2-cycle test. Hardness (the height of the first compression curve) and chewiness (original compression distance divided by second compression distance) were recorded. Statistical analyses were performed on the differences (pre-soaked – unsoaked) between paired samples of the two methods of preparation.

In the grouped rice samples, undesirable sewer/animal flavor significantly increased and sweet taste significantly decreased with pre-soaking for 30 min. For individual rice samples, significantly higher sewer/animal intensity was observed with pre-soaking for the two Basmati rice samples and one of the U.S. long-grain rice samples. When pre-soaked, sweet taste was significantly lower in one of the Basmati and Jasmine rice samples, the U.S. medium-grain rice, and one U.S. long-grain rice. Water-like metallic was also found to be significantly higher in one of the pre-soaked Basmati samples. Pre-soaking also resulted in significant increases in summed negative flavor attributes and significant decreases in summed positive flavor attributes for all rice samples grouped. The effects of pre-soaking on texture, as measured by TPA hardness and chewiness, did not explain the observed increases in negative flavor attributes. An increase in free sulfur-containing amino acids with pre-soaking could have resulted in an increase of their breakdown products and contributed to the increase in sewer/animal flavor. The decreases in sweet taste and summed positive flavor attributes were likely the result of masking caused by the increases in sewer/animal and summed negative flavor attributes.

Functional Properties of Rice as Affected by Degree of Milling and Cooking Method

Coleman, S.M., Patindol, J.A., and Wang, Y.J.

It is known that cooked rice texture is affected by a variety of factors, such as amylose, protein, lipids, amylopectin structure, and processing. This study aimed to evaluate the effects of milling degree on rice physiochemical and textural properties and to understand the effect of cooking method on the texture and staling of cooked rice. Samples included two medium-grain (Bengal and Medark), two long-grain (Wells and CL161), and a commercial parboiled long-grain rice. Rough rice was dehulled and milled to different degrees by varying milling time (30, 50, and 70 s). Head rice was separated from brokens using a double-tray shaker table. Head rice whiteness was measured using a Kett whiteness meter. Amylose content was determined by iodine colorimetry, and protein content was measured using the micro Kjeldahl method. Rapid extraction with isopropanol was used to extract milled rice surface lipids. Pasting properties were evaluated with a Micro-ViscoAmyloGraph. Head rice was cooked using two basic cooking methods, excess-water (Western style) and optimum-water (Asian/Pilaf style). The hardness and stickiness of the cooked rice kernels were measured with a texture analyzer. Results from this study show that as the degree of milling increased, there was an increase whiteness, cooked rice expansion volume, and water uptake. There was a decrease in total milled rice yield, head rice yield, protein, and surface lipids, and cooked rice hardness with increasing milling time. For cooking method comparison, the results show that rice cooked using the optimum-water method was harder, less sticky, and staled faster than the batch cooked using the excess-water method.

Functional Properties as Affected by Laboratory-Scale Parboiling of Rough Rice and Brown Rice

Patindol, J.A., Newton, J., and Wang, Y.J.

Parboiling can be applied on either rough rice (RR) or brown rice (BR). The energy requirement for parboiling BR is less because of the removal of hulls. This work compared the functional properties of parboiled rice prepared from RR and BR. Pre-soaked RR and BR from cultivars Bolivar, Cheniere, Dixiebelle, and Wells were parboiled under mild (20 min, 100°C, 0.0 kg/cm^2) and severe (20 min, 120°C, 1.0 kg/cm^2) laboratory-scale conditions. Head rice yield was lower for parboiled BR, particularly the batch subjected to mild parboiling. The head rice yield of parboiled rice samples from RR was comparable with that of a commercial sample and higher than the control (without parboiling). Parboiling resulted in lower head rice whiteness, lower apparent amylose content, and higher total lipids. Gelatinization temperature increased as a result of parboiling and the increase was higher for BR under the severe condition. Paste peak and breakdown viscosities were lower for BR than RR and for severe than mild condition. Percentage gelatinized starch was higher for the parboiled rice from BR than the RR counterpart. The pasting and thermal properties of the laboratory-parboiled samples were different from those of the commercial sample. Cultivar differences in parboiled rice functional properties were evident.

The Use of Silica Gel in Drying Small Samples of Rough Rice

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

A great number of small rough rice samples are generated annually in rice breeding and production research programs. These samples typically must be dried to storage moisture contents (MCs) of approximately 12.5%. Laboratory-scale driers are available, but unless expensive humidity controls are provided, there can be a large variation in the final MC of the samples, which introduces great variability in milling and functional property measurements. There is, therefore, a need for an effective method of drying small samples of rice to produce minimal final MC variation.

The objectives of this study were to determine the adsorptive capacity of silica gel packets when placed inside a sealed container of rough rice, to measure the final MC variation in rice samples dried using silica gel packets, and to determine the duration required to dry small samples from harvest moisture content to a desired 12.5% MC. The experiment incorporated the use of silica gel in 1 and 5 g moisture-permeable packets placed inside plastic bags containing rough rice. Francis, Wells, Bengal, and Cybonnet cultivars harvested at 16.7 to 21.0% MC from the Rice Research and Extension Center near Stuttgart, Arkansas, USA, in the fall of 2007 were used. Drying experiments were conducted at 21 to 26°C.

The adsorptive capacity of the silica gel packets, after being placed inside sealed plastic bags of rough rice, averaged 27.5% of the desiccant mass. Using this adsorptive capacity in calculating the necessary amount of silica gel to dry rice samples to 12.5% MC, drying experiments yielded minimal rough rice final MC variation; rice MCs measured after a week of drying were within 0.1 pp of the target, 12.5% MC. Rough rice drying curves indicated that approximately 1 week was necessary to achieve equilibrium MC.

Rough Rice Fluidized Bed Drying Rates Using High Air Temperature

Siebenmorgen, T.J. and Gayanilo, V.G.

Rice drying is an energy-intensive, time-critical, and quality-sensitive operation. Thus, rapid drying of newly-harvested rice with the least cost, without incurring quality losses, is of great interest to the rice industry. High temperature fluidized bed drying offers fast and uniform drying of granular products such as rice; however, its beneficial effects have yet to be fully verified and ascertained under controlled conditions. This study was conducted to quantify rice drying rates using air temperatures (Ts) in the range of 60 to 90^{o}C in combination with air relative humidities (RHs) ranging from 7 to 75%, using a specialized drying chamber. The study included the determination of rice equilibrium moisture content (EMC), an important element in establishing mathematical prediction equations for drying rice at desired T and RH conditions. Results of the study show regression equations and plots of rice drying rates and effects of airflow rates and grain bed depths on rice drying rates.

Effect of Rough Rice Sample Preparation Procedures on Rice Milling Quality

Pan, Z., Kihr, R., and Thompson, J.F.

Sample preparation procedures of rough rice are closely related to accuracy of rice milling quality appraisal. The objective of this research was to investigate the effect of the drying procedures and storage duration on rice milling quality. The study was carried out during a 2-year period.

In the first year, rice samples at two moisture contents, 25.1 and 20.5%, were dried under three different procedures. The common drying procedure was 20 min at 43°C, followed by 4 hours tempering without heat for each drying pass. Rice was also dried with ambient air, both with and without tempering. Then, the dried rice samples were stored for 1, 4, 7, 14, and 28 days before they were milled using the standard GIPSA procedures. The milling quality, including total rice yield, head rice yield, and whiteness index, was determined. It was found that the rice samples dried with the common drying procedure had up to 8% lower head rice yield than ambient air drying, which was unexpectedly high. The milling quality results also showed that dried rice milled one day after drying had about 2% lower head rice yield compared with samples stored 4 days or more.

During the second year study, effect of tempering and storage duration on milling quality was further investigated. Rice samples with original moisture contents of 21.9 and 25.6% were dried to 14% moisture content with air at three different temperatures (23, 36, and 43°C). Rice samples dried at the higher two temperatures were allowed to temper at ambient temperature for 4 hours. Additionally, the 43°C sample was tempered in an incubator. Dried samples were stored in plastic bags to prevent moisture absorption during storage. Rice samples were milled with the new standard GIPSA procedures at 1, 2, 3, 4, and 14 days after drying.

Rice dried at 43°C, followed by heated tempering, had higher milling quality compare with the other drying and tempering combinations. Maximum head rice yield values were achieved when rice was milled 2 days after drying. The whiteness of rice samples dried with ambient air was slightly higher than the other drying and tempering procedure but not to a significant extent. These findings suggest rice should be stored at least 2 days to improve appraised milling quality and low temperature drying or high temperature drying with heated tempering is preferred.

Optimal Harvest Moisture Contents for Maximizing Milling Quality of Long- and Medium-Grain Rice Cultivars

Bautista, R.C., Siebenmorgen, T.J., and Counce, P.A.

The harvest moisture contents (HMCs) at which head rice yields (HRYs) peaked for various rice lots were determined. Multiple samples per field of cultivars Bengal, Cypress, and Drew were harvested at northeast and southeast Arkansas locations in 1999 and 2000. Additional field sample sets of multiple cultivars were collected in 2004, 2005, and 2006 at various locations in Arkansas, Mississippi, and Missouri. The dataset comprised 139 rice lots.

Head rice yields were described by a quadratic equation with HMC as the independent variable. The optimal HMC for a given lot set, determined as the MC at which HRY peaked, varied from 18.7 to 23.5% for long-grain cultivars and 21.5 to 24.0% for medium-grain Bengal. The general range of optimal HMCs was 19 to 22% for long grains and 22 to 24% for medium-grain Bengal. For rice lots with HMCs less than the optimal, the amount of HRY reduction from peak values was strongly correlated to the percentage of fissured kernels at harvest; the fissured kernel percentage accounted for 77% of the variation in HRY reduction from peak HRYs. Peak HRYs varied from 63.8 to 70.6%. Based on recent research, the effects of nighttime air temperatures during kernel development could offer an explanation for this inexplicable variation. The hypothesis is that high nighttime air temperatures during the filling stage of kernel development could lead to disruptions in the enzymatic activities responsible for kernel filling, which would result in lower average kernel strengths and thereby lower HRYs. Because the critical stage for this effect is at kernel filling, the negative effects of high nighttime air temperatures would be manifested if the rice growth stage and high ambient nighttime air temperatures coincided. While beyond the scope of this study, efforts are underway to correlate HRY reductions from the theoretical maximum to the incidence of nighttime air temperature levels for each lot set used in this study.

Factors Affecting Rice Sample Milling

Pan, Z., Kihr, R., and Thompson, J.F.

Rice milling quality is normally appraised by milling a small amount of rough rice sample. Until September 2007, GIPSA had two different rice sample milling procedures that were normally called Southern and Western milling procedures. The difference was that the Western procedure used higher weight (10 lb for milling and 2 lb for polishing) compared with the Southern procedure using lighter weight (7 lb for milling and 0 lb for polishing). To obtain representative milling quality from small rice samples, there was a great need to study the relationship between milling conditions and appraised milling quality. This research studied the effect of milling temperature, pressure, and time on the results of milling quality.

When six rice samples were sequentially milled with the Western procedure, the temperature of the rice mill cutting bar increased from room temperature to 74°C. The corresponding head rice yield was reduced up to 4.5%, and the high temperature also caused about 1% moisture loss in milled rice. To reduce the negative effect of high milling temperature, an external heat exchanger using ice water as a cooling medium was designed and used with the rice mill. The cooling method reduced the milling temperature by about 5°C compared with no cooling and improved head rice yield up to 4%. When an internal heat exchanger was used along with the external heat exchanger, the improvement was even greater. The improvement was more significant for low quality rice than high quality rice. The appraised milling quality with cooling was also much higher than that from the Southern procedure. Typically, the Southern procedure had about 2% higher head rice yield with lower whiteness than the Western procedure.

When the weights and times of milling and polishing were studied with a central composite design, it was found that high head rice yield can be obtained by using a combination of low weights and long times of milling and polishing. The results match with the current commercial rice milling practice using multiple breaks to achieve high rice milling quality and yield. Based on the research results, GIPSA has implemented a universal milling procedure in the entire United States with low milling and polishing weights.

Milled Rice Fissure Occurrence Kinetics

Siebenmorgen, T.J., Estorninos, Jr., L.E., and Bautista, R.C.

A system was assembled to measure the rate at which fissures appeared in milled rice kernels. The system comprised a temperature (T) and relative humidity (RH) control chamber, inside which was placed a rotating platform. Open Petri dishes holding samples were placed around the platform periphery. The platform rotation was controlled by a stepper motor and motion controller such that samples could be introduced to the viewing area of a camera. The camera was used to capture images of kernels with the aid of two fiber optic lights, which allowed fissures to be illuminated. Images were stored on a cassette recorder to allow fissures to subsequently be counted.

Thirty milled rice kernels of Bengal, Wells, and CL161 at 11, 12, 13, or 14% moisture content were introduced to the camera viewing area every 4 minutes over a 24-h exposure duration. This procedure was conducted for 35 chamber air conditions, ranging from 5 to 30^{o}C and 10 to 90% RH.

Kernel moisture content played a role in determining overall number of fissures formed; however, the rate of fissure formation was practically similar across MCs. The medium-grain cultivar Bengal incurred more fissures than the long-grain cultivars, under given air conditions. The rate of fissuring increased with temperature, particularly at the low RH levels. Severe fissuring occurred at both low and high RH levels; relatively little fissuring occurred in the 30 to 75% RH levels. At the lowest and highest RH air conditions, fissures formed very rapidly. For example, over 50% of kernels of all cultivars at all MCs had fissured within 4 minutes when milled rice was exposed to 30^{o}C and 10% RH air. The results indicate that fissures can occur within minutes if milled rice is exposed to severe moisture adsorbing or desorbing environments.

Amylose Content – Rice Chemists of the World Unite to Make It a Useful Predictor of Quality

Fitzgerald, I.

Amylose content contributes to variability in the sensory properties of rice. The International Network for Quality Rice (INQR) is bringing new science to the old trait of amylose content to determine global consistency in amylose assays, with the longer term aim of moving beyond apparent amylose to real amylose and to its fractions.

Exploring the Use of *Oryza* Species to Enhance the Lipid Fraction of Cultivated Rice

Bergman, C., Goffman, F., and Chen, M.H.

In the past few several years, efforts to collect rice germplasm were broadened to collect more widely from the *Oryza* gene pool. The *Oryza* genus includes only 23 species, but it is remarkably diverse in-terms of its ecological adaptation. This diversity may not only be restricted to ecological characteristics but also to kernel end-use quality characteristics. This study evaluated *Oryza* species as a gene pool for improving the lipids of rice grain. Several accessions of 11 *Oryza* species were grown in a greenhouse, along with eight rice (*Oryza sativa* L.) accessions displaying low and high bran oil content as well as low and high palmitic acid content. The total lipid content of the *Oryza* species was within the levels found for *Oryza sativa* accessions. However, the level of palmitic acid in the *Oryza* species was as high as that reported for both soybean and flax high-palmitic acid mutants. The *Oryza* species also contained significant levels of the tocotrienol, tocopherol, and gamma-oryzanol fractions. Thus, suggesting the lipid fraction of cultivated rice can be improved for the production of margarine, shortening and frying oils using *Oryza* wild species in targeted breeding efforts.

Rice Property Characterization Database

Bautista, R. C., Siebenmorgen, T.J., Meullenet, J.F., Counce, P., Gibbons, J., Moldenhauer, K., Morawicki, R., and Mauromoustakos, A.

Recent work in measuring properties of rice harvested over a range of moisture contents (MCs) and across the rice ecosystems of Arkansas has shown that in most location/cultivar combinations, head rice yields (HRYs) varied with harvest MC according to a parabolic relationship. As harvest MCs decreased after the peak HRY was reached, HRYs decreased as a result of fissuring in low MC kernels due to rapid moisture adsorption. This work has shown that the HRY vs. harvest MC relationships are cultivar-dependent and, to a certain degree, location-dependent. This dependency is speculated to be due to variations in nighttime air temperatures during the kernel filling period. Past research has shown that harvest MC affects functional properties such as paste viscosity. The objective of this study is to develop a database from which the effects of harvest MC, cultivar, location, and environmental conditions (nighttime temperature and humidity) on rice milling and functional properties can be quantified. This study also involves determination of harvest MC effects on economic return after drying and milling and the development of a calibration for NIR spectrometers.

To meet these goals, the Arkansas Rice Performance Trials (ARPT) plot system, with its plantings at six Arkansas locations, is being utilized. The plots were designed in a complete randomized block with three replications per cultivar. By at least 50% heading, two sensors will be installed at each location to record hourly temperature and relative humidity data until the final harvest. Field sampling, which started in 2007, involves cutting rice panicles at various harvest MCs beginning at approximately 26% and ending at approximately 12.5% of six selected cultivars at the ARPT locations. Panicles were immediately threshed and cleaned before drying to approximately 12.5% MC. Individual kernel MCs were measured in the field during harvest using an individual kernel MC meter. After drying, lab analysis will include determination of head rice yield, degree of milling, individual kernel dimensional distributions, breaking force distributions, fissure counts, chalkiness, pasting properties, total lipid and protein contents, textural properties, and cooking rates. For the 2007 fall harvest, a total of 375 lot samples were collected. This study also will provide a robust sample set/data from which NIR calibrations of functional properties will be developed.

Progress Made on the Development of High Iron and Zinc Rice for Latin America and the Caribbean Region

Martínez, C.P., Borrero, J., Carabalí, J., Pereira, J.A., Neves, P., and Tohme, J.

Micronutrient malnutrition, the result of diets poor in vitamins and minerals, affects more than half of the world's population. Women and children are especially susceptible to deficiencies in micronutrients, particularly vitamin A, iron, and zinc. The costs of these deficiencies are high. In Latin America and the Caribbean (LAC), economic and health indicators have been deteriorating. To meet this challenge, AgroSalud, a project funded by CIDA-Canada has implemented a new paradigm that views agriculture as an instrument for improving human health and nutrition, as well as for increasing productivity. The goal is to improve the health of the poor by breeding staple foods that are rich in iron and zinc with priority in Latin America.

Rice has become particularly important in the diets of poor people, who make up about 40% of LAC's total population. Food purchases account for more than half of all expenditures by the poor, and rice accounts for about 15% of their food purchases. Among the poorest 20% of the population, rice supplies more protein to the diet than any other food source, including beef and milk. However, people living in several areas where rice consumption is high have been suffering from a number of major nutritional problems. This is the result of vitamins and/or minerals naturally present in the rice grain but otherwise removed during the milling process or that naturally are not present in sufficient amounts. Preliminary data obtained at CIAT indicated that, on average, 59 and 26% of the total iron and zinc present in brown rice is lost after milling, respectively. Milled rice samples collected in several countries had 2 to 3 mg/kg of iron and 10 to 11 mg/kg of zinc, while some promising varieties showed two to three times more iron.

We plan to increase iron and zinc content in the rice grain by using a conventional breeding strategy. On a fast track, landraces and breeding lines conserved in germplasm banks are screened for mineral content to identify products that could have immediate utility, as potential varieties or donors for a second phase to combine high iron and zinc with high yield potential, tolerance to main biotic and abiotic stresses, and good grain quality. This project is carried out in close partnership with partners in Colombia, Bolivia, Cuba, Brazil, Dominican Republic, Panama, and Nicaragua. Preliminary results from the screening process and the breeding activities will be presented.

Genetic Variability in Arsenic Concentration and Speciation in Rice Grain

Loeppert, R.H., Raghvan, T.R., Yan, W.G., Agrama, H.A., James, W.D., McClung, A.M., and Gentry, T.J.

Recently, there has been increased attention to arsenic (As) within the environmental and health disciplines, in large part due to the natural contamination of the groundwater in south Asia that has placed millions of people at risk of As toxicosis. The major concern has been with drinking water; however, there has also been considerable interest within the agricultural and biological disciplines, especially in considerations of agricultural sustainability, human nutrition, and As resistance, and food quality. Almost all plant materials, including rice, contain traces of As. From a toxicological standpoint, the major considerations are total quantity and speciation (chemical form) of ingested As. The current experiment was conducted to determine if genetic variability exists for the characteristics of grain-As concentration and speciation in rice grown under uniform conditions.

Field studies were conducted in 2004 and 2005 with 37 rice cultivars, including Japonica and indica subspecies, selected from the USDA world-germplasm collection. Individual cultivars were selected to obtain a range in susceptibility to straighthead. The experiments were conducted in a split block design, where soil As was the main plot and cultivar was the sub-plot with four replicates. The cultivars were grown under continuous flooding and two soil treatments, namely a native soil with a total As concentration of approximately 6 ppm (predominantly as inorganic As) and a MSMA-amended soil used for straighthead testing with an As level of approximately 19 ppm. Total As concentration in milled rice grain was determined by ICP-MS following digestion by HNO_3/H_2O_2. The As species (inorganic As^{III}; inorganic As^{V}; monomethyl As^{V} [$MMAs^{V}$]; dimethyl As^{V} [$DMAs^{V}$]) were quantified by HPLC-ICP-MS following extraction with trifluoroacetic acid (TFA).

Individual replicates agreed quite well, but total grain-As concentrations and speciation of cultivars within each soil treatment varied considerably but with no uniform trend in the relative As-concentration rankings of cultivars. The only As species detected in the TFA extracts of grain flour were As^{III} and $DMAs^{V}$, representing an average of approximately 85% of the total grain-As concentration. Though grain-As^{III} concentrations differed substantially between cultivars, for any given cultivar, the rice-grain As^{III} concentrations were remarkably similar between non-amended and MSMA-amended plots. However, the latter treatment resulted in considerably higher and cultivar-dependent rice-grain $DMAs^{V}$ and total As concentrations. These results taken together indicate that both inorganic and total grain-As concentration varied between varieties. Inorganic arsenic is an especially important characteristic, since in the human digestive system, inorganic arsenic is approximately 20 times more toxic than the methyl As^{V} species. The results of this study demonstrate that significant genetic variability exists for grain-As concentration and As speciation allowing the development of mapping populations that can be used to identify markers associated with low As accumulation in rice.

Effect of Nitrogen Application and Crop Rotation on Rice Grain Quality

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

Due to increase cost in rice production, some farmers are trying alternative ways of managing their farm in order to increase production and profit. Crop rotation and increase nitrogen (N) application are two ways that are being tried. Although increase N application is known to increase protein content and change the processing quality of rice, little is known about the effect of crop rotation and its interaction with N application on grain quality.

Rice cultivars Cybonnet and Wells were grown in a field experiment near Stuttgart, AR. The rotation systems used were continuous rice (*Oryza sativa* L.) (R/R), rice after soybeans (*Glycine max* L.) (R/SB), and rice after corn (*Zea mays* L.) (R/C). Two fertility rates were used preflood (1) N = 112 kg/ha (100 lb/A), phosphorus (P_2O_5) = 45 kg/ha (40 lb/A), and potassium (K_2) = 67 kg/ha (60 lb/A) [standard rate] and (2) N = 168 kg/ha (150 lb/A), P_2O_5 = 67 kg/ha (60 lb/A), and K_2 = 101 kg/ha (90 lb/A) [used as the high rate]. After harvesting, the seeds (rough rice) were cleaned, dried, and milled and the milled samples were used to determine processing qualities, i.e. apparent amylose contents, gelatinization temperature, protein content, lipid content, and pasting properties.

As expected the protein content increased with increased fertility. However, the protein for R/SB rotation was higher than that of R/R rotations. Apparent amylose content, gelatinization temperature, and lipid content were not affected by crop rotation or fertility but were influenced by cultivar. Peak and trough viscosity of the RVA profile were higher for R/R rotation than they were for the R/SB rotation. Increased fertility caused a decrease in all the RVA parameters other than setback 2, although the degree was different depending on crop rotation. The results of this study show that although fertility had an effect on grain quality, i.e. protein and RVA profile, crop rotation systems can determine the magnitude of the impact.

Processing Efficiency and Quality of Rough Rice Dried with Infrared Radiation Heating

Pan, Z., Kihr, R., Thompson, J.F., Godfrey, L.D., and Champagne, E.T.

Infrared radiation heating as a high efficient method has been reported for various applications, including drying disinfestation of food and agricultural products. This research investigated the feasibility and advantages of using infrared heating for rice drying and disinfestation.

Rough rice achieved uniform temperatures of 36 and 45°C after 4 and 8 min heating when it was heated using an infrared dryer with the vibration bed at 5-cm bed thickness. The infrared heating also resulted in about 2% moisture removal. However, the uniform temperature could not be achieved when heated air was used, even for a long heating time. When rice with moisture content of about 22% was dried to 17% using both infrared heating and hot air heating with single and multiple passes, the results showed that infrared heating had about 1% higher head rice yield on average compared with hot air heating and 3% higher than commercial rice drying. The single- and multiple-pass drying of infrared heating had a similar milling quality for most of the tests.

To further improve the drying efficiency of infrared drying, rice with two harvest moistures, 20.6 and 25%, were dried as a single layer. It took only 60 s to heat the rice to 60°C and removed 1.7 and 1.8% moisture correspondingly during the heating period, which was very efficient. After the heated rice was tempered in an incubator, it was found that additional 1.1 and 1.7% moistures were removed, respectively, through slow cooling without additional need in energy. The milling quality results showed that rice with tempering and slow cooling had much higher milling quality than the rice without tempering or with tempering followed by forced air cooling. Especially, the highest milling quality was obtained with rice having 60°C temperature. This result was also validated with thick layer drying. When rough rice was infested with beetles and moths, using infrared to heat rice to 60°C, followed by tempering, achieved complete disinfestation. Therefore, the infrared heating can achieve simultaneous drying and disinfestation for harvested rice. When a similar approach was used for disinfestation of storage rice, effective disinfestation was also achieved without compromising the milling quality. It has been concluded that infrared heating is an efficient heating method that can be used for rough rice drying and disinfestation.

The Economic Value of Rice as a Function of Harvest Moisture Content

Siebenmorgen, T.J., Cooper, N.T.W., Bautista, R.C., Counce, P.A., Wailes, E., and Watkins, K.B.

The economic value of rice is affected by the moisture content (MC) at which it is harvested. Drying costs are typically applied at a progressively increasing rate with harvest MC (HMC). Milling quality also is a major determinant of economic value and can vary dramatically with HMC. The net economic value (NV) of rice was quantified using a 5-year data set comprising eight cultivars harvested over a wide range of MCs from 11 locations across the Southern US rice-producing regions. A quadratic relationship was used to characterize the change in NV across HMC; this relationship resulted from the progressively increasing fee structure for commercial drying costs and the quadratic relationship between head rice yield (HRY) and HMC. The gross value of rice was estimated by assuming head rice price levels of 16.50, 18.00, and $19.50/cwt and brokens price levels of 60, 70, and 80% of the price of head rice.

A sensitivity analysis revealed that as the price of brokens increased, there was a subsequent, slight decrease in the optimum HMC at which NV was maximized. The optimum HMC, in terms of maximizing NV, was consistently lower than the optimum HMC determined with the purpose of maximizing HRY. Fluctuations in head rice price did not affect the optimum HMC. In general, NV was at a maximum at HMCs in the range of 17 to 20%. When NV was plotted against HMC regardless of cultivar, location or harvest year, the HMC at which NV peaked was 17.6% for a typical commercial drying cost schedule.

Head Rice Yield and Yield Stability of California Medium-Grain Rice Varieties

Thompson, J.F., Mutters, R.G., and Plant, R.E.

Field tests at the Rice Experiment Station near Biggs, CA, and field trials near Colusa and Natomas, CA, demonstrated for a second year that California medium-grain rice variety M206 maintains high head rice quality over a wide range of harvest moisture contents, compared with the older M202 variety. The 2007 season results also indicated M206 has high head rice quality and high yield when drained about 1 week earlier than normal. Variety M205 has better stability in head rice quality than the older variety M202 but not quite as good as M206. A replicated laboratory test where paddy rice was continuously soaked in distilled water verified that M206 is less susceptible to fissuring than M205, which is less susceptible than M202. If testing over additional seasons and in more growing areas verifies these results, the stability of head rice quality for M206 will allow the industry to harvest at lower moisture content and reduce column-drying costs.

Abstracts of Posters on Processing, Storage, and Quality
Panel Chair: J.F. Thompson
Poster Session Chair: C.A. Greer

Analysis of Genotypic Diversity in Lipid Hydrolytic Stability of Rice Bran during Storage

Chen, M.H. and Yan, W.

Rice bran is a by-product of the rice milling process. It is rich in protein, fat, crude fiber, minerals, and vitamins and is a valuable source of antioxidants. It can be used for ingredients, be developed into a functional food, and can be extracted for rice bran oil production. However, rice bran becomes rancid rapidly after milling due, in part, to the activity of the lipase enzyme, which hydrolyzes triglycerols into free fatty acids (ffa). Stabilizing the bran by inactivating the lipase through a heating process can prevent oil deterioration but might reduce the levels of heat-labile antioxidants. Brown rice has a short shelf life (3 to 6 months) because of the hydrolytic and oxidative deterioration of bran oil. It was suggested that de-hulling paddy or rough rice to produce brown rice disrupts the outer bran layer, resulting in the contact of lipase enzymes with the lipid. Selection for rice genotypes that are more stable against hydrolytic rancidity might be an alternative solution. This report presents the genotypic diversity of hydrolytic stability among 148 genotypes, a subset of rice germplasm from the National Small Grain Collection. The rice accessions were grown and harvested in Stuttgart, AR, in 2002 and were stored at 4°C and 20% relative humidity in their paddy form. The hydrolytic rancidity of the rice bran was assessed by measuring the quantity of the ffa in the bran (expressed as mg of C18:1 equivalent/g of rice bran), i.e. the products of hydrolytic deterioration of bran lipid, after having subjected the bran to a 48-h period of storage at an elevated temperature. The rice stored in paddy form for 5 years at 4°C were low in lipid deterioration with a mean ffa of 3.1 mg/g bran (ranged from 0.98 to 7.42). The deterioration of lipid in the milled bran fraction increased 4.3 fold on average when stored at 35°C for 2 days; the ffa ranged from 3.7 to 50.1 mg/g bran with a mean value of 13.2. The purple and red bran genotypes had the lowest hydrolytic rancidity among all genotypes of different bran color classes. The mean ± SD ffa was 7.1 ± 0.5 for the purple bran and 6.9 ± 1.9 mg/g bran for the red bran genotypes. The ffa of other color-bran classes were: brown, 16.5 ± 8.2; light brown, 17.1 ± 9.2; and white bran, 15.6 ± 7.4 mg/g bran. The range of ffa in the light-brown bran class, which is the typical bran color class of U.S. cultivars, was 5.38 to 50.15 mg/g bran. The two Arkansas cultivars, Wells and Francis, which were grown in the same field and had gone through the same post-harvest management and storage, had the ffa of 13.8 and 21.2 mg C18:1 mg/g bran, respectively. Comparing the U.S. cultivars with the germplasm evaluated in this study, it is evident that opportunity exists for improving the hydrolytic stability of brown rice and its bran fraction through the use of breeding techniques.

A Survey of Postharvest Yellowing in Southern U.S. Rice Cultivars

Miller, H.

Rice endosperm can yellow during storage when moisture levels and temperatures are elevated. Although this postharvest yellowed (PHY), or stackburn, rice results in a reduction of monetary value, no study has investigated the inherent potential within rice germplasm collections for limiting PHY. A laboratory-scale method to test yellowing was used. A specified amount of milled or rough rice was put into a test tube, rinsed with water, and then incubated for 4 days at 70^{o}C. The degree of coloring was measured through the glass tube with a colorimeter. The ability of a large number of southern U.S. rice varieties to yellow was tested using these conditions. Selected varieties from the same planting that had tested as low-yellowing or high-yellowing were retested using larger amounts and containers. The low-yellowing cultivars were still distinguishable from the high-yellowing cultivars. The cultivars retested all exhibited a high level of coloring, indicating that a more diverse germplasm should be investigated to increase the likelihood of identifying low PHY varieties.

Abstracts of Papers on Rice Culture
Panel Chair: R.E. Plant

Soil Quality Changes in Rice Rotations

Anders, M.M.

Rice production, as it is practiced in much of the Mississippi Valley area of the United States, is considered tillage intensive. Years of continual tillage have resulted in soils that have very low organic matter content, poor infiltration, high resistance, and a tendency to crust easily. Even though fields are constructed so that water can be held on the field during the growing season, there are severe erosion problems during the wet winter months, early spring, and when the fields are drained following rice production. While much of row crop production in the United States has seen a shift from conventional tillage to conservation tillage, rice production areas have not made that change. There is some concern that these degraded soils cannot continue to support sustainable rice yields and that they are contributing to declining water quality. Recent increases in fuel prices have stimulated rice farmers to consider reducing tillage operations. While considerable information exists on how soil quality is impacted by reduced tillage, there is little information on how no-till might impact soil quality in various rice rotations. This study was initiated to measure grain yields and resource quality in rice rotations that were managed using conventional-till and no-till. Soil quality was measured as water stable aggregates with additional information collected on aggregate carbon and nitrogen content.

In 1999, a long-term rotation study containing seven rice-based rotations was initiated at the University of Arkansas Rice Research and Extension Center, Stuttgart, Arkansas. These rotations varied in that they contained rice every year, alternate years, and every third year. Other crops used in the rotations were soybeans, corn, and wheat. In 2005, samples were collected from paired fertility and variety plots from conventional and no-till treatments. Four 10-cm core samples were collected at two depths (0-5 cm, 5-10 cm) from each plot. Samples were dried and separated into five class sizes (>4 mm, 4-2 mm, 2-1 mm, 1-0.50 mm, 0.50-0.25 mm) using a wet shaker method. Samples were dried and percent of total dry weight determined for each class size. Each class size was then analyzed for total carbon and total nitrogen content.

Percent of total water stable aggregates was significantly affected by rotation, tillage, and sample depth. All interactions, with the exception of rotation x tillage, were significant. Changes in percent total soil water stable aggregates were primarily confined to the top 5-cm soil layer, with highest values in the no-till managed rotations. Highest percent of total water stable aggregates was in the rice (wheat)-rice (wheat) rotation. This rotation has a canopy cover throughout much of the year and the highest annual biomass input. There was a trend of increasing percentage of water stable aggregates with increasing frequencies of rice in a rotation. Lowest values for percent total water stable aggregates were in the rotations where rice appeared every third year. There was a trend of decreasing aggregate percent with increasing sieve size for all rotations and tillage treatments. Percent aggregate carbon content was highest for the 1.00 to 0.50 aggregate size class with decreasing values as aggregate size increased or decreased. Differences between aggregate content increased as aggregate size increased. The same trends were found in aggregate nitrogen content. Rice grain yields were inverse to soil aggregate content with those rotations having rice most frequently yielding less than those where rice appeared every third year.

Landscape and Nutritional Factors Associated with Localized Decline in Louisiana Rice

Breitenbeck, G.A., Kraska, J.E., and Saichuk, J.K.

'Localized Decline' is a disorder of rice commonly reported in the southern parishes of Louisiana. This disorder occurs early in the season and symptoms are most evident at tillering. The onset of symptoms has not been observed following panicle initiation. The most reliable symptoms for diagnosing this disorder are the presence of reddish brown spots on lower leaves and reduced stand. Once diagnosed, rapid drainage of the field is recommended because leaving flood water can result in rapid spread of symptoms throughout the field, sometimes causing complete loss of the crop.

The results of laboratory, pot, and field studies to determine the specific causes of the disorder will be reviewed. Tissue analyses clearly indicated that symptoms are invariably associated with the accumulation of >500 mg/kg Fe and Al, levels generally considered toxic to rice. The soils in most fields where the disorder occurs, however, have pH values >6.0 and negligible concentrations of plant-available Fe and Al in soil pore water. While affected plants typically contain modest amounts of Zn and K, these amounts are typically within the 'adequate' range. Moreover, applications of supplemental Zn and K to fields with a history of the disorder have not prevented the onset of symptoms. Silica (Si) tissue concentrations appear to be lower in affected rice (avg. 3.2%) than in healthy rice, though Si values of <5% are common in early-season rice grown in Louisiana. Adequate Si uptake has been reported to reduce susceptibility to Fe and Al toxicity.

Once the disorder has occurred, it frequently reoccurs in the same field each subsequent year rice is grown, though often it originates at a somewhat different location. The disorder commonly occurs near drop pipes and well-heads and symptoms can follow the flow path for several hundred yards. Other landscape features associated with this mysterious disorder will be discussed.

Impact of Land Forming and Cultural Management on Rice Irrigation Input Requirements

McCauley, G.N.

The first rice in Texas was grown about 1890. The water-loving crop flourished in the Texas coastal prairie region because of the impervious soils and abundance of water. There was minimal competition for the water during the first 80 years of production. The population explosion has placed tremendous demand on the region's water supply. The rice industry is being forced to conserve and fight for the remaining water supplies.

A third research effort was initiated in 2005 and continued in 2006 to reevaluate the impact of land forming and conservation tillage on rice irrigation water use. Land forming is defined as changing the surface topography of a complete field. The study evaluated eight main crop fields and six ratoon crop fields in 2005 and 12 main crop fields and nine ratoon crop fields in 2006. Fields were instrumented with rain gauge, inflow measurement, sharp crested weirs, and water depth recorders. The inflow, rainfall, and runoff were measured while the field use was calculated. Data were limited and interactions could not be evaluated.

Observations:

- All degrees of land forming reduced rice irrigation water requirements.
  - No major difference between zero grade, continuous grade, and bench grading were observed.
  - Maximum irrigation inflow reductions were observed when tall, permanent inside and outside levees were installed.
- Early studies showed a significant savings from multiple inlets and levee spacing. Levee spacing controls flood depth, which also has been shown to increase yields of the semidwarf varieties.
- Lowest irrigation inflow always occurs with groundwater fields.
- Early studies indicated reduced irrigation inflow for lighter soil textures. This may relate to the number of flushes required.

- The only influence of varieties is the days from emergence, which translates to the days under flood. Each day of flood adds about 0.35 inch of irrigation requirements.
- Reduced tillage can reduce irrigation inflow. The greatest impact occurs in dry years that require more flushes.
- The reduction from any management practice is related to the intensity and experience of management.

Effects of High Nighttime Temperature on Respiration Rates, Membrane Thermal Stability, Total Antioxidant Capacity, Pollen Viability, and Yield of Rice Plants

Mohammed, A.R. and Tarpley, L.

The presence of seasonally high nighttime temperatures (HNT) along the United States Gulf Coast and in regions of similar climate, occurring during the critical stages of development, reduces rice (*Oryza sativa* L.) yield and quality. The objective of this study was to determine the effects of HNT and chemical preventive treatments on respiration rates, membrane thermal stability (MTS), antioxidant capacities, pollen viability, and yield. Plants were grown under ambient nighttime temperature (ANT) (27^{o}C) or HNT (32^{o}C) in the greenhouse. They were subjected nightly to a HNT through use of continuously controlled infrared heaters, starting from 2000 h until 0600 h. The chemical treatments included salicylic acid (SA), glycinebetaine (GB), and α-tocopherols (vitamin E), which play an important role in inducing thermo-tolerance in many plant species. High nighttime temperature increased respiration rates and decreased MTS and pollen viability, and negatively affected the yield. Application of preventive chemicals negated the negative effects of HNT by decreasing the respiration rates and increasing MTS and total antioxidant capacities of rice plants.

Rate Effect of HM9754A on Rice Production in Two P and K Soil Fertility Regimes

Dunn, D.J., Stevens, G., Kenty, M.M., and Alford, B.

A 3-year rate evaluation of HM9754A, an organic soil amendment, was conducted in Missouri. This evaluation was conducted on two research areas. On one area, P and K soil test levels were maintained at optimum levels. On the second level, P and K soil test levels were below optimum.

Nitrogen Fertility and Growth Regulator Effects on Hybrid Rice Yield in Texas

Tarpley, L. and Walker, T.W.

The early-maturing rice (*Oryza sativa* L.) hybrids have the highest yield potential among cultivars for the mid-south United States. Yet, studies indicate their yield is limited by current nitrogen (N) fertilization rates, at least on the clay soils. For example, in 2005, at Beaumont, Texas, the use of 225 kg/ha N applied to the main crop as a three-way split provided a total (main and ratoon) crop yield of 17,963 kg/ha (13,072 main; 4,891 ratoon) (adjusted to 12% moisture). In 2006, in Beaumont, Texas, the use of 225 kg/ha N to the main crop as a three-way split increased total (main and ratoon) crop yield by 1,568 kg/ha to 16,232 kg/ha compared with 160 kg/ha N to the main crop as a two-way split. However, adding additional N increases the risk of lodging. The use of a plant growth retardant (Palisade [Syngenta]) applied about 14 d after panicle differentiation was evaluated to decrease final plant height and the risk of lodging.

The plant growth retardant, Palisade, used in this study, has the active ingredient Trinexapac-ethyl, which acts against gibberellic acid synthesis. Palisade is registered on turfgrass and is known to be effective on rice. Texas study sites were at Beaumont, Texas, in 2006 on a League clay soil and at Eagle Lake, Texas, in 2007 on a Nada fine sandy loam. The study was conducted with replicated, small research plots. The plant material was RiceTec's early maturing "tall semidwarf" rice hybrids: in 2006, XL723 and in 2007, Clearfield XL729. Recommended and greater-than-recommended (e.g. typical for inbred cultivars in the area) N rates were tested. The Palisade was applied at 85 g ai/ha at about 14 d after panicle differentiation. Plant height, and main and ratoon crop yields (adjusted to 12% moisture) were determined.

In 2006, the additional use of the plant growth retardant resulted in yields that were 560 kg/ha less than those observed with the greater-than-recommended N rates alone but still provided a net gain due to the combined treatments of 1,000 kg/ha. Similar results were seen in Mississippi in 2007 on a clay soil. In 2007, on the sandier soil at Eagle Lake, the higher N rates did not increase yield. The plant growth retardant led to a shorter plant height by 20 cm and also decreased yield by 1,600 kg/ha. The decreased relative effect of the higher N rate on the sandier soil was probably due to the higher N availability of soils with low clay content, which is associated with the greater ammonium diffusion in these soils.

A compatible technology is the use of gibberellic acid applied at main crop soft dough at a rate of 10 g ai/ha to improve ratoon crop yield through enhancement of early ratoon tiller vigor. The early-maturing rice hybrids (XL7 and XL723) show a strong response to the gibberellic acid treatment, with an average increase in ratoon crop yield of 672 kg/ha.

On clay soil, the higher N rate increases yield of these hybrid rice cultivars. Palisade decreases plant height, so it should help decrease lodging potential, although Palisade also decreased yield some. The study demonstrated the feasibility of using a combination of greater-than-recommended N rate and the use of a plant growth retardant to increase yield without increasing the risk of lodging on clay soil. On soil with a lower clay content, the combination of greater-than-recommended N rate and use of a plant growth retardant does not appear to be effective for increasing yield; however, the use of the plant growth retardant at lower rates as a means to decrease lodging potential without greatly impacting yield on these soils deserves further study.

Assessing Midseason Nitrogen Status of Rice Using Spectrophotometry

Satterfield, J.M., Walker, T.W., Bajwa, S.G., Norman, R.J., Harrell, D.L., Bond, J.A., and Varco, J.J.

Nitrogen (N) accounts for one of the largest expenses associated with rice production. Since 2000, the N cost has more than doubled; and with increased demand from developing countries, this cost is not likely to decrease. One way to decrease costs associated with N fertilizer and its application is to make more informed decisions about amount of N needed at midseason. Growers typically apply a predetermined rate of N at the panicle initiation or panicle differentiation (PD) growth stage without considering the plant's N status at the time of topdress application. Research has indicated that greater than 70% of the total N accumulated by rice plants occurs by the time internodes begin to elongate. The objective of this study was to evaluate the potential for using spectrophotometry as a non-destructive measurement to assess the N nutrition status for rice at midseason.

Three rice cultivars (Cocodrie, Wells, and XL723) were drill seeded on Sharkey clay soil. Within each cultivar, six preflood N rates (0, 67, 101, 134, 168, and 202 kg N/ha) were arranged in a randomized complete block design and replicated four times. At PD, spectral reflectance was measured from each plot using a GER 1500 spectrophotometer capable of measuring reflectance in 1.5 nm increments from 350 to 1050 nm. Reflectance was measured during the hours of 1100 and 1400 to reduce the angle at which the sun's energy would be reflected by the plant tissue. Aboveground biomass was harvested from 0.9 m of row and analyzed for total dry matter (TDM) and % N content. The product of these two variables was total N uptake (TNU). Additionally, rice grain yield was harvested at maturity. Reflectance (%REF) at each wavelength, TDM, %N, TNU, and yield were subjected to PROC CORR in SAS.

For all three cultivars, significant ($R^2 > 0.8$, $P<0.0001$) correlations existed between TDM and yield. Similar relationships were detected between reflectance measured at 810 to 890 nm; therefore, a single waveband (850 nm) where sensitivity appeared to be the greatest between N treatments was chosen based on visual inspection of a plot of %REF and wavelength. Regression analysis using PROC GLM in SAS resulted in the following linear models based on reflectance at 850 nm for TDM: $TDM_{Cocodrie} = 123.95 (\%REF) – 861.69$ ($R^2 = 0.85$; $P<0.0001$); $TDM_{Wells} = 164.26 (\%REF) – 519.35$ ($R^2 = 0.77$; $P<0.0001$); $TDM_{XL723} = 96.38 (\%REF) – 498.72$ ($R^2=0.69$; $P<0.0001$). Yield for each cultivar was also related to reflectance by the following models: $Yield_{Cocodrie} = 135.97 (\%REF) + 3000$ ($R^2=0.84$; $P<0.0001$); $Yield_{Wells} = 201.56 (\%REF) + 1654.68$ (R2=0.80; $P<0.0001$); $Yield_{XL723} = 290.85 (\%REF) – 1139.86$ ($R^2=0.82$; $P<0.0001$). These data suggest that spectrophotometry can potentially be used as a non-destructive measurement tool to assess midseason N status.

The Potential for Maximizing Nitrogen Use Efficiency in Hybrid Rice Using a Plant Growth Regulator

Walker, T.W., Tarpley, L., and Bond, J.A.

Hectarage planted to hybrid rice in the mid-southern United States has increased greatly in recent years. Currently, hybrid rice cultivars that are commercially available have yield potential reaching approximately 30% greater than comparable in-bred cultivars. However, the greatest potential from hybrid cultivars is seldom achieved due to their propensity to lodge when fertilized with large amounts of N fertilizer.

A study was conducted to evaluate the effects of applying a plant growth regulator (PGR), trinexapac-ethyl, to a popular hybrid rice cultivar (XL723) when grown under recommended and greater than recommended N rates. A factorial combination of two preflood (PF) nitrogen (N) rates (134 and 202 kg N/ha), two topdress N timings [panicle differentiation (PD) or panicle emergence (PE)], and two rates of trinexapac-ethyl (0 and 0.7 L/ha) applied at PD+14 d were included.

Rice grain yield was affected by the main effects of PF N rate and PGR. Pooled across topdress N timings and PGR rates, rice grain yields were 11.3% greater when 202 kg N/ha were applied PF. Pooled across PF N rates and topdress N timings, a 4% grain yield reduction was obtained when trinexapac-ethyl at 0.7 L/ha was applied at PD+14 d. Plant height was affected by PF N and PGR rates. When averaged across topdress N timings and PGR rates, plant height was 5.6 cm greater when 202 kg N/ha was applied PF compared with plant height following 134 kg N/ha; however, when pooled across PF N rate and topdress N timing, trinexapac-ethyl at 0.7 L/ha reduced plant height by 27 cm. This height reduction also impacted harvest index; plants treated with trinexapac-ethyl exhibited a greater harvest index (0.46 compared with 0.44 for plants receiving no trinexapac-ethyl). Preflood N rate, topdress N timing, and PGR rate affected 1,000-seed weight. Pooled across main effects, greater PF N and an application of trinexapac-ethyl both decreased 1,000-seed weight; however, differences were only 2% for both factors. These data suggest that trinexapac-ethyl could potentially be used in hybrid rice production systems to decrease plant height and, thus, reduce the risk of lodging, while capitalizing on the hybrid's ability to more efficiently utilize N relative to inbred rice cultivars.

Spatial Estimations of Water Use in Sacramento Valley Rice Cultivation

Hauselt, P. and Plant, R.E.

There are increasing concerns over water use efficiencies in California's water supply. While there has been much research on the quality of water used in rice production systems due to concerns over pesticides, less has been done to understand the quantities of water used in California rice production. During the 1990s, average water-use was estimated by various organizations. However, there is no spatially explicit description of the inflows to and outflows from the regional rice production system.

We developed a spatial water balance model using the ArcGIS geographic information system (GIS) to estimate water use in Sacramento Valley rice production (ESRI, Redlands, CA). Spatial layers were created describing the monthly variation of system inflows and outflows: precipitation (P), irrigation (IR), evapotranspiration (ETc), surface run-off (RO), and percolation (D). Spatial layers were also created to describe the soil storage (S) and the surface water holding capacity (F) of the system. The water layers were estimated from secondary data sources such as the California Department for Water Resource CIMIS weather station and the USDA Soil Survey Geographic (SSURGO) Database. Water use in the system was modeled with the following spatial water-balance equation: $IR + P - (ETc + RO + D) = S + F$. The spatial model was run to simulate 24 months from January 2003 to December 2004 for the Glenn-Colusa Irrigation District (GCID) in the northwestern quarter of the Sacramento Valley. The multi-scale model was run at various spatial resolutions: fields, sub-districts, and district. The water-balance model was based on the concept of conservation of matter. It was assumed that the amount of water entering the system was equivalent to the amount of leaving the system. The water model was assessed by determining if the equation was balanced.

The contributions of each component varied throughout the year. Irrigation was the dominant input, especially during the summer growing season. Irrigation also increased during the fall months as growers flooded the fields for straw decomposition. Reflecting the Mediterranean rain patterns, P was highest during the winter months. Evapotranspiration peaked during the hot summer months, while RO increased when growers drained their fields and during the early-winter rainy season. Among the water-balance components, P was the most problematic. Percolation was held constant throughout the year, assuming the fields were flooded. The water model was assessed by determining if the equation was balanced. When the inputs and outputs were equal to zero, it was assumed that the model was working as intended. The model was most balanced at the beginning and the end of the rice-growing season. The summer months tended to have greater inputs than outputs. During the winter months, the model tended to overestimate outflow. Too much water was estimated to leave the system during several winter months. The imbalance was assumed to be the monthly error factor of the model.

Nutrient Management Challenges with Changing Water Management Practices in California Rice Systems

Linquist, B.A., Lundy, M., Ruark, M., Koffler, K., Hill, J., and van Kessel, C.

Increased restrictions on how herbicides are applied are impacting early-season crop management, particularly how water is managed. Restrictions on certain herbicides require that they be applied by land (as opposed to aerially) if they are a certain distance from another crop. Land applications require draining the field and letting it dry enough to support a vehicle. Drain times may be up to 3 weeks between the time the field is drained and when it is reflooded. Changes to early-season water management require a change in fertilizer practices, especially nitrogen (N) management. The soil-water status has a large effect on the form of N found in soils and their susceptibility to losses. Both soil N (soil indigenous N) and fertilizer N are affected. In conventional systems, there is a loss of soil N following flooding; however, after the initial flood, the soil remains flooded (anaerobic), reducing losses due to denitrification. With these new management practices, there is an additional drain event (or events) that varies in time and duration. Draining may result in a change in the soil-water status from an anaerobic to aerobic state, depending on duration which would result in a change in the form of available soil N from NH^4 (ammonium) to NO^3-N (nitrate). When the soil is reflooded and the soil returns to an anaerobic state, NO^3-N is susceptible to gaseous loss via denitrification. Therefore, using current N management practices with these alternative systems increases the potential N loss and results in lower N use efficiency. The objective of this study was to quantify nitrification during drain periods in order to develop more efficient N management systems.

Field studies were conducted in 2006 and 2007. In 2006, a "ring" study was conducted in two fields differing in straw management (burned vs. incorporated). For this study, the N management was done by the grower using the standard management practice for those fields. The study had two treatments (no drain and early-season drain). In order to maintain a flooded condition in the undrained plots, metal rings approximately 76 cm in diameter were forced 20 cm deep into the soil. Similar rings were also used for the drained treatment to eliminate any ring effect. The rings that were drained had holes in them that were unplugged when the field was drained. In the undrained rings, water was kept 5 to 10 cm deep by adding water when needed. Plant and soil samples were taken from rings from before the drain period, through the drain period, and up to 3 weeks after reflooding. Soils were analyzed for extractable NO_3 and NH_4 and plants analyzed for total N. At harvest, samples were also taken for yield and N uptake determination. In 2007, a similar study was conducted except that ^{15}N labeled N was placed either on the surface or 8 to 10 cm below the soil surface. The rates used for the surface and subsurface N were the same as that used by the grower. Sampling was done as in 2006. In 2007, an additional study was conducted in 23 rice fields in the Sacramento Valley region where growers were draining their fields for herbicide applications. In each field, soils were sampled at 2- to 4-day intervals through the drain period until about 2 weeks after reflooding. Soils were analyzed for extractable NO_3 and NH_4.

In the ring studies, the drain period lasted from 7 to 11 days. In 2006, NO_3 accumulation in the drained rings during the drain period ranged from approximately 28 to 35 kg N/ha and in 2007 from 4 to 20 kg N/ha. NO_3 did not accumulate in the undrained rings. In 2006 (2007 data not yet available), N uptake through the drain period was similar between the drained and undrained rings; however, 20 days after the drain N accumulation was 42 to 53 kg N/ha less than in the undrained rings. By the end of the season, grain yields ranged between 97 to 666 kg/ha less and total N uptake ranged between 14 to 20 kg/ha less in the drained than undrained rings. While N deficiency resulting from denitrification may have resulted in decreased yields, ^{13}C discrimination analyses of plant samples taken during the drain period suggest that the plants were also drought stressed at the end of the drain period. In the regional field study, NO_3 accumulation varied widely between fields from as little as 0.35 kg/ha to as high as 62 kg N/ha. Averaged across sites, the NO_3 concentration increased by 1.1 ug N/g soil/day. Nitrification will be affected by soil moisture, soil properties (texture and carbon), and temperature. The data are being analyzed to better determine the relative effects of each of these factors. These results clearly indicate the large potential for N losses in these rice systems where an early-season drain is part of the management. Improved N management practices will likely require changes to the timing or placement of N fertilizer in order to achieve acceptable N use efficiency.

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., Brye, K.R., and Siebenmorgen, T.J.

Due to 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 predictions of (1) temperature projections during rice reproductive growth stages (RRGS) starting at R3, (2) timing of various RRGS, (3) maximum amounts of water used by the rice crop at each growth stage, and (4) the water held in the soil profile after draining, which is available to the rice crop. 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. Experiments to test the predictions were conducted in 2005 and 2006 at Gillett and Stuttgart. An experiment was also conducted at DeWitt in 2006. In 2005, the model predicted the safe stages for draining were R6 at Gillett and R8 at Stuttgart. In 2005, the study was drained 13 and 14 days earlier, respectively, than the controls at Gillett and Stuttgart. In 2006, the model predicted safe stages of growth to be R7 for all three locations, and fields were drained 7 (Gillett) and 14 (Stuttgart) days earlier than the controls. For the control at DeWitt, pumping was ceased the day after the plots were drained. 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. Predicted water savings from one less 76-mm irrigation ranged between $9.81 and $46.49/ha, depending on pump depth. Implementation of the program by farmers can save money, increase rice yields, reduce tillage costs, lessen management problems associated with red rice, and reduce unnecessary depletion of the aquifers.

A 25-Year Summary of the University of Arkansas Rice Research Verification Program

Runsick, S.K., Wilson, Jr., C.E., and Watkins, K.B.

In the early 1980s, rice yields were declining, prices were low, and production costs were high. The future of the rice industry in Arkansas was much in doubt. Producers requested that the University of Arkansas field test existing technology to determine the profitability of rice production. In 1983, the Arkansas Cooperative Extension Service initiated the Rice Research Verification Program (RRVP). The program is an interdisciplinary program that stresses intensive management and integrated pest management to maximize returns. The overall goal is to verify that management, according to University of Arkansas recommendations, can result in increased profitability. The objectives of the program 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, and (6) provide in-field training to county agents in rice production practices.

The RRVP fields and cooperators are selected prior to the beginning of the growing season. Cooperators agree to pay production expenses, provide expense data, and implement university recommendations in a timely manner from planting to harvest. A designated county agent from each county assists the RRVP coordinator in collecting data, scouting the field, and maintaining regular contact with the producer. Weekly visits by the coordinator and county agents are made to monitor the growth and development of the crop, determine what cultural practices needed to be implemented and to monitor type and level of weed, disease and insect infestation for possible pesticide applications. Management decisions are based on integrated pest management philosophy and current University of Arkansas research based recommendations. Management begins with field history, soil testing, and variety selection and includes all aspects of production. An advisory committee consisting of Extension specialists and university researchers with rice responsibility assists in decision-making, development of recommendations, and program direction. Field inspections, by committee members, are utilized to assist in fine-tuning recommendations.

Since 1983, the RRVP has been conducted on 274 commercial rice fields in 33 rice-producing counties in Arkansas. The program has been conducted on 6,406 ha (15,829 A), with an average field sized of 23.5 ha (58 A). The Arkansas average rice yield over the last 25 years was 6,463 kg/ha while the RRVP average was 7,326 kg/ha. On average, RRVP fields have yielded 12% higher than the Arkansas state average. In 2007, the RRVP recorded the highest yields in the history of the program, with an average of 9,526 kg/ha. The RRVP has been a successful educational program for the past 25 years. Producers enrolled in the program have been able to increase yields and gain valuable knowledge of rice production practices. The trends in yields, management decisions, and impacts will be discussed.

A Comparison of Hand-Sampled Grain Moisture versus Combine-Sampled Grain Moisture to Determine Rice Harvest Timing

Saichuk, J.K., Blanche, S., Harrell, D., Hebert, J., Landry, K., and Theunissen, S.

The most common means used by rice farmers to determine whether their rice is ready to harvest is to harvest a small area of their field with a combine then measure the moisture in that sample. The time and expense involved can be avoided by taking hand samples, measuring the moisture, and then adding a factor to obtain an accurate estimate of harvest moisture.

Beginning in 2003, in conjunction with our Rice Research Verification Program, we began to collect data comparing hand samples of grain at harvest and comparing them to samples taken from combines in the field as they harvested rice from the same area where the hand samples were obtained.

Since then, approximately 140 paired samples have been obtained. Percent grain moisture for each sample was measured with a portable grain moisture meter in the field to simulate what a grower might do as well. These data have been analyzed statistically.

It appears hand samples can be used to accurately estimate grain harvest moisture, thereby eliminating the need to harvest a small portion of a field with a combine to determine whether the field is ripe enough to harvest and/or to schedule combine moves from field to field.

New Methods for Making Midseason Nitrogen Decisions on Rice

Stevens, G., Wrather, A., Rhine, R., Dunn, D., and Vories, E.

A simple method is needed to aid farmers with midseason nitrogen (MSN) decisions in dry-seeded, delayed flood rice (*Oryza sativa* L.). Managing nitrogen (N) fertilization can be a challenge due to potential N losses from urea volatilization before flooding and denitrification after flooding. Extension recommendations for preflood N (PFN) rates in rice are usually based on empirical N field tests, and adjustments are made for specific varieties, crop rotation, and soil texture. To help reduce rice N deficiency stress from early-season N losses and supply N needs during grain-filling growth stages, MSN by aerial topdressing on rice can be applied near panicle differentiation (R1) growth stage. Measurements, such as leaf area index, biomass accumulation, Y-leaf (most recently fully expanded leaf) N concentration, and whole-plant N concentration, have been used to estimate midseason plant N sufficiency for determining whether topdressing is likely to increase rice yields. Plant area measurements with a rice gauge have also been used to predict MSN need. Scientists in Arkansas found that plant area values from a rice gauge were a good estimator of rice dry matter and a more reliable estimator of total N accumulation than Y-leaf N concentrations and SPAD readings. Although the use of the rice gauge for predicting rice needs for MSN has been widely promoted by state extension services in the upper Mississippi Delta region, very few rice consultants or farmers use it because of the labor required.

This study was conducted to develop thresholds using visual and digital image measurements for predicting rice yield response to MSN. Francis and Cheniere rice were drill seeded on a 19-cm row spacing from 2004 to 2006 on silt loam and clay soils at Glennonville and Portageville, Missouri. Preflood N was applied at rates of 0, 39, 78, 118, and 157 kg urea-N/ha with and without two MSN applications of 34 kg N/ha at panicle differentiation and at R1+ 7d. Plant area observations were made 1 to 2 d before R1. Three methods of measuring midseason plant area per plot were evaluated 1 to 2 d before R1 growth stage. For the first method, a yardstick was floated on floodwater between two center drill rows and the numbers visible were counted. Inch digits on the yardstick were approximately 2.0 mm tall. Standing between adjacent rows and leaning over the sampling rows, we counted the inch numbers showing on the yardstick (not hidden by rice leaves) out of 36 numbers possible. When a rice leaf obstructed the view of one digit in a two-digit number to the point that the whole number was not recognized, we did not count that number. For the second method, plant height was measured at the same sample location in each plot. One location per plot was sampled. For the third method, digital images were collected 1 to 3 days before MSN applications with a camera mounted on a 1.53-m (5-ft) rod held above the plot in 2005-2007. This method was not used in 2004. The camera was positioned level with the soil surface and recorded a plot area of 0.81 x 1.14 m (32 x 45 inches). A computer macro program developed at University of Arkansas was used with Sigma Scan Pro 5.0 image software to determine the percentage of green pixels in each photo. Green color was defined in Sigma Scan as 52 to 110^o hue on the color wheel and a saturation of 35 to 100%.

No significant yield increase was produced from MSN when 117.6 kg/ha (105 lb N/A) was applied preflood with small plot water management. However, in large rice grower fields, managing to reduce volatilization and denitrification losses is more difficult. Critical plant area threshold values for R1 growth stage rice were developed using visual and digital image measurements for predicting rice yield response to MSN. Although plant height is used as an input for estimating rice crop canopy with the rice gauge, we found little value for this measurement for predicting rice N status at midseason. Regression coefficients of determination for plant height and rice yield change from MSN applications were very low. Highest rice yields on both soils were most often achieved with 78 kg N/ha with MSN or 118 kg N/ha without MSN. Preflood N significantly affected visible yardstick numbers, plant height, and percent green pixels. Height was the least reliable indicator of rice N status. Using regression analysis, no rice yield increase from MSN was produced when fewer than 13 yardstick numbers were showing or more than 64% of image pixels were green.

Production Progress Resulting from 30 Years of the Rice Check-off Program in Arkansas

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Branson, J.D., Runsick, S.K., and Mazzanti, R.S.

Rice production in Arkansas has progressed substantially since it began over a century ago. Average yields have increased from about 30 bu/A to a record 160 bu/A in 2007. However, the yields have increased more than 50% during the past 30 years. This increase has been attributable to many factors, but none more important than the implementation of the rice check-off program. Because of the importance of this program, a comprehensive evaluation of the direct effects on the rice industry will be discussed.

The Arkansas rice check-off program officially began in 1985. However, farmers began voluntarily contributing to research as early as the late 1970s. The program began as a volunteer contribution to support research and promotion but became mandatory in 1993 by farmer referendum. Since then, the Rice Check-off program has contributed between $2.5 and $3.5 million each year for research and equal amounts for promotion. Currently $0.0135/bushel is contributed by producers for research and $0.0135/bushel is contributed by the buyer at the first point of sale to support promotion.

The investment in research by producers has resulted in significant returns through improved varieties and improved management technology. Examples include the development of the blast-resistant lines Katy, Kaybonnet, and Drew. During this same time period, researchers were able to increase knowledge of the blast fungus that would help in management. By maintaining a deep flood, farmers were able to produce blast-susceptible varieties with low risk of major blast infestations. Similar advances in nutrient management, weed management, and insect management have allowed farmers to increase yields and maintain a small profit margin in spite of higher input costs.

With the recent spike in energy prices, major advancements are needed again. On-farm diesel prices have doubled in the last 3 years. Irrigation and fertilizer, which are directly related to energy costs, are the most costly inputs into the rice crop. Research is needed to increase productivity and also ensure that maximum benefits are gained from these two major inputs.

Landscape and Nutritional Factors Associated with Localized Decline in Louisiana Rice

Breitenbeck, G.A., Kraska, J.E., and Saichuk, J.K.

'Localized Decline' is a disorder of rice commonly reported in the southern parishes of Louisiana. This disorder occurs early in the season and symptoms are most evident at tillering. The onset of symptoms has not been observed following panicle initiation. The most reliable symptoms for diagnosing this disorder are the presence of reddish brown spots on lower leaves and reduced stand. Once diagnosed, rapid drainage of the field is recommended because leaving flood water can result in rapid spread of symptoms throughout the field, sometimes causing complete loss of the crop.

The results of laboratory, pot and field studies to determine the specific causes of the disorder will be reviewed. Tissue analyzes clearly indicated that symptoms are invariably associated with the accumulation of >500 mg/kg Fe and Al, levels generally considered toxic to rice. The soils in most fields where the disorder occurs, however, have pH values >6.0 and negligible concentrations of plant-available Fe and Al in soil pore water. While affected plants typically contain modest amounts of Zn and K, these amounts are typically within the 'adequate' range. Moreover, applications of supplemental Zn and K to fields with a history of the disorder have not prevented the onset of symptoms. Silica (Si) tissue concentrations appear to be lower in affected rice (avg. 3.2%) than in healthy rice, though Si values of <5% are common in early-season rice grown in Louisiana. Adequate Si uptake has been reported to reduce susceptibility to Fe and Al toxicity.

Once the disorder has occurred, it frequently reoccurs in the same field each subsequent year rice is grown, though often it originates at a somewhat different location. The disorder commonly occurs near drop pipes and well-heads and symptoms can follow the flow path for several hundred yards. Other landscape features associated with this mysterious disorder will be discussed.

An Evaluation of Commercially Available Imagery of Rice Crop Canopy Affected by Nitrogen Nutrition

Walker, T.W., Satterfield, J.M., Bajwa, S.G., Norman, R.J., Harrell, D.L., Bond, J.A., and Varco, J.J.

Precision agriculture has dominated the research community in recent history due to the development of new tools and the desire of growers to be better stewards of crop inputs. Economics and environmental concerns have largely driven producers to search for more precise methods to apply agrochemicals. Because of the cultural practices employed by rice farmers in the United States, as well as other countries, one area that could potentially use precision agriculture is that of nitrogen (N) fertilization. Research has shown that high yielding cultivars produced on the majority of the hectarage in the midsouthern USA rice-producing area can produce yields equal to or greater when single preflood (SPF) applications of N are made compared with N applications split between PF and panicle differentiation (PD). The split method remains the most popular method utilized by growers due to the potential for decreased N efficiency, resulting from uncontrollable causes, i.e., flood loss. Currently, commercial companies will provide aerial imagery that consists of reflectance data captured from a crop canopy. Based on reflectance of solar energy, inferences can potentially be made about biomass and other crop components, which contribute to final grain yield. The objective of this study was to evaluate the ability of commercially available imagery to assess the N nutrition status of rice.

Three rice cultivars (Cocodrie, Wells, and XL723) were drill seeded on Sharkey clay soil. Within each cultivar, six PF N rates (0, 67, 101, 134, 168, and 202 kg N/ha) were arranged in a randomized complete block design and replicated four times. At PD, reflectance was collected from an airplane equipped with a multi-spectral camera capable of measuring reflectance in the blue, green, red, and near-infrared (NIR) wavelengths. Aboveground biomass was harvested from 0.9 m of row and analyzed for total dry matter (TDM) and N content (%N). The product of these two variables was total N uptake (TNU). Additionally, rice grain yield was harvested at maturity.

A Green Normalized Difference Vegetative Index (GNDVI) was computed for each plot by the following equation [GNDVI= (NIR-Green)/(NIR+Green)]. Total dry matter, %N content, TNU, and yield were regressed against GNDVI values using PROC GLM in SAS, and each resulted in significant linear models ($P<0.0001$). Coefficients of determination increased in the order of %N (R^2=0.59 to 0.69) < TNU (R^2=0.73 to 0.77) < TDM (R^2=0.70 to 0.85) < Yield (R^2=0.9 to 0.97). These data suggest that GNDVI calculated from commercially available reflectance data can potentially be used as a non-destructive measurement tool to assess midseason N status in rice.

Evaluation of Conventional and Reduced Tillage Practices on Optimum Seeding Rate, Nitrogen Fertilization Rate, and Yield Components

Harrell, D.L.

Conventional tillage is currently the most common tillage system used in drill-seeded Louisiana rice. However, reduced tillage systems have become increasingly more common every year. Early estimates from the 2007 growing season in Louisiana indicate that approximately 42% of the planted acreage was planted using some form of reduced tillage. Reduced tillage systems, such as no-till, spring, and fall stale seedbeds, have several benefits over conventional tilled rice seedbeds, which make them more desirable. Most notably is the ability to reduce overall production costs, speed planting of drill-seeded rice by reducing seedbed preparation time, and minimizing soil and nutrient losses associated with draining rice fields. Nonetheless, only limited research is available that focuses on seeding and nitrogen (N) fertilization rate differences, which may exist between conventional and reduced tillage systems of currently used rice cultivars. The primary objectives of the study are threefold: 1) to evaluate the seeding rate differences that may occur between a fall stale and conventionally tilled seedbed for drill-seeded rice; 2) evaluate N fertilization requirement differences between the two tillage systems; and 3) to determine if a less than optimum stand or N fertilization rate can be compensated for by increasing the N rate or seeding rate, respectively.

Two studies were initiated in the spring of 2007 at the LSU AgCenter's Rice Research Station South Farm located just south of Crowley, Louisiana. The first study evaluated Jupiter, a high yielding semidwarf medium-grain cultivar, while the second evaluated Cheniere, a high yielding semidwarf long-grain cultivar. Two tillage treatments (conventional and fall stale seedbed), four seeding rates (161, 323, 484, and 646 seed/m^2), and four N rates (101, 134, 168, and 202 kg/ha) were used in each study. Treatments were arranged in a randomized complete block with a factorial arrangement of treatments with four replications. Both trials were drill seeded into a Crowley silt loam soil (fine, smectitic, thermic Typic Albaqualfs) on May 16. Data obtained from the studies included days to 50% heading, plant height, yield, total and whole milling percentage, stand density, and yield components (panicle density, filled grains/panicle, and grain weight).

Days to 50% heading was increased by 1 day for both cultivars under conventional tillage compared with conventional tillage when pooled across all treatments. Yield was also significantly higher in the stale seedbed (8,731 kg/ha) compared with the conventional tilled seedbed (8,412 kg/ha) for Jupiter when pooled across all treatments. However, Cheniere yields were not significantly affected by tillage at the $P = 0.05$ level of confidence. Optimum plant densities of approximately 107 to 161 plants/m^2 were achieved even at the lowest seeding rate for both cultivars. There was not a significant tillage by seeding rate interaction for either cultivar, suggesting that a modified seeding rate recommendation for reduced tillage systems may not be needed when properly managed.

There was no significant N by tillage or N by seeding rate interaction in the Cheniere trial. When yield data were pooled across all treatments, optimum N fertilization was achieved at the 101 kg/ha rate. There was a significant tillage by N rate interaction for the Jupiter trial. Optimum N fertilization was achieved at 101 kg/ha under a conventionally tilled seedbed and at 134 kg/ha when managed under a stale seedbed system. Data suggest that higher N fertilization rates may be needed in a reduced tillage system for some rice cultivars.

Further research is needed to validate the current data over years. Applied research in the area of tillage system differences is paramount in order to provide end-users with optimal N and seeding rate recommendations in drill-seeded rice.

Evaluation of First Crop Cutting Height on Ratoon Crop Yield and Panicle Origin in Drill-Seeded Rice

Harrell, D.L., Bond, J.A., and Dunand, R.T.

The climate in the Gulf Coast region of southwest Louisiana is conducive for growing a second rice crop from the stubble left behind after the first crop harvest. The practice of growing a second rice crop, also known as the ratoon crop, is often done with the addition of nitrogen fertilizer and few other agro-chemical inputs. Because additional inputs are minimal, the ratoon crop has a higher margin of profit, giving rice producers in the region a major economical advantage over producers from other areas. Nonetheless, producers are always looking for ways to increase ratoon crop yields. Manipulating the rice stubble of the first crop by various methods, such as lowering the cutting height at harvest, rolling or flail mowing the stubble after harvest, have all been experimented with by producers with mixed results. All stubble management practices increase the overall production cost of the ratoon crop. For example, harvesting with a lower than normal cutting height requires a slower than normal combine speed, resulting in more harvest time, higher fuel costs, and generally results in slightly lower first crop harvest efficiency. Nonetheless, because fuel costs have risen considerably the past few years, many believe that harvesting with a lower cutting height may be the least expensive of all the aforementioned stubble manipulation practices. The objectives of the current study is twofold: 1) determine if harvesting at a lower height can provide a consistent ratoon yield advantage over normal harvesting practices and 2) evaluate the origin and density of ratoon panicle development when the first crop is harvested at differing heights.

The 2-year study was initiated in the spring of 2006 at the LSU AgCenter's Rice Research Station South Farm located just south of Crowley, Louisiana. Treatments included two cultivars (Trenasse and Cocodrie) and two harvest heights (20 and 40 cm). The experimental design was a randomized complete block with two replications and four subsamples per replication. Rice was drill seeded into a Crowley silt loam soil (fine, smectitic, thermic Typic Albaqualfs) on March 29 and March 15 in 2006 and 2007, respectively. Ratoon rice panicles were tagged after emergence each week beginning 3 weeks after first crop harvest (WAH) and concluding 10 WAH. Four subsample areas within each plot were used. Subsample areas were harvested by hand prior to combine harvest of whole plot areas. Panicle origins were determined from subsamples. Data obtained from the study included plant height, grain yield, panicle density, panicle weight, and panicle origin from 3 to 10 WAH.

Significant panicle emergence was not noted until 3 to 4 WAH during both years. Total ratoon grain yield and panicle weight were not significantly different between main crop cutting height treatments for either cultivar in 2006. However, panicle density 10 WAH was 44 and 43% higher at the higher cutting height compared with the lower cutting height for the Cocodrie and Trenasse cultivars, respectively. Currently, ratoon panicle densities and origins are being determined for the 2007 growing season. When completed, both years of data will be pooled and statistically analyzed by SAS. Results will be shared during the meeting.

Rice Seeding Rate and Row Spacing Revisited

Buehring, N.W., Walker, T.W., and Bond, J.A.

In recent years, the adoption of grain drills with 25.4-cm (10-inch) row spacings has increased. Rice producers have adopted grain drills with 25.40-cm spacings because these can be purchased at a lower cost than 20.32-cm (8-inch) models. Furthermore, grain drills with 25.40-cm spacings can easily be utilized to plant soybean on 50.80-cm centers. Previous research has reported a slight yield reduction when rice is planted on 25.40-cm compared with 20.32-cm row spacings. Even with this documentation, some rice producers have still opted for 25.40-cm grain drills and have been satisfied with rice yields. Since the adoption of 25.40-cm grain drills, producers have generally planted the same amount of seed per acre that they planted when using 20.32-cm grain drills. Doing so results in more seed per linear meter of row (seed/m) in 25.40-cm spacing. In 2007, research was initiated to determine if the same seeding rate per linear row meter could be utilized for both 20.32- and 25.40-cm row spacings.

The study was designed as a randomized complete block with treatments arranged as a three-factor factorial. Factor 1 was row spacing (20.32 and 25.40 cm). Factor 2 was seeding rate per linear meter of row (22, 43.6, 65.6 and 87.6 seed/m). With a 20.32-cm row spacing, seeding rates of 22, 43.6, 65.6, and 87.6 seed/m are equivalent to 108, 215, 323, and 431 seed/m^2, respectively. Factor 3 was rice cultivar (Cocodrie and Wells). The study was conducted on Sharkey clay and Forestdale silt loam soils. Data were collected for rough rice yield, rice panicles/m^2, rice grains/panicle, and rice seed weight. Rough rice yields were determined on a whole plot basis and adjusted to 12% moisture content. Data were subjected to ANOVA with means separated by Fisher's Protected LSD at P = 0.05.

On both soil types, the 25.40-cm row spacing produced higher rough rice yield than the 20.32-cm row spacing. These results are contrary to previously published data. At the clay soil site, the 20.32-cm row spacing resulted in greater panicles/m^2 and no differences in rice grains/panicle or rice seed weight with respect to row spacing were detected. At the silt loam site, no differences in rice panicles/m^2, rice grains/panicle, or rice seed weight with respect to row spacing were detected. These data indicate that the same seeding rate, in seed per linear row meter, could be used for both 20.32- and 25.40-cm row spacings without resulting in lower yields.

Rough rice yields generally increased with seeding rate on both soil types. No interaction between seeding rate and row spacing was observed at either site. At both sites, the number of rice panicles/m^2 increased with seeding rate. However, the number of rice grains/panicle decreased with increasing seeding rate. On the clay soil, rice seed weight generally decreased with decreasing seeding rate. On the silt loam soil, no differences among seeding rates were observed for rice seed weight.

Assessment of Polymer-Coated Urea for Delayed-Flood Rice Production

Golden, B.R., Slaton, N.A., Norman, R.J., Delong, R.E., and Wilson, C.E.

Nitrogen (N) fertilization of rice (*Oryza sativa* L.) in the direct-seeded, delayed-flood production system relies heavily on aerial application of N fertilizer. The ability to apply N fertilizer with ground equipment before seeding would benefit rice producers by reducing N application costs. The research objective was to compare the effects of preplant application of polymer-coated urea fertilizers with the standard practice of preflood urea fertilizer application on growth and yield of rice in the delayed-flood production system.

Experiments were established during 2006 and 2007 at the Pine Tree Branch Station on a Calhoun silt loam, Lake Hogue Research Farm on a Hillemann silt loam, and Rice Research and Extension Center on a Dewitt silt loam. At the Pine Tree Branch Station, two studies were established in 2006 and one in 2007. Soybean [*Glycine max* (Merr.) L.] was the previous crop grown at all site-years. Two polymer-coated urea fertilizers (ESN, 44% N; and Duration type V, 43% N; Agrium Inc., Calgary, AB, Canada) were broadcast at total N rates, ranging from 34 to 168 kg N/ha immediately before seeding Wells (2006) or Francis (2007) rice at 112 kg seed/ha. At the 5-leaf stage, prior to establishing a permanent flood, urea was applied at six N rates, ranging from 0 to 168 kg N/ha to plots receiving no polymer-coated urea. Total aboveground N uptake was determined near the panicle differentiation (PD) and early heading (HDG) stages by harvesting whole plants from 1.8-m sections from the first inside row of each plot that received 0 and 134 kg N/ha. Plants were dried to a constant weight, weighed, ground to pass a 1-mm sieve, and whole-plant N concentration was determined by combustion. Net N uptake was calculated by multiplying %N concentration by dry matter and subtracting the untreated control and expressed as kg N/ha. Grain yield, adjusted to 12% moisture content, was determined by harvesting the middle five rows of each plot with a small-plot combine. Each experiment was arranged as a randomized complete block with a 3 (N source) × 5 (N rate) factorial treatment structure and compared with a no N control. Each treatment was replicated four times. Mean grain yield data were initially regressed on N rate allowing for both linear and quadratic terms with coefficients, depending on N source and site-year. Non-significant model terms were removed sequentially and the model was refit until a satisfactory model was obtained. Differences among all remaining coefficients, which varied by N source, site-year, or both were determined using single degree of freedom contrasts. Nitrogen uptake at PD and HDG were analyzed using Fishers protected LSD at the 0.05 significance level. Statistical analyses were performed using SAS version 9.1.

Grain yield was significantly affected by the N source × rate interaction. The non-linear slope coefficient was similar among site-years within each N source but differed among N sources. Rice grain yield increased linearly (ESN, non-linear term not different than zero) or non-linearly (D5 and urea) as N rate increased within each N source. The linear slope coefficients varied among N sources and site-years with coefficients for preplant applied ESN and D5 fertilizers being significantly lower than coefficients for urea applied preflood. Thus, near maximal grain yields were produced with urea and D5, but a greater N rate was required to maximize yield with D5. Rice grain yield among site-years for 134 kg N/ha applied preflood as urea ranged from 7,798 to 11,528 kg/ha compared with 5,607 to 10,149 kg/ha for ESN and 5,885 to 11,093 kg/ha for D5 applied preplant at 134 kg N/ha. Intercept coefficients among N sources within each site-year were similar. Nitrogen uptake at PD and HDG among N sources applied at 134 kg N/ha showed that urea N applied preflood was taken up more efficiently than N from either ESN or D5.

Nitrogen fertilizer applied preflood as urea consistently produced maximal grain yields with the lowest N rates and was taken up more efficiently compared with polymer-coated urea fertilizers applied preplant. The N release rates, determined in companion studies, indicate that the evaluated polymer-coated urea fertilizers release N too rapidly before flooding, which likely results in nitrification before flooding and substantial denitrification losses of N after flooding at the 5-leaf stage. The ESN and D5 fertilizers may be well suited for water-seeded rice, but further research is needed to verify this hypothesis. Polymer-coated urea fertilizers with a slower N release rate are needed for rice grown in the delayed flood system.

Potassium Fertilization Influences Growth, Yield, and Stem Rot Severity of Rice

Maschmann, E.T., Slaton, N.A., Cartwright, R.D., Norman, R.J., DeLong, R.E., Wilson, C.E., and Micheri, P.H.

Potassium (K) deficiency of rice (*Oryza sativa* L.) has become an increasing problem in Arkansas over the last 20 years due in part to inadequate fertilization programs and increasing crop yields. Knowledge of the influence of K deficiency on rice yield components, such as number of spikelets per panicle and percentage filled spikelets and disease reaction, would be useful information for management of K-deficient rice. The research objectives were to determine the effect of K fertilizer rate on grain yield, whole-plant K concentrations at panicle differentiation (PD) and early heading (EH), selected yield components, and stem rot (*Sclerotium oryzae*) severity of rice grown on K-deficient soils.

Experiments were conducted in Arkansas on K-deficient soils at the Pine Tree Branch Station (PTBS) on two Calhoun silt loams in 2007 and a Henry silt loam in Poinsett County in 2004. One additional study was established on a K-sufficient Dewitt silt loam at the Rice Research and Extension Center (RREC). Muriate of potash fertilizer was applied at rates ranging from 0 to 150 kg K/ha at all sites. Whole-aboveground plant samples were collected at PD and EH for determination of tissue K concentrations. At maturity, panicles were collected from plots receiving 0, 75, and 150 kg K/ha and assayed for total spikelet number and percentage of filled spikelets (or percent blanks). Grain yield was determined by harvesting the middle rows of each plot. Stem rot severity at maturity was determined on culms harvested from a 0.9-m section of row using a 1 to 5 disease index rating system with 1 being a healthy culm and 5 being a dead culm. Stem rot severity was rated on two trials conducted at PTBS in 2007. For statistical analysis, site-year data were grouped by the soil-K sufficiency status (deficient or sufficient), analyzed as a randomized complete block with split-plot treatment structure (deficient soils), and results interpreted at the 0.10 significance level.

Soil-test K ranged from 54 to 74 mg/kg at the three K-deficient sites and averaged 150 mg/kg at the K-sufficient sites. As expected, K fertilizer rate had no influence on grain yield (8,870 kg/ha), whole-plant K concentration at EH (2.03% K), spikelet number/panicle (151), and percent blank spikelets (11%) of rice grown in the K-sufficient soil (RREC). In K-deficient soils, rice receiving no K fertilizer contained deficient whole-plant K concentrations at PD (1.14-1.33% K) and EH (0.78-1.00% K), which increased to a sufficient level (>1.7% at PD and 1.3% at EH) when K rate exceeded 75 kg K\ha. Averaged across K-deficient sites, grain yields of rice receiving no K fertilizer (7,812-9,374 kg/ha) were increased significantly by 13 to 17% from application of 75 to 150 kg K/ha with maximum numerical yields (9,475-10,382 kg/ha) produced by the greatest applied K rate. Panicle assays, averaged across K-deficient sites, showed that total spikelet number increased significantly (156 vs 169-175 spikelets/panicle) and percent blank spikelets decreased (24% vs 20-22%/panicle) when 75 and 150 kg K/ha were applied. Stem rot severity, averaged across PTBS sites, decreased as K rate increased with the unfertilized control having an average stem rot index of 3.5, which declined to 3.0 for 37 kg K/ha and 2.6 to 2.8 for 75 to 150 kg K/ha.

These data suggest that yield loss from K deficiency is partially attributed to a reduction in spikelet number/panicle plus an increase in blank spikelets/panicle. Further yield losses may be the result of increased disease severity. Adequate, early-season K fertilization is important to establish rice yield potential because spikelet number per panicle is set and stem diseases begin during vegetative growth. Additional research is needed to determine whether K fertilization after PD may aid in reducing disease incidence, severity, and/or reduce spikelet blanking.

Evaluation of Agrotain- and Nutrisphere-Coated Urea Applied Preflood to Delayed-Flood Rice

Norman, R.J., Wilson, Jr., C.E., Roberts, T.L., Walker, T.W., Frizzell, D.L., Enochs, A.J., Branson, J.D., and Slaton, N.A.

One of the difficulties in the management of nitrogen (N) fertilizer applied preflood to delayed-flood rice is the timeliness of the flood following urea-N fertilizer application. Previous research in Arkansas has shown that 20 to 30% of the urea-N applied preflood can be lost via ammonia volatilization if the flood is delayed for 5 to 10 days past the N fertilizer application. Most commercial rice fields require 5 to 10 days to establish a flood across the entire field. Urease inhibitors have been promoted as a means to significantly slow ammonia volatilization losses from urea and allow time for the floodwater to incorporate the urea in the soil. Two products promoted as containing urease inhibitors are Agrotain and Nutrisphere. Ammonium sulfate is a viable alternative to urea because it is slightly acid in its initial reaction when applied to soil so it is much less prone to ammonia volatilization loss. The objectives of the studies reported here were to evaluate urea, Agrotain, Nutrisphere, and ammonium sulfate as to their ammonia volatility when applied to soil and their influence on rice yield when applied at various times prior to flood establishment.

Field experiments were conducted in Arkansas and Mississippi on silt loam soils having a pH of 5.8 to 7.8. The cultivar Wells was seeded at 100 kg/ha in nine-row plots of 4.6 m in length. The rice was grown upland until the 4- to 5-leaf growth stage and then a permanent flood was applied and maintained until maturity. A randomized complete block factorial design with four replications was utilized in all field experiments. Fertilizer N sources were: i) urea, ii) Agrotain, iii) ammonium sulfate, or iv) Nutrisphere. Fertilizer N rates ranged from 67 to 134 kg N/ha. The N fertilizers were applied to a dry soil surface at 1, 5, and 10 days prior to flooding. Ammonia volatilization of the N fertilizers was measured in the field and/or laboratory utilizing static chambers in a randomized complete block experimental design with three or four replications. At maturity, the plots were harvested with a small plot combine. Statistical analyses were conducted on grain yield and ammonia volatilization data with SAS and mean separations were based upon protected LSD where appropriate.

Ammonium sulfate followed closely by Agrotain lost the least amount of N via ammonia volatilization of the four N fertilizers studied. Urea and Nutrisphere lost significantly more N via ammonia volatilization compared with Agrotain and ammonium sulfate. There was no significant difference between urea and Nutrisphere in the amount of N lost via ammonia volatilization at 1 and 15 days after application, but Nutrisphere did lose significantly more N via ammonia volatilization compared with urea at 7 and 11 days after application. When urea was the N source, rice grain yields were the highest when urea was applied 1 day before flooding and steadily declined as the flood was delayed to 5 and then 10 days after urea application. When the flood was established 1 day after N fertilizer application, all the N fertilizers resulted in rice yields similar to urea. When the flood was delayed until 5 and 10 days after N application, ammonium sulfate and Agrotain produced yields significantly higher than urea and similar to when the N fertilizers were applied 1 day prior to flooding. Rice yield significantly decreased when Nutrisphere and urea were applied 5 and 10 days prior to flooding compared with when they were applied 1 day prior to flooding. The rice grain yields produced within each application time were similar when urea and Nutrisphere were the N sources. In conclusion, the data indicates Agrotain significantly inhibited ammonia volatilization of urea while Nutrisphere did not inhibit ammonia volatilization of urea and, at times, appeared to enhance the loss process. Ammonium sulfate resulted in the least loss via ammonia volatilization over the measurement periods. If a flood can be established across a field in less than 3 days, urea can be the N source, but if a field requires more than 3 days for a flood to be established, Agrotain or ammonium sulfate should be utilized. The ammonia volatilization data and the field data indicate Nutrisphere is not an effective inhibitor of ammonia volatilization of urea.

Soil-Based Nitrogen Tests for Fertilizer Recommendations in Arkansas Rice Production

Roberts, T.L., Norman, R.J., Slaton, N.A., Wilson Jr., C.E., Ross, W.J., and Bushong, J.T.

The face of modern agriculture continues to change due to increased concern over rising production costs and the potential environmental impacts of crop production. Conventional rice production has relied on yield goal estimates for determining nitrogen (N) fertilizer needs, which can often lead to over-fertilization of crops and potentially higher impacts on the surrounding environment. Nitrogen fertilizer recommendations in rice have traditionally been based on yield goal, variety, soil texture, and previous crop, but this approach often leads to either over or under application of N to most commercial fields. Currently, texture is the only soil property taken into account, and it has no predictive ability for a soil's N mineralization potential. Increasing costs of production and environmental concerns have led to the demand for a soil-based N test for rice fertilizer applications. Understanding and estimating the soil's natural ability to supply N during the growing season is an essential step towards insuring the continued profitability and success of Arkansas rice producers.

Recent developments in soil testing, such as the Illinois Soil Nitrogen Test (ISNT) and direct steam distillation (DSD), show promise in their ability to predict soil N availability but have been met with much criticism due to inconsistencies and inability to predict yield in corn. Field experiments were conducted in Arkansas to evaluate the ability of the ISNT, DSD, and Total Nitrogen (TN) to predict N response characteristics in rice under conventional soil sampling depths (0-15 cm). Nitrogen response trials were planted at several locations throughout the state over a 3-year period. Field trials were randomized complete block designs with four replications and fertilizer rates ranging from 0 to 202 kg N/ha as a split application. During the early stages of development, a trend between relative grain yield and ISNT and DSD were found but with coefficients of determination <0.50. Sampling 15 cm deep was not providing the information necessary to develop a successful soil-based N test and a new sampling procedure was incorporated. Soil cores were taken in 15-cm increments to a depth of 60 cm and analyzed using either the ISNT, DSD, or TN. Percent relative grain yield was regressed against the average soil test value for each depth (0-15, 0-30, 0-45, and 0-60 cm). Calibration of the soil-based N tests was achieved by comparing the N rates to achieve 95% relative grain yield against the average soil test value for each depth (0-15, 0-30, 0-45, and 0-60 cm).

Currently, 17 site-years of data have been collected within the state of Arkansas on silt loam soil, including two sites that did not respond to N application. Initial results show a strong correlation between percent relative grain yield and ISNT and DSD at the 0- to 45-cm depth. The coefficients of determination increased for percent relative grain yield and N rate to give 95% relative grain yield as depth increased to 45 cm but then dropped significantly at the 0- to 60-cm depth. The predictive value of TN for use in N fertilizer application also increased with depth but did not result in coefficients of determination as high as either the ISNT or DSD. These results suggest that sampling depth can play a major role in a soil test's ability to predict potentially mineralizable soil N and its ability to predict agronomic factors such as grain yield. The plant's ability to access mineralized N plays an important role in the success of a soil-based N test and should be taken into consideration when determining sampling depth protocol.

Annual Potassium Fertilization Influences Rice and Soybean Yields and Soil-Test Potassium

Slaton, N.A., DeLong, R.E., Norman, R.J., Wilson, Jr., C.E., and Golden, B.R.

Fertilizer recommendations are often developed from short-term fertilizer rate trials performed across numerous site-years to encompass soils having a range of availability indices (i.e., soil-test) for a specific nutrient. The correlation between soil-test nutrient values and crop growth indicates the soil's need for fertilization and can be calibrated to determine the nutrient rates required to produce near maximal yields. Although such studies are invaluable and appropriate for their intended purpose, long-term fertilization trials are needed to verify the sustainability of soil-test based nutrient recommendations for common cropping systems. Our research objectives were to evaluate how annual K fertilization rate influences 1) rice (*Oryza sativa* L.) and soybean [*Glycine max* (Merr.) L.] yields across time and 2) indices of soil-K availability. The ultimate goal was to verify the effectiveness of K fertilization recommendations and develop guidelines on how rapidly a soil commonly used for rice and soybean production accumulates or becomes depleted of soil K.

A K fertilization trial was established on an alkaline Calhoun silt loam in 2000, cropped to rice, and subsequently rotated between soybean and rice. Four complete rice-soybean rotation cycles have been completed since 2000. Muriate of potash fertilizer was applied annually to the same plots at 0, 28, 56, 84, and 112 kg K/ha from 2000 through 2005 and increased to 0, 37, 72, 112, and 149 kg K/ha during 2006-2007. Crops were established with no tillage in 5 of 8 years to minimize soil disturbance and movement of soil among plots. Soil samples were collected from the 0- to 10-cm depth between February and April each year and extracted with Mehlich-3 and boiling concentrated HNO_3 to monitor exchangeable and exchangeable plus non-exchangeable soil K, respectively. Rice and soybean yields were measured annually and K removal by the harvested rice and soybean grain was estimated using values of 0.30% K for rough rice grain and 1.62% for soybean seed. Net K (net-K) was calculated as the difference between cumulative K removed as harvested grain and applied as fertilizer. The study contained eight replicates of each annual K rate, and yield data were analyzed by year as a randomized complete block design. Trends in soil test and relative yield means across K rates and years were evaluated using linear regression. In the first 2 years plots were cropped to rice, 2000 and 2002, grain yields were not affected by K fertilizer rate, but the lowest numerical yields were always produced by the unfertilized control. In 2001, soybean yields were increased by 6 to 12% by K fertilization. In 2004, the second year soybean was grown, yields were low due to poor stand and drought, and yields were statistically similar among K rates but numerically greater when K fertilizer was applied annually. Thus, for the first two crop rotation cycles, only one soybean crop responded positively and significantly to K fertilization. Beginning with the third rice crop (2004), significant yield increases from fertilization were measured each year. Crop yield increases from K fertilization were 7 to 15% (2004) and 13 to 19% (2006) for rice and 15 to 37% (2005) and 38 to 49% for soybean during the third and fourth crop rotation cycles.

The annual K removal among K rates, averaged across years by crop, ranged from 23 to 25 kg K/ha for mean rice yields of 7,600 to 8,500 kg/ha and 44 to 56 kg K/ha for mean soybean yields of 2,700 to 3,500 kg/ha. The average annual K removals approximate the rate of K fertilizer needed to balance K inputs and removals from harvested grain and suggest soil K would decrease for annual rates ≤28-37 kg K/ha and increase at greater rates. Soil samples collected in late winter 2007 were used to evaluate the influence of annual K fertilization on soil K pools and determine the rate of soil K accumulation and depletion by the first seven rice and soybean crops. Mehlich-3 and HNO_3 extractable K increased linearly as the average annual K rate increased. Mehlich-3 K ranged from 65 to 96 mg K/ha and HNO_3 K ranged from 270 to 355 mg K/kg for soil receiving annual rates of 0 to 112 to 149 kg K/ha, respectively. Exchangeable K changed by ±1 mg/kg for every 31 kg net-K/ha (slope = 0.0339) and HNO_3 K changed by ±1 mg/kg for every 11 kg net-K/ha (slope = 0.098). Data indicate that building Mehlich-3 K levels on this Calhoun silt loam with initially low soil-test K requires application of high K rates for a number of years. After 7 years of cropping and fertilization, an appreciable amount of the surplus K (i.e., rates greater than crop removal) resided as non-exchangeable K. Conversely, the non-exchangeable and exchangeable K pools declined when K rates were insufficient. Intensive cropping of silt loam soils requires annual K applications to sustain high crop yields and soil K fertility.

Abstracts of Posters on Rice Culture
Panel Chair: R.E. Plant
Poster Session Chair: C.A. Greer

Impact of Hurricane Flooding on Low Lying Rice Land in Louisiana

Breitenbeck, G.A., Kraska, J.E., Saichuk, J.K., and Cormier, H.J.

Hurricanes Katrina and Rita came ashore in 2005 accompanied by storm surges that flooded vast areas in the southern parishes with salt water. Flooding was especially severe in the western parishes where the surge from Rita covered rice and sugarcane fields more than 35 miles inland. The amount of salts deposited in fields by the storm surges varied, depending upon numerous factors including the 'saltiness' of the surge and its duration. North of east-west Highway 14, flood waters generally receded within a few days. More south, floods remained for weeks and, in some cases, several months. This was sufficient time for water to deposit a heavy load of salt in the fields.

To assess the impact of coastal flooding on soil salts prior to the 2006 growing season, a survey was conducted. Extension agents and others sampled soils in more than 170 impacted rice fields to a depth of 12 inches. At each site, 10 replicate 1-inch diameter cores were collected in an area ~10 feet in diameter to a depth of 12 inches. Each core was divided into 0- to 3-inch, 3- to 6-inch, and 6- to 12-inch sections to determine vertical distribution of salt in the rhizosphere. The electrical conductivity (EC) in saturated paste extracts, extractable cation (Ca, Mg, Na, K) composition, pH, and chloride (Cl) concentrations were determined for each sample. The sodium adsorption ratio (SAR) was calculated based on relative concentrations of Ca, Mg, and Na. Additional 2-inch diameter cores were collected from 12 sites selected to represent a range in salinity and soil type for use in studies to determine the behavior of salts in these soils.

The salt impact at each site classified into one of five categories based on EC and SAR values. When only the surface 6 inches of soil was considered, the impact at 35% of the sites was classified as 'none,' 19% as 'mild,' 10% as 'moderate,' 30% as 'severe,' and 6% as 'very severe.' Soils at sites where the impact was 'very severe' had SAR values >13, suggesting that they were at risk of structural collapse. At the time of the survey, the surface 6 inches generally contained more salt than the underlying 6 inches. Over time, salts moved both horizontally and vertically. Following a period of drying, salts accumulated near the soil surface, especially on levees and other higher points. Following a rainfall, salts were rapidly leached downward into the subsoil. Studies to determine the relationship between floodwater and soil water salt concentrations indicated that only limited exchange occurred and the amount of salt diffusing into floodwater varied greatly by soil type. Remediation techniques are discussed.

Correlation of Soil-Test Potassium with Grain Yield and Plant Concentration and Uptake of Potassium by Rice

DeLong, R.E., Slaton, N.A., Norman, R.J., Golden, B.R., and Wilson, Jr., C.E.

Potassium (K) is taken up by rice (*Oryza sativa* L.) in greater quantities than all other essential nutrients except nitrogen (N). Crops grown on low cation exchange capacity soils are known to respond positively to K fertilization. Farmers depend on accurate soil-test based fertilizer recommendations to ensure that soil productivity is maintained and near maximal crop yields are produced. Our research objectives were to i) develop a database of rice response to K fertilization across a range of soil-test K values to delineate the correlation between soil-test K and rice growth and yield parameters, ii) develop diagnostic whole-plant K concentrations for identifying K-deficient rice plants near the panicle differentiation (PD) and early heading (EH) stages of growth, and iii) calibrate the K fertilization rate needed to produce near maximal grain yields for different soil-test K levels. The first two objectives will be the focus of this presentation.

Potassium fertilization trials were established at 31 site-years having silt loam soils between 2004 and 2007. Muriate of potash was applied at rates ranging from 0 to 149 kg K/ha (0 to 160 lb K_2O/A) and other nutrients (i.e., Zn, P, and N) were applied as needed to insure they were not limiting rice growth or yield. A composite soil sample was collected (0- to 10-cm depth) from the unfertilized control of each replicate (n = 4-7) at each site and extracted with Mehlich-3 and boiling 1M HNO_3 to determine exchangeable and exchangeable plus non-exchangeable K concentrations, respectively. Whole aboveground biomass samples were collected near the PD and EH growth stages, dried, weighed, ground, digested with concentrated HNO_3 and 30% H_2O_2, and K concentrations determined by inductively coupled plasma spectroscopy. Grain yield was measured at maturity and converted to percent relative yield by dividing the unfertilized control yield by the highest yielding treatment receiving K fertilizer. Linear and non-linear regression analyses were used to characterize the relationship between soil-test K and rice yield, K concentration, and total-K uptake of the unfertilized control.

Boiling HNO_3 extractable K (exchangeable + non-exchangeable K) was significantly and non-linearly correlated ($P<0.10$) with relative rice yield but explained only 32% of the yield variability among sites. Mehlich-3 extractable soil K was also positively correlated with relative grain yield of rice receiving no K and explained 47% of the variability in relative rice yields among sites. Relative yield increased non-linearly as Mehlich-3 K increased with predicted relative yields of 90 and 95% occurring at 84 and 104 ppm, respectively. The intercept (42.5) and linear (0.81) and non-linear (-0.0029) coefficients were all statistically significant ($P<0.05$). Positive and significant yield increases to K fertilization were measured at 13 of 15 site-years when Mehlich-3 K was ≤84 ppm and at 2 of 8 site-years when soil test was 85 to 104 ppm. Positive yield increases from K fertilization did not occur at 7 site-years having soil-test K>104 ppm and ranging from 116 to 164 ppm. Relationships between Mehlich-3 K and whole-plant K concentrations at PD and EH were significant and linear. Mehlich-3 K explained 72 and 82% of variation in tissue K at PD and EH, respectively, among sites indicating that soil-test K is a very good parameter for estimating soils that may potentially produce rice plants with deficient K concentrations. Whole-plant K concentrations at PD and EH were also significantly related to relative rice yield. At PD, relative yields increased linearly ($r^2 = 0.42$) as plant K concentration increased, but relative yields increased non-linearly ($r^2 = 0.52$) as EH plant K concentrations increased. The critical whole-plant K concentrations needed to produce relative yields of 90 to 95% ranged from 1.8 to 2.3% at PD and 1.1 to 1.4% at EH.

The defined relationships have been used to develop soil-test based K-fertilizer recommendations for rice in Arkansas using the Mehlich-3 extractant. Soil-test K concentrations <90 ppm are considered ‘Low’ and/or ‘Very Low’ and nearly always require K fertilizer to maximize rice yield potential. Soils with 91 to 130 ppm soil-test K are considered ‘Medium’ since they sometimes respond positively to K or require annual K application to maintain soil productivity and soil-test K level. Soils testing >130 ppm are considered ‘Optimum’ and receive no recommendation for K fertilization. Critical whole-plant K concentrations are being used to diagnose K nutrition-related maladies that occur during the growing season.

Evaluation of Tillage and Rotation System Effects on Rice Yield and Selected Chemical and Physical Properties: First Three Years

Harrell, D.L. and Bond, J.A.

Reduced tillage systems have been widely used in upland cropping systems throughout the United States in an effort to reduce nutrient laden sediment losses from agricultural fields, improve soil tilth, improve nutrient use efficiency, and reduce overall production costs. Nonetheless, conventional tillage has traditionally been the most popular tillage system in Louisiana rice production. However, reduced tillage systems have been on the rise in Louisiana rice production. In fact, early estimates from the 2007 growing season in Louisiana indicate that approximately 42% of the planted acreage was planted using some form of conservation tillage practice. One additional advantage reduced tillage provides over traditional tillage is the ability for a farmer to enter fields and plant in a timelier manner. This is a particular advantage in the Gulf Coast rice production areas where earlier planting provides a longer growing season that, in turn, increases the potential success of the ratoon rice crop. Crop rotations have also been shown to have a considerable yield impact over non-rotated crops in upland systems. Crop rotations have also been attributed with positive changes in soil chemical and physical properties. The interaction of tillage and crop rotations on subsequent crop yields and changes to soil properties have been investigated extensively in upland cropping systems. However, little research in the past has focused on common rice rotation and tillage system effects on rice yields and soil properties. This lack of knowledge has increased the importance of conducting both basic and applied tillage and rotation research for low land rice cropping systems. The objectives of the following study are to 1) evaluate rice yield changes associated with common tillage and crop rotation systems and 2) evaluate annual changes in selected soil physical and chemical properties under differing tillage and rice rotation systems.

A long-term crop rotation study was established in 2005 at the LSU AgCenter's Rice Research Station South Farm located just south of Crowley, Louisiana. Rice rotations included in the study were: rice-rice, rice-soybean, rice-grain sorghum, and rice-fallow. Two tillage systems, no-till and conventional till, were included in the study. The experimental design was a split-plot with tillage as the main plot and crop rotation as the sub-plot. The rice cultivar Cheniere was used in all years. All crops were drill-seeded into a Crowley silt loam soil (fine, smectitic, thermic Typic Albaqualfs) at recommended seeding rates and were managed using recommended cultural and fertility management practices. Data obtained from the trial include grain yield (all crops), plant height, days to 50% heading, Mehlich III soil test extractable nutrients (Ca, Cu, Mg, P, K, Na, S, and Zn), soil pH, soil organic matter (OM), total soil nitrogen (N), total soil carbon (C), and soil bulk density (P_d). All soil properties were determined biannually, prior to planting and post harvest.

Initial soil test results revealed that no differences in soil chemical and physical properties existed prior to establishment in 2005. Mean rice yields during the first year were statistically similar, averaging approximately 8,960 kg/ha. In 2006, the rice grain yields from the rice-rice rotation were approximately 6,331 and 6,129 kg/ha for the no-till and conventional tillage systems, respectively. During the third year of the trial, crop rotation did not have a significant yield effect at α=0.05 level of confidence. However, the main effect of tillage was statistically significant (P=0.009), with no-till (7,936 kg/ha) out yielding conventional tillage (7,427 kg/ha). A rotation by tillage interaction was not seen. Also during the third year, OM was significantly lower in the conventional tilled (19.0 g/kg) compared with the no-till (21.0 g/kg). Initial spring soil testing indicated that total soil N was higher in no-till (16.0 g/kg) compared with conventional tilled (15.1 g/kg) rice.

Conservation tillage practices, when carefully managed, can provide similar or even enhanced rice yields as compared with traditionally tilled seedbeds in southern rice producing areas. Additional improvements in soil nutrients and properties, such as total N and OM, over time can also be realized. Further research is needed in the area of rotation and tillage system interactions in southern rice production systems.

The Use of Sub-Surface Drip Irrigation for Rice

Medley, J.C. and Wilson, L.T.

The increased demand for water from cities and industries is a growing concern for the Texas rice industry. Because of this, it has become important to develop more efficient irrigation practices. An experiment was conducted, with the cooperation of NetafimUSA, to determine the feasibility of using sub-surface drip irrigation for rice crops. A 2-year large-scale sub-surface drip irrigation study was conducted in 2006 and 2007 at the Texas A&M University Agricultural Research and Extension Center at Beaumont, Texas. The study consisted of four randomized blocks, each with a single sub-surface drip-irrigated plot and a conventional flood-irrigated plot. Plots were approximately 0.46 ha each. The drip irrigation tubing used was Netafim Typhoon 636 with emitters spaced at 45.7 cm. The drip tubing was installed at a 15.2-cm soil depth and 76.2-cm row spacing. The rice variety Cocodrie was drill seeded onto all plots at 67.2 kg/ha on March 8, 2006, and in 2007, the variety Trenasse was drill seeded at 61.6 kg/ha on April 30. Fertilizer and water applications were similar for the 2006 and 2007 growing seasons. Two hundred twenty-four kg N/ha (using Urea) were applied during both seasons, beginning with an aerial application of 56 kg N/ha at planting. On the flood-irrigated plots, the remaining 168 kg N/ha were aerial applied at permanent flood (89.6 kg N/ha) and panicle development (78.4 kg N/ha). The remaining 168 kg N/ha on the drip-irrigated plots were applied through the irrigation system in small amounts beginning at 30 days after emergence and continuing to panicle initiation. The average amount of water applied to each treatment over the 2-year period was 40.4 and 79.8 cm for the drip-irrigated and conventionally flood-irrigated treatments, respectively. Approximately 25 cm more water were applied to the flood-irrigated treatment in 2006 due, in part, to seepage through border levees. Average water savings using the drip irrigation, over 2006 and 2007, was 49%. Average yields for the 2 years were 6,647 and 6,632 kg/ha for the flood-irrigated and the drip-irrigated treatments, respectively. An analysis comparing yields over both years showed no significant difference between treatments, blocks, or years.

Canopy Photosynthetic Rates of Some Commercially Available Hybrid and Inbred Rice Cultivars

Medley, J.C. and Wilson, L.T.

Research has shown that single leaf photosynthesis measurements, in most cases, do not correlate well with dry mass production and grain yields. Problems that exist with single leaf measurements include leaf age and its position within the canopy. Gas exchange rates decline as a leaf ages past full expansion and as it becomes shaded by newer leaves. However, canopy level photosynthesis can represent the entire leaf area and will more closely relate to biomass production. To measure canopy photosynthesis, a chamber was designed and constructed that would utilize the LiCor LI-6400 Photosynthesis Meter (LI-COR, Inc., Lincoln, NE) to measure the gas exchange rates of rice plants in a flooded field. The chamber was constructed of a wood base with four evenly spaced pieces of 0.95-cm (3/8-in.) PVC pipe bent in a 'U' shape that act as 'ribs' for the chamber. The chamber's base measured 0.76 x 2.44 m and enclosed four rows of rice spaced at 17.8 cm. The chamber height was approximately 1.25 m. The chamber was covered with a 3-mil clear greenhouse plastic (AT Plastics, Dura-Film Super 1 UV). Air flow into the chamber was from a Dayton Model 4C445A centrifugal blower. The 15.24 cm blower intake was reduced to 10.16 cm to slow the air flow through the chamber to approximately 0.10 m^3/s. The air intake was approximately 3 m from the surface and consisted of two 10.16-cm 90 degree PVC pipe fittings to form a 'gooseneck,' which is connected to a 1.52-m length of 15.24-cm PVC pipe using a 15.24- to 10.16-cm PVC reducer. An air velocity transducer (Model 8455-6, TSI Inc., Shoreview, MN, USA) measured the amount of air entering the chamber and was recorded by the LI-6400. Air entering and exiting the chamber was sampled by the LI-6400 to determine the CO_2 levels. The difference in CO_2 levels of the air entering and exiting the chamber and the amount of air through the chamber was used by the LI-6400 to calculate the canopy photosynthetic rate. A Vaisala Model HMP50Y temperature/humidity sensor (Vaisala, Inc., Woburn, MA) placed inside the chamber was used to measure chamber temperature and relative humidity. In order to test the chamber's design and functionality, eight identical chambers were constructed and used to measure the canopy photosynthetic rates of eight rice cultivars, four conventional inbred cultivars, and four hybrid cultivars. A gas and analog multiplexer was used to switch between chambers. Data were logged every 30 seconds in each chamber for a 5-minute period before switching to the next chamber. Data were then averaged over the 5-minute period. Sampling periods were for 3 days. Results of a 3-day run conducted June 23-26 showed that the average daytime (PAR>10 µmol/m^2/s) photosynthetic rates were higher for the hybrid cultivars (24.2 µmol CO_2/m^2/s) compared with the conventional inbred (19.45 µmol CO_2/m^2/s). Average daily photosynthetic rates ranged from 17.59 to 30.78 µmol CO_2/m^2/s for the inbred cultivar Banks and the RiceTec hybrid XL-723, respectively.

Responses of Southern Rice Cultivars to Elevated Ultraviolet-B (UV-B) Radiation

Mohammed, A.R. and Tarpley, L.

Depletion of global stratospheric ozone could intensify ultraviolet-B radiation, which can alter rice crop productivity. The objective of these studies was to determine the effects of supplementary UV-B radiation on rice growth, development, and physiology, with special emphasis on screening for UV-B-tolerant rice cultivars. Eight popular southern U.S. rice cultivars were selected for the UV-B screening process. Plants received no natural UV-B radiation due to the UV-absorption characteristics of the greenhouse glass, hence UV-B was artificially supplied by supplemental UV-B lighting. Plants were grown in soil collected from research plots and exposed to UV-B radiation of 0, 8 (ambient), or 16 (high) kJ/m^2/d for 90 days. Significant differences were observed among rice cultivars in sensitivity to increased UV-B radiation (16 kJ). For most of the cultivars, plants grown under a high UV-B treatment showed significant decreases in plant yield, photosynthesis, primary branches on the main-stem panicle, total number of grains, and filled grain weight of the main stem compared with plants grown under UV-B-free environment. However, the magnitude of decrease in the above mentioned parameters varied among the cultivars. In our studies, the hybrids were less sensitive to high UV-B radiation (16 kJ) compared with conventional cultivars.

Regional Assessment of Soil-Based Nitrogen Tests for Rice Production in the Mid-South USA

Roberts, T.L., Norman, R.J., Walker, T.W., Harrell, D.L., and McCauley, G.N.

Increasing nitrogen (N) fertilizer prices threaten the long-term sustainability of U.S. rice production. Soil fertility researchers have searched for a soil-based N test to manage N fertilization for nearly half a century, with few results that could be incorporated into mainstream public or private soil testing laboratories. Residual inorganic N in the form of NO_3^- has often been used to assess the soil N status for several crops, but this method has limitations for rice production as there is little inorganic N remaining in the soil and the potential for loss is extremely high due to denitrification following establishment of a permanent flood. Current N fertilizer recommendations in the Mid-South are based on yield goal, variety, soil texture, and previous crop. Soil texture is the only soil characteristic that is taken into account during N recommendations and has no predictive ability for N mineralization during the growing season. A basic understanding of the organic N fractions that are mineralized during the growing season may shed light on the native soil N supply. Identification of a soil-based N test for rice production will allow more precise application of N fertilizers while utilizing native soil N and lowering the potential environmental impacts due to excessive N application.

Soil testing has developed several methods to predict N availability but with little success. Most methods require rigorous treatments and long hours that poorly correlate to either crop yield or N uptake. Recently, researchers in Illinois developed a test that shows promise in lowering N applications in corn production and has sparked interest in other crops. The Illinois Soil Nitrogen Test (ISNT) quantifies potentially mineralizable N by measuring the NH_4^+ and amino sugars in the soil. This approach has been well correlated to N response trials in corn and has been shown to predict whether or not sites will respond to N application. Following the release of the ISNT, researchers at the University of Arkansas developed an alternative direct steam distillation (DSD) method that gives comparable results to the ISNT. Based on the new developments in soil testing, a multi-state collaboration was proposed to determine the ability of soil-based testing methods to predict rice yield and N uptake, as well as calibrate the soil test for N fertilizer recommendations.

In order to assess the validity of a soil-based N test on a regional level, each rice-producing state in the Mid-South was asked to conduct N response trials based on the current recommendations utilized within their state. Individual states were able to choose the N fertilization application times and rates that best fit their production practices but would provide data to determine if similar responses were seen among states on a wide geographical region. The ability of a soil-based test to predict basic agronomic indices is an important component that must be considered before calibration can be accomplished. The ISNT, DSD, and Total N were the three soil-based tests that were used during the experiment. Correlation of percent relative grain yield and N uptake at 50% heading were chosen to assess the validity of a soil-based N test. Sampling depth is an important component of any soil-based test method. Published literature suggests that rice roots grow as deep as 45 cm so a sampling protocol was designed to sample in 15-cm increments to a depth of 60 cm. Calibration of the soil test was accomplished using regression of the fertilizer N rate (kg/ha) to achieve 95% relative grain yield versus the soil-based test result.

Dissolved Organic Carbon Losses from Rice Production Systems under Various Straw and Water Managements

Ruark, M.D., Linquist, B.A., van Kessel, C., Six, J., Greer, C.A., Mutters, R.G., and Hill, J.E.

Managed wetland ecosystems (including rice agroecosystems) dominate the landscape of California's Sacramento Valley. Historically, rice straw was burned, but since the mid-1990s, most rice straw is incorporated and fields are flooded over winter to promote decomposition. While this practice has improved air quality, some water quality concerns have arisen related to the potential increase in dissolved organic carbon (DOC). Greater quantities of DOC exported into surface waters can affect in-stream biogeochemical processes, and in turn, the quality of drinking water. The objectives of this study were to (1) measure seasonal concentrations and fluxes of DOC from rice agroecosystems and (2) assess how varying straw and water management practices affect DOC losses. At four locations, straw-burned and straw-incorporated fields were monitored between 2005 and 2007. Water samples were collected from field inlets and outlets during winter flooding and growing season flooding. Weirs and pressure sensors were used to estimate drain flow. During the first month of winter flooding, DOC concentrations among all straw-incorporated fields ranged between 35 and 77 mg/L. Burned fields were not typically flooded over winter, but DOC concentrations in runoff ranged between 6 and 14 mg/L. At the onset of drainage during the growing season, DOC concentrations from straw-incorporated fields were larger (two sites) or similar (two sites) compared with straw-burned fields. No practical differences in DOC concentrations were observed later in the growing season. Results indicate that changes in rice straw management have increased annual DOC flux and seasonal DOC concentrations from these managed wetlands.

Nitrogen, Phosphorus, and Potassium Losses from Flooded Rice Fields in Northern California

Ruark, M.D., Linquist, B.A., van Kessel, C., Six, J., Greer, C.A., Mutters, R.G., and Hill, J.E.

Rice production accounts for approximately 200,000 ha of land in California's Sacramento Valley. Dissolved nutrient losses from these flooded fields can have agronomic, economic, and environmental impacts. Increasing nitrogen (N) and phosphorus (P) concentrations in surface waters can cause increase eutrophication and alter natural in-stream processes. Over the past 10 years, management of rice straw has changed from burning to incorporation. While this has likely led to improvements in air quality, little is known regarding its effects on water quality. The overall objective of this study was to determine the effects of straw management on seasonal and yearly N, P, and potassium (K) loading from rice production fields into the Sacramento Valley. Specific objectives were to determine (1) water flux, (2) N loads and flow-weighted (FW) concentrations [as total dissolved nitrogen (TDN), nitrate, ammonium, and organic N), (3) P loads and FW concentrations [as total dissolved reactive phosphorus (DRP) and total P], and (4) K loads and FW concentrations [as dissolved potassium (DK)] from burned and straw-incorporated rice fields. Between April 2006 and April 2007, paired fields (burned vs. incorporated) at four locations throughout the Sacramento Valley were studied. The outlets of each field were outfitted with rectangle weirs and pressure sensors to record water flow. Yearly losses of TDN, DRP, and DK ranged from 0.2 to 8.9, 0.1 to 5.7, and 0.5 to 7.8 kg/ha, respectively. Yearly FW concentrations of TDN suggest that incorporated fields would lose greater amounts of TDN compared with burned fields. However, TDN concentrations were noticeably higher during the winter months for incorporated fields, while burned fields had noticeably lower concentrations. There were no apparent differences in DRP and DK between incorporated and burned fields. Total water losses were significantly and positively correlated with TDN, DRP, and DK losses.

Nitrogen in Surface Water and Silt Loam Soil Cores Following Fertilizer Application and Surface Ponding

Savin, M.C., Tomlinson, P.J., Norman, R.J., Daigh, A., Brye, K.R., and Miller, D.M.

Urea is a commonly used fertilizer in delayed-flood rice production in eastern Arkansas, and its use worldwide has increased dramatically in recent decades. Urea is recommended if a flood can be established immediately following fertilizer application because the movement of urea into soil is critical to retaining N in the terrestrial ecosystem. While under and over-applying N can reduce yields, management factors such as soil moisture at the time of fertilizer application and any delay before flood establishment also affect N losses and, consequently, yields. Thus, while urea is frequently recommended, ammonium sulfate or urea treated with a urease inhibitor such as Agrotain is also recommended, especially if there is to be a delay between fertilization and flood establishment, or if fertilizer is applied to muddy soil. While previous studies have evaluated soil moisture and the timing of N fertilizers in terms of ammonia volatility and influence on grain yield, the objective of these studies was to measure the extent to which surface water ponded on a silt loam soil incorporates N into surface soil cores following application of urea, Agrotain, or ammonium sulfate.

These studies were conducted in 2005 and 2006 using intact 10-cm length Dewitt silt loam soil cores. Fertilizers (90 mg N to approximate 200 kg/ha) were dissolved on the soil surface and Mariotte bottles were employed to continually maintain 5 cm of surface water. Untreated urea, Agrotain, or ammonium sulfate was applied to dry soil, and urea was applied to muddy soil. Controls received no fertilizer. Ponding durations ranged from 0.5 to 12 hours in 2005 and from 12 to 96 hours in 2006. There was either no delay after urea and ammonium sulfate applications or a 5-day delay after urea and Agrotain applications before water was ponded on the soil surface. Surface water and soils, sectioned into 2-cm depth intervals and extracted with 2 *M* KCl, were analyzed for N. Ammonium-N (and nitrate) concentrations were analyzed colorimetrically on a nutrient auto-analyzer and urea N was analyzed colorimetrically using a microplate method.

When there was no delay in establishing a “flood,” ammonium N in soil receiving ammonium sulfate was greatest at the surface 2 cm, decreased with depth, and was not significantly affected by ponding duration. In contrast, in the surface 2 cm of soil amended with urea, ammonium-N concentrations tended to be lower than those measured with ammonium sulfate. However, more N moved deeper into the soil; ammonium-N concentrations at 2 to 4 cm were similar or greater than concentrations at 0 to 2 cm, and N increased with ponding duration at depths below 4 cm. This pattern did not hold if urea was applied to muddy soil; N remained in the surface 2 cm. Measured directly, although decreasing with time, urea N was detected in surface water up to 96 hours after ponding dry and muddy soil. Surface water urea-N concentrations were much higher when muddy soil was ponded.

When there was a 5-day delay before ponding, ammonium-N concentrations in cores receiving urea were greatest at the surface 2 cm of soil and decreased with depth, and little to no urea was measured in surface water or in soil. In contrast, in soil receiving Agrotain with a 5-day delay before ponding, urea was detected in soil up to 48 hours after ponding. After 96 hours of ponding, little urea was measured and ammonium N concentrations were consistent with those measured when untreated urea was applied to soil and ponded immediately.

While urea is expected to move farther into the soil than ammonium sulfate, these results empirically measure the resulting distribution of N, differentiated over intervals of surface water ponding from 0.5 to 96 hours. These results are consistent with previous findings demonstrating N losses when there is a delay between urea application and flooding or if urea is applied to wet soil. Measured urea was in surface water for up to 96 hours after application and immediate flooding. Additionally, when urea is applied to muddy soil, it is not carried into the soil further than 2 cm and higher concentrations remain in the surface water. Nitrogen losses following urea breakdown and greater limitation of N movement into the soil become greater concerns when there is a 5-day delay before the “flood” is established unless a urease inhibitor is used.

Effects of Planting Date and Seeding Rate on Grain Yield and Yield Components of Southern Long- and Medium-Grain Rice

Sha, X., Theunissen, S.J., Henry, B.J., and Linscombe, S.D.

Delayed planting resulted in significant yield loss in rice. Previous research using traditional rice varieties suggested that the yield reduction of late-planted rice was attributed to fewer panicles per unit area and/or smaller panicle size. However, there is no report on late-planting effects on yield components of modern U.S. rice varieties. This study was designed to determine whether some or all yield components are affected by different seeding dates and whether yield loss of late-planted rice can be compensated for by higher seeding rates. Four recently released long-grain varieties (Cocodrie, Trenasse, CL131, and CL151) and two medium-grain varieties (Jupiter and LA2028) were drill seeded at 1x and 1.5x recommended seeding rates in Crowley, LA, in 2007. The three planting dates were March 19, April 20, and May 14. Grain yield and its components, which included panicles/m^2, filled grains/panicle, total grain/panicle, fertility, and grain weight, were measured and compared.

As expected, the May 14 planting had the lowest ($P<0.01$) grain yield at 7.26 t/ha compared with 9.34 and 9.14 t/ha for April 20 and March 19 plantings, respectively. The yield reduction at the latest planting date primarily resulted from a lower number of panicles per unit area, fewer filled grains per panicle, and lighter grain weight. The average number of panicles per square meter was 242, 291, and 326 for the May 14, March 19, and April 20 planting dates, respectively. Rice panicles from the May 14 planting date had an average of 71 filled grains compared with 73 and 79 filled grains for the March 19 and April 20 dates, respectively. The mean grain weight from the May 14 planting was 22.2 mg, while the March 19 planting had the heaviest grain at 25.2 mg. The average number of spikelets per panicle was similar among the three planting dates; however, grain fertility decreased as planting date was delayed. Seed set for the March 19 planting date was the highest at 75.5%, while that for May 14 planting was only 68.8%. The 1.5x recommended seeding rate failed to produce higher grain yields than the normal seeding rate for the May 14 planting date. The 50% of additional seed only added 4.2% more panicles (248/m^2 vs 238/m^2).

Production Economics of Rice Fields Enrolled in the Arkansas Rice Research Verification Program

Mazzanti, R.S., Runsick, S.K., Watkins, K.B., Wilson, Jr., C.E., and Hignight, J.A.

As rice production input costs continue to rise, it becomes difficult for Arkansas rice producers to be profitable. In 1983, the Cooperative Extension Service initiated the Rice Research Verification Program (RRVP) to help address this problem. The program is an interdisciplinary program that stresses intensive management and integrated pest management to maximize returns. The overall goal is to verify that management, according to University of Arkansas recommendations, can result in increased profitability. The objectives of the program 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 levels, and (6) provide in-field training to county agents in rice production practices.

Since 1983, the RRVP has been conducted on 274 commercial rice fields in 33 rice-producing counties in Arkansas. The program has been conducted on 6,406 ha (15,829 A), with an average field size of 23.5 ha (58 A). The Arkansas average rice yield over the last 25 years was 6,463 kg/ha while the RRVP average was 7,326 kg/ha. On average, RRVP fields have yielded 12% higher than the Arkansas state average. In 2007, the RRVP recorded the highest yields in the history of the program, with an average of 9,526 kg/ha. Yields are collected from each field and adjusted to a standard moisture content of 120 g/kg.

In this poster, results from the Arkansas RRVP yields are compared with data obtained from the National Agricultural Statistics Service and costs estimates are generated from the Arkansas Cooperative Extension Service, along with actual production quantities of inputs. Total direct and fixed costs are generated for each farm. Returns vary each year due to harvest price, yields, and costs. While increasing grain yield is a significant means of increasing net returns to producers, effectively minimizing input costs without sacrificing yield is also very important. To accomplish this goal, intensive scouting is used to manage the crop. Treatments for pests are made only when conditions warrant and after other cultural management practices have been implemented to ensure optimum plant growth conditions. With that in mind, pest management and optimum fertility management are often areas where the greatest effects of the program are achieved.

In 2007, the RRVP average input costs for seed, fertilizer, herbicides, fungicides, insecticides, and irrigation were \$710.13/ha while 2006 and 2005 input costs averaged \$702.62/ha and \$761.65/ha, respectively. Over the past 3 years, input costs for irrigation, fungicides, and fertilizer have been decreasing. Managing irrigation use has been a key focus for the RRVP because of rising fuel cost and declining ground water supplies. Fungicide costs have been decreasing but the use of rice varieties susceptible to disease such as blast has also been decreasing. In 2005, approximately 5% of the RRVP fields were planted in hybrid varieties compared with 50% in 2007. This has increased the average seed cost but also has been a factor in higher yields. Since 2005, overall prices and yields have increased while input costs have decreased, therefore generating higher returns for the RRVP fields.

Nutrient Uptake Comparison between RiceTec XL723 and Trenasse

Frizzell, D.L., Dawson, V., Norman, R.J., Wilson, Jr., C.E., Branson, J.D., Roberts, T.L., and Slaton, N.A.

Hybrid rice cultivars have recently been introduced into the southern U.S. rice region. Hybrid cultivars routinely produce higher yields compared with conventional cultivars in research studies and commercial fields, even though less N fertilizer is applied to the hybrids. We questioned whether the hybrids take up less N than conventional varieties, take up fertilizer N more efficiently than conventional varieties, and/or are able to more efficiently take up native soil N than conventional varieties. The question has also arisen concerning other nutrient uptake amounts and concentrations in hybrid rice compared with conventional rice. Therefore, a study was initiated during 2006 to determine nutrient uptake of the conventional rice cultivar Trenasse and the hybrid rice cultivar RiceTec XL723. The study was conducted on a DeWitt silt loam (fine, smetitic, thermic, Typic Albaqualf) and a Perry clay (very-fine, thermic, Chromic Epiaquert) using urea application rates of 0, 101, 134, and 168 kg N/ha and 0, 134, 168, and 202 kg N/ha, respectively. Aboveground plant samples were taken 7 days after beginning internode elongation (BIE + 7 days) and at heading for total dry matter, N concentration, and total N accumulation. Nitrogen concentrations in the rice tissue at midseason and heading were determined with a dry combustion technique using a LECO analyzer and other nutrient concentrations in the rice tissue at heading were determined by digestion of the plant tissue in concentrated HNO_3 and 30% H_2O_2 and analyzed utilizing ICAP. Grain yields were determined by harvesting a 0.92-m wide section of each plot 3.96 m in length using a small plot combine. The study was arranged as a factorial with four replications. Treatment means were compared using Fisher's Least Significant Difference in SAS.

Total N accumulation at BIE +7 days was comparable for each cultivar at the two locations but was generally higher in XL723 than Trenasse at each N rate. Total N accumulation at heading was higher for XL723 than Trenasse within each N rate at both locations. At both locations, XL723 exhibited greater N accumulation between BIE + 7 days and heading compared with Trenasse. Nitrogen concentration at heading increased in both cultivars on both soil types with increased N rate. The N concentration was higher in XL723 compared with Trenasse within each N rate at both locations. Total P accumulation in both cultivars grown on the DeWitt silt loam increased at heading as N rate increased with XL723 having higher P accumulation than Trenasse. The P accumulation patterns between the two cultivars when grown on the Perry clay were similar to the silt loam, did not differ significantly in Trenasse between the 134 and 202 kg N/ha, or in XL723 between 134 and 168 kg N/ha. Total P uptake was higher for XL723 compared with Trenasse within each N rate at both locations. At heading, on the silt loam, the P concentration increased in both cultivars with increased N rate. The exception at this location is a significant decrease in P concentration in XL723 between 134 and 168 kg N/ha. On the clay soil, the P concentration in Trenasse increased as the N rate increased from 0 to 168 kg N/ha and then leveled off as the N rate increased from 168 to 202 kg N/ha. With XL723, the P concentration increased as N rate increased from 0 to 134 kg N/ha but did not differ significantly between 134 and 202 kg N/ha. Generally, rice tissue P concentrations were similar between soil types at each N rate in both Trenasse and XL723. Phosphorus concentration was higher in XL723 compared with Trenasse within each N rate at both locations. Total K accumulation also increased in both cultivars on both soil types with increased N rate. Potassium uptake in Trenasse did not differ significantly between 134 and 168 kg N/ha and 134 and 202 kg N/ha on the DeWitt silt loam and Perry clay, respectively. Total K uptake was higher for XL723 compared with Trenasse within each N rate at both locations. On the silt loam, the K concentration increased in both cultivars between 0 and 101 kg N/ha and remained constant as N rate increased from 101 to 168 kg N/ha. On the clay soil, K concentration increased in both cultivars between 0 and 134 kg N/ha and then remained constant as N rate increased from 134 to 202 kg N/ha. Potassium concentration was higher in XL723 compared with Trenasse within each N rate on both the clay and silt loam soils.

Maximum grain yield was attained on the silt loam soil at 134 kg N/ha for both Trenasse and XL723 and 134 kg N/ha for Trenasse and 202 kg N/ha for XL723 on the clay soil. As seen in previous studies, XL723 achieved a significantly higher maximum grain yield compared with Trenasse at both locations. This study year suggests that XL723 does have greater ability for N, P, and K uptake compared with Trenasse. The increased nutrient uptake may then contribute to the higher grain yields that are generally seen with hybrid rice cultivars compared with conventionally bred cultivars.

Utilization of On-Farm Testing to Evaluate Performance of Rice Cultivars

Branson, J.D., Frizzell, D.L., Yingling, J.A., Parsons, C.E., Wilson, Jr., C.E., Cartwright, R.D., Runsick, S.K., Gibbons, J.W., and Norman, R.J.

Rice diseases continue to reduce yield, milling quality, and profit in Arkansas rice production. Cultivar choice is the first line of defense against disease, and the correct choice will result in less production cost and higher profits to the grower by minimizing disease problems. Diseases are greatly influenced by the environment as well, and rice is grown in dozens of field situations around the state. This makes information on cultivar performance across multiple environments very valuable. Other factors besides disease are also important in determining the yield potential of a rice cultivar in a particular setting, thus performance evaluation across many environments is an important program.

The Disease Monitoring Program (DMP) was initiated in 1995 with three main objectives. First, by growing several rice cultivars in various farm environments, Extension specialists can monitor the disease pressure in the different regions of Arkansas. Secondly, these cultivars also may be exposed to various diseases that are not commonly observed on Experiment Stations. Lastly, this program provides additional yield potential comparisons that help support expected performance from a particular cultivar.

Tests typically consist of 20 to 25 cultivars annually. Cultivars entered into the study include the most commonly grown cultivars, brand new cultivars, and advanced experimental lines. Rice cultivars are planted in 8-row (17.8 cm spacing) x 7.62 m long plots and replicated three times in a randomized complete block design. Conventional cultivars are planted at a seeding rate of 36.4 kg/ha while all hybrids are planted at 16 kg/ha. Plots are established in grower fields selected by the local county agent and managed by the grower with the rest of the field with respect to fertilization, irrigation, weed, and insect control. In general, plots do not receive a fungicide application. Plots are inspected periodically for disease and other problems and then harvested at maturity with yield adjusted to 12% grain moisture. Data are analyzed using analysis of variance with means separation using a standard LSD test.

The tests are conducted at 15 to 20 sites annually. Beginning in 2007, an additional five locations were dedicated to only Clearfield cultivars. Under normal conditions, tests do not receive applications of imazethapyr (Newpath) herbicide labeled for Clearfield rice. However, these five locations that consisted of only Clearfield cultivars were planted in Clearfield rice fields. These tests received two applications of Newpath and one application of imazamox (Beyond) that are typical for Clearfield rice fields. Application of these herbicides allows evaluation of cultivar tolerance and, hopefully, provides advanced knowledge of cultivars that may not have complete resistance.

Abstracts of Papers on Rice Weed Control and Growth Regulation
Panel Chair: A. Fischer

Herbicide Options for Glyphosate-Resistant Soybean Control in Rice

Bond, J.A., Walker, T.W., Buehring, N.W., and Vaughn, L.C.

Glyphosate resistance is a growing problem in Midsouth row crop production and is now beginning to impact rice production in the region. Volunteer glyphosate-resistant soybean (*Glycine max*) has been a problem in Mississippi rice production for a number of years, and this weed is becoming increasingly troublesome. A number of factors have contributed to the prevalence of glyphosate-resistant soybean as a weed in Mississippi rice production. The majority of rice in Mississippi is grown in rotation with glyphosate-resistant soybean, predisposing rice to problems with volunteers whose seed over-wintered from the previous year's soybean crop. Mild, dry conditions during the winter months stimulate early spring emergence of glyphosate-resistant soybean. Finally, there is a limited amount of burndown herbicide options for use in rice. Research was initiated in 2007 at the Mississippi State University Delta Research and Extension Center in Stoneville to (1) evaluate volunteer glyphosate-resistant soybean control and rice tolerance to herbicides applied at planting and (2) determine the efficacy of in-season rice herbicides against volunteer glyphosate-resistant soybean.

At-planting treatments targeting volunteer glyphosate-resistant soybean included the maximum labeled rate and one-half the labeled rate of three burndown herbicides. Paraquat (Gramoxone Inteon) at 1.05 and 0.53 kg ai/ha, glufosinate (Ignite) at 0.59 and 0.30 kg ai/ha, and thifensulfuron plus tribenuron (Harmony Extra) at 0.021 and 0.01 kg ai/ha were applied to volunteer glyphosate-resistant soybean in the V3 growth stage. Glufosinate is not currently labeled for burndown in rice, and thifensulfuron plus tribenuron received labeling, allowing application at planting in 2007. Control was visually estimated at 7, 14, 21, 28, and 56 days after treatment (DAT). Both rates of paraquat and glufosinate at 0.59 kg/ha controlled volunteer glyphosate-resistant soybean >94% at all evaluations. Control with glufosinate at 0.59 kg/ha was greater than that with glufosinate at 0.30 kg/ha at 7, 14, 21, and 28 DAT. Both rates of thifensulfuron plus tribenuron were less effective than paraquat and glufosinate at all evaluations. Furthermore, thifensulfuron plus tribenuron applications caused rice injury at all evaluations and delayed rice maturity. Rice yields following both rates of thifensulfuron plus tribenuron were lower than rice yields following both rates of paraquat and glufosinate at 0.59 kg/ha.

In-season herbicides targeting volunteer glyphosate-resistant soybean were also applied at the maximum labeled rate and one-half the labeled rate. Treatments included propanil (Super Wham) at 4.48 and 2.24 kg ai/ha, bispyribac (Regiment) at 0.038 and 0.019 kg ai/ha, penoxsulam (Grasp) at 0.049 and 0.025 kg ai/ha, halosulfuron (Permit) at 0.071 and 0.035 kg ai/ha, and triclopyr (Grandstand) at 0.43 and 0.21 kg ai/ha applied to volunteer glyphosate-resistant soybean in the V3 growth stage. Control was visually estimated at 7, 14, 28, and 56 DAT. At 14 DAT, the higher rates of all herbicides provided greater control than half rates. With the exception of halosulfuron, all herbicides controlled volunteer glyphosate-resistant soybean at least 81% 14 DAT when applied at the maximum labeled rate. By 28 DAT, control with both rates of bispyribac, penoxsulam, halosulfuron, and triclopyr was at least 97%. Propanil at 4.48 and 2.24 kg/ha controlled volunteer glyphosate-resistant soybean 88 and 73%, respectively, 28 DAT. By season's end, rice yields following all treatments were equivalent and ranged from 7,830 to 8,770 kg/ha.

Results from 2007 indicate that volunteer glyphosate-resistant soybean can be effectively managed with at-planting or in-season herbicide applications. Among herbicides currently labeled for application at rice planting, paraquat would be preferred over thifensulfuron plus tribenuron for optimizing volunteer glyphosate-resistant soybean control and rice yield. For in-season applications, bispyribac, penoxsulam, and triclopyr are the best options for season-long volunteer glyphosate-resistant soybean control.

Permit and Strada Tank-Mixes for Conventional and Clearfield Rice Programs

Bullington, J.A., Smith, K.L., Burgos, N.R., and Meier, J.R.

Barnyardgrass and hemp sesbania are major weed problems in Arkansas rice production. This study was designed to evaluate the efficacy on barnyardgrass and hemp sesbania of Permit (*Halosulfuron*) and Strada (*Orthosulfamuron*) in tank-mixes for conventional and Clearfield rice. Three field trials were established in a randomized complete block design with four replications at Rohwer, AR, on a Sharkey clay soil. Trials 1 and 2 were planted with CL161 variety, and Trial 3 was planted with Wells variety; all three trials were planted at 100 kg/ha. All trials were managed according to the University of Arkansas Cooperative Extension Service recommendations for this location. All plots were 1.9 m wide by 7.6 m long on 19-cm spacing (nine drilled rows). Treatments were evaluated 7, 14, and 21 days after each application.

In Trial 1: (1) Command (0.56 kg A/ha) applied PRE followed by Strada (0.0735 kg A/ha) or Permit (0.0347 kg A/ha) applied 4- to 5-leaf and (2) Newpath 1-leaf (0.105 kg A/ha) followed by Newpath (0.105 kg A/ha) + Strada (0.0735 kg A/ha) or Permit (0.0527 kg A/ha) applied 4- to 5-leaf provided season-long control of barnyardgrass. Command (0.56 kg A/ha) applied PRE followed by Strada (0.0735 kg A/ha) applied 4- to 5-leaf provided 53% control of hemp sesbania 7 days after 4- to 5-leaf application and 100% control 21 days after 4- to 5-leaf application. Newpath (0.105 kg A/ha) applied 1-leaf followed by Newpath (0.105 kg A/ha) + Strada (0.0735 kg A/ha) applied 4- to 5-leaf provided 70 % control 7 days after 4- to 5-leaf application and 100% control 21 days after 4- to 5-leaf application. Newpath (0.105 kg A/ha) applied at 1-leaf followed by Newpath (0.105 kg A/ha) + Permit (0.0527 kg A/ha) applied 4- to 5-leaf provided 95% control 7 days after 4- to 5-leaf application and 100% control 21 days after 4- to 5-leaf application. The addition of propanil (3.37 kg A/ha) to any tank-mix applied 4- to 5-leaf stage provided 100% control of barnyardgrass and hemp sesbania 7 and 21 days after 4- to 5-leaf application.

Trial 2: Newpath (0.07 kg A/ha) applied 1- to 2-leaf followed by Newpath (0.07 kg A/ha) applied 4- to 5-leaf provided 100% season-long control of barnyardgrass and 0% control of hemp sesbania. Newpath (0.07 kg A/ha) applied 1- to 2-leaf followed by Newpath (0.07 kg A/ha) + Strada (0.0735 kg A/ha) applied 4- to 5-leaf provided 45% control of hemp sesbania 7 days after 4- to 5-leaf application and 100% control 21 days after 4- to 5-leaf application. Newpath (0.07 kg A/ha) applied 1- to 2-leaf followed by Newpath (0.07 kg A/ha) + Permit (0.0525 kg A/ha) applied 4- to 5-leaf provide 75% control 7 days after 4- to 5-leaf application and 100% control 21 days after 4- to 5-leaf application. The addition of propanil (3.37 kg A/ha) to any tank-mix applied 4- to 5-leaf provided season-long control of barnyardgrass and hemp sesbania.

Trial 3: Strada (0.0735 kg A/ha) or Permit (0.0525 kg A/ha) applied 1 week postflood did not improve control of barnyardgrass or hemp sesbania over the standard applications of Command (0.56 kg A/ha) applied PRE followed by Propanil (4.5 kg A/ha) applied 1- to 2-leaf, which provided season-long control of both barnyardgrass and hemp sesbania.

Combinations of Newpath + Strada or Permit and combinations of Command + Strada or Permit + Propanil were able to provide delayed but season-long control of barnyardgrass and hemp sesbania.

Evaluation of DE-750 (aminopyralid) for Broadleaf Weed Control and Crop Response in Rice

Meier, J.R., Smith, K.L., Bullington, J.A., Doherty, R.C., and Scott, R.C.

Two field studies were conducted in 2007 at the University of Arkansas Southeast Research and Extension Center located in Rohwer, AR, to evaluate weed control and crop response of DE-750 in conventional drill-seeded rice. Wells rice cultivar seed were drill-seeded in nine rows 19.1 cm apart at 101 kg/ha on a sharkey clay soil in a complete randomized block design with four replications in both trials. Plots were 4.2 m wide by 10 m long with 1.6-m allies in Trial 1 and 2.1 m wide by 10 m long with 1.6-m allies in Trial 2. Trial 1 was planted on May 1, 2007, and Trial 2 on May 21, 2007. DE-750 was applied at 0, 17.5, 26.3, and 35 g ai/ha in both trials, and in Trial 1, an additional rate of 70 g ai/ha was included. These treatments were applied as a preemergence (PRE) application tank-mixed with clomazone at 566 g ai/ha in both trials. All applications were made with a CO_2 pressurized backpack sprayer calibrated to deliver 112 L/ ha. Weed control and crop response were evaluated 14 and 21 days after application (DAA) and again prior to harvest and yield was obtained using a small plot combine in both trials. Data were subjected to ANOVA, and means were separated using Duncan's New multiple range test (P=0.05).

Crop injury was not observed from 17.5 and 26.3 g/ha 21 DAA in Trial 2, whereas injury from these rates in Trial 1 was 27.5% and 37.5%, respectively. Injury from 35 g/ha was observed 21 DAA in both trials and was 22.5% in Trial 2 compared with 37.5% in Trial 1. Injury in Trial 1 from DE-750 at 70 g/ha 21 DAA was 87.5%. In the first trial, injury from 17.5 g/ha had diminished by 43 DAA and was only 5% from 26.3 g/ha and 15% from 35 g/ha compared with 67.5% from 70 g/ha. These differences in injury between trials may be attributed to significant rainfall events that occurred for 3 consecutive days after planting in Trial 1, which possibly moved the herbicide into the germination zone causing greater injury. Trial 2 was planted into soil with adequate moisture for germination and did not receive additional water until 4 days after planting. Control of hemp sesbania and morningglory 14 and 21 DAA was consistent between trials and was greater than 90% with all rates of DE-750. By harvest, control of hemp sesbania was 88% or greater and was consistent between rates in both trials. There were no significant differences in yield between 17.5, 26.3, and 35 g/ha within trials. Applications of DE-750 at 70 g/ha in Trial 1 resulted in a significant yield reduction when compared with 17.5, 26.3, and 35 g/ha. DE-750 at rates of 17.5, 26.3, and 35 g/ha provided excellent control of hemp sesbania and morningglory 21 DAA and injury sustained did not reduce yield in either trial; however, in Trial 1 DE-750 at 70 g/ha also provided excellent weed control but did result in greater crop injury and a reduction in yield.

Weed Control in Drill-Seeded Rice with Halosulfuron

Williams, B.J., Godara, R.K., and Burns, A.B.

Field studies were conducted at the Northeast Research Station near St. Joseph, LA, on a Sharkey clay soil in 2005, 2006, and 2007 to evaluate the effects of preplant (PP) and PRE halosulfuron applications on weed control and rice yield. Rice was seeded at 100 kg/ha to plots measuring 2 by 4.5 m. Permanent floods were established 4 to 5 weeks after planting. Nitrogen, in the form of urea, was applied at 126 kg/ha just before permanent flood. At panicle initiation, an additional 42 kg/ha of nitrogen was applied. The experimental design was a randomized complete block with a factorial treatment arrangement. Factor A was application timing (PP and PRE). The PP application was applied 10 to 14 days before planting. The PRE timing was applied immediately after planting. Factor B was halosulfuron rate (25 and 35 g/ha). A control that did not receive halosulfuron PP or PRE was included. The entire test area was treated with 615 g/ha of clomazone applied PRE followed by 28 g/ha of bispyribac plus 25 g/ha of halosulfuron applied 3 days before permanent flood (DBF). Herbicide treatments were applied in 140 L/ha of water using a CO_2 pressurized backpack sprayer. Data were combined across years.

Halosulfuron rate did not affect weed control or rice yield. Rice yield increased 30% when halosulfuron was applied PP and 15% when halosulfuron was applied PRE. These yield increases were likely due to improved early-season broadleaf and sedge weed control. At 3 weeks after planting, hemp sesbania (*Sesbania exaltata* (Raf.) Rydb. ex A.W.Hill), rice flatsedge (*Cyperus iria* L.), and yellow nutsedge (*Cyperus esculentus* L.) control was 75, 95, and 90% when halosulfuron was applied PP. Similarly, hemp sesbania, rice flatsedge, and yellow nutsedge control was 78, 95, and 93% when halosulfuron was applied PRE. While clomazone provided early-season grass control, it did not control sesbania, rice flatsedge, and yellow nutsedge. The 3 DBF application of bispyribac plus halosulfuron controlled all weeds at least 95% at 4, 8, and 12 weeks after permanent flood. In other trials, halosulfuron at 13 and 18 g/ha were less effective than 25 g/ha. Furthermore, the rate response of 25 and 70 g/ha was minimal. Regardless of the halosulfuron rate in these trials and others, a follow-up treatment was required for season-long weed control.

A PRE application of clomazone followed by a POST application for broadleaf weed, sedge, and/or escaped grass control is a common program for controlling weeds in drill-seeded rice. The POST application is generally delayed until just before permanent flood. These data show that allowing broadleaf weeds and sedges to compete until permanent is established can result in significant rice yield reductions.

Annual Weed Control in Drill-Seeded Rice with V-10142

Williams, B.J., Godara, R.K., and Burns, A.B.

Three sets of studies were conducted at the Northeast Research Station near St. Joseph, LA, on a Sharkey clay soil in 2006 and 2007 to evaluate V-10142 for Amazon sprangletop (*Leptochloa panicoides* (Presl) Hitchc.) control in rice. In the first set of studies, two in 2006 and one in 2007, the efficacy of V-10142 applied PRE was evaluated. The experimental design for this set of studies was a randomized complete block. Treatments were 112, 224, 336, and 448 g/ha V-10142. Clomazone at 336 g/ha and thiobencarb at 3.7 kg/ha were included as standards. In the second set of studies, one in 2006 and one in 2007, residual sprangletop control from EPOST applications of V-10142 applied with cyhalofop or bispyribac was evaluated. The experimental design was a randomized complete block with a factorial treatment arrangement. Factor A was cyhalofop or bispyribac. Factor B was V-10142 rate (112, 224, 336 and 448 g/ha). In the third set of studies, one in 2006 and one in 2007, POST activity of V-10142 on sprangletop was evaluated. The experimental design was a randomized complete block with a factorial treatment arrangement. Factor A was application timing (EPOST, MPOST, and LPOST). Factor B was V-10142 rate (0, 112, 224, and 560 g/ha). A sequential application of cyhalofop was used as a standard. In all studies, rice was seeded at 100 kg/ha to plots measuring 2 by 4.5 m. Permanent floods were established 4 to 5 weeks after planting. Nitrogen, in the form of urea, was applied at 126 kg/ha just before permanent flood. Herbicide treatments were applied in 140 L/ha of water using a CO_2 pressurized backpack sprayer. Data in each set were combined across years.

In the first set of studies, 112, 224, 336, and 448 g/ha V-10142 controlled sprangletop 54, 82, 82, and 85% 4 weeks after application (WAA), respectively. Sprangletop control from V-10142 at 224 or more g/ha was comparable with 336 g/ha clomazone (87%) and 3.7 kg/ha thiobencarb (84%). In the second set of studies, sprangletop control 8 WAA from cyhalofop alone was 62%. Control increased to 89% when cyhalofop was applied with 600 g/ha clomazone. Cyhalofop applied with 112, 224, 336, or 448 g/ha V-10142 controlled sprangletop 78, 74, 85, and 85%, respectively. Bispyribac alone did not control sprangletop. Sprangletop control increased from 0 to 47% when bispyribac was applied with 600 g/ha clomazone. When bispyribac was applied with V-10142 at 112, 224, 336, and 448 g/ha V-10142 sprangletop control increased to 53, 71, 80, and 86%, respectively. In the third set of studies, 560 g/ha V-10142 applied EPOST controlled sprangletop 89% 4 WAA, which was equal to the sequential cyhalofop application at 90%. While less effective, the lower rates of 112 and 224 g/ha of V-10142 controlled sprangletop 77 and 82%, respectively. V-10142 was less effective at controlling sprangletop when applied MPOST and LPOST. In fact, sprangletop control from 560 g/ha decreased from 89% when applied EPOST to 69 and 57% when applied MPOST and LPOST, respectively. Sprangletop control from 112 and 224 g/ha of V-10142 applied MPOST or LPOST was less than 50%.

While unexpected, V-10142 demonstrated good sprangletop activity when applied to small sprangletop or before sprangletop emergence. These data suggest that V-10142 may be an additional tool for managing sprangletop in drill-seeded rice.

Evaluation of V-10142 for Weed Management in Drill-Seeded Rice

Godara, R.K., Williams, B.J., and Burns, A.B.

V-10142 (Imazosulfuron), an ALS inhibitor, is being developed by Valent for use in drill- and water-seeded rice. It is reported to provide good post-emergence control of several important broadleaf weeds and sedge. It also suppresses annual grasses, and demonstrates excellent selectivity in rice.

Field experiments were conducted at the LSU AgCenter's Northeast Research Station near St. Joseph, LA, on a Sharkey clay soil in 2005, 2006, and 2007 to evaluate preemergence and postemergence activity of V-10142 against annual weeds in drill-seeded rice. Cocodrie rice was drill seeded at 100 kg/ha to plots measuring 2 by 4.5 m. Permanent floods were established 4 to 5 weeks after planting. Nitrogen, in the form of prilled urea, was applied at 126 kg/ha just before permanent flood. At panicle initiation, an additional 42 kg/ha of nitrogen was applied. A randomized complete block (RCB) design with three replications was used for all the experiments. Herbicide treatments were applied in 140 L/ha of water using a CO_2 pressurized backpack sprayer.

V-10142 showed good preemergence activity on hemp sesbania and Texasweed. V-10142 at 224 g/ha provided above 80% control of both the weeds at 4 weeks after application. EPOST application of V-10142 alone at 224 g/ha provided around 90% control of broadleaf weeds. Bispyribac-sodium at 17.6 g/ha provided good control of hemp sesbania but did not control Texasweed. Tank mixing bispyribac-sodium with V-10142 at 112 g/ha provided 90% or better control of broadleaf weeds. MPOST applications of V-10142, bispyribac-sodium, and their tank mixtures provided very good hemp sesbania control. Texasweed control was not satisfactory with alone applications of the two herbicides. Tank mixtures of bispyribac-sodium and V-10142 provided good control of broadleaf weeds, but higher rates of V-10142 were required as compared with EPOST timings. LPOST applications of V-10142 and bispyribac-sodium provided excellent hemp sesbania control but not Texasweed. Texasweed control was improved with tank mixtures, but higher rates (168 g/ha) of V-10142 were required for 90% or better Texasweed control. At 4 weeks after application, EPOST application of V-10142 at 224 g/ha provided 42 and 92% control of barnyardgrass and Texasweed, respectively; whereas the respective control of these two weeds with regiment applied at 23.5 g/ha was 83 and 76%. Barnyardgrass and Texasweed control with a tank mixture of V-10142 at 112 g/ha and bispyribac-sodium at 23.5 g/ha provided 81 and 93%, respectively.

These studies indicate that V-10142 is very effective against broadleaf weeds when applied preemergence or EPOST but not when applied MPOST or LPOST. Tank mixtures of V-10142 and bispyribac-sodium provide control of both annual grasses and broadleaf weeds in drill-seeded rice.

Effects of Simulated Glyphosate and Imazethapyr Drift on Rice

Hensley, J.B., Webster, E.P., Bottoms, S.L., Atwal, J.A., and Harrell, D.L.

Two studies were conducted at the LSU AgCenter Rice Research Station near Crowley, Louisiana, in 2005, 2006, and 2007 to evaluate the effects of simulated herbicide drift on rice. The experimental design for each study was a randomized complete block with four replications. The herbicides were applied at drift rates of 12.5 and 6.3% of the usage rate of 1.07 kg ai/ha glyphosate (133 and 66 g/ha, respectively) and 70 g ai/ha imazethapyr (8.7 and 4.4 g/ha, respectively). Each application was made with the carrier volume varying proportionally to herbicide dosage based on a carrier rate of 234 L/ha. Treatments were applied at three application timings: the panicle differentiation growth stage, the boot growth stage, and physiological maturity in 2005. A fourth application timing, the 1-tiller growth stage, was also evaluated in 2006 and 2007. Rice plant height and rice grain moisture at harvest and rough rice yield were obtained.

A 66 g/ha application of glyphosate applied to rice at panicle differentiation resulted in a yield 75% of the nontreated. Glyphosate applied at 133 g/ha to rice at panicle differentiation and at 66 g/ha to rice at the boot and 1-tiller timings resulted in yields 54, 54, and 46% of the nontreated, respectively. An application of glyphosate at 133 g/ha to rice at the boot and 1-tiller timings resulted in yields 33 to 36% of the nontreated; however, these yields were not significantly different than those for rice treated with 66 g/ha at the 1-tiller timing. Glyphosate applied at 66 g/ha to rice at panicle differentiation and at 66 and 133 g/ha to rice at boot resulted in rice plant height at harvest 90, 89, and 88% of the nontreated, respectively. Glyphosate applied at either rate to rice at 1-tiller and at 133 g/ha to rice at panicle differentiation resulted in rice plant heights at harvest 84 to 85% of the nontreated; however, this was not significantly different than results observed from either application rate at boot. Averaged across rates, glyphosate applied at 1-tiller, panicle differentiation, and boot resulted in significantly higher grain moisture at harvest, 19.2 to 19.8%, than when applied at maturity, 18.0%. Compared with the nontreated rice grain moisture at harvest, 18.0%, glyphosate applied at 6.6 g/ha resulted in significantly higher rice grain moisture at harvest, 19.2%, when averaged across application timings. Glyphosate applied at 133 g/ha resulted in the significantly highest rice grain moisture at harvest, 20.2%, when averaged across application timings.

An imazethapyr application at 8.7 g/ha at panicle differentiation resulted in a yield 76% of the nontreated. Imazethapyr applied at 4.4 and 8.7 g/ha to rice at 1-tiller and at 4.4 g/ha at boot resulted in yields 45 to 49% of the nontreated. A boot application of imazethapyr at 8.7 g/ha resulted in a yield 31% of the nontreated. Imazethapyr applied at either rate to rice at 1-tiller and boot and at 8.7 g/ha at panicle differentiation resulted in rice plant height at harvest 88 to 91% of the nontreated. When averaged across application rates, an imazethapyr application to rice at boot, panicle differentiation, 1-tiller, and maturity timings resulted in rice grain moistures at harvest of 19.2, 18.3, 18.1, and 17.7%, respectively. The rice grain moisture at harvest for the boot, panicle differentiation, and 1-tiller application timings were not significantly different from each other; however, the rice grain moisture at harvest resulting from a boot application was significantly higher than that resulting from a maturity application.

In both studies, a drift application rate of either herbicide to rice at physiological maturity did not result in any negative impacts on rice plant height at harvest, rice grain moisture at harvest, or rough rice yield. A drift application rate at the boot timing generally resulted in the greatest reduction in yield in both studies; however, a drift application rate at the 1-tiller and panicle differentiation timings also resulted in unacceptable yield losses. These data indicate that herbicide applicators should use caution when applying glyphosate and imazethapyr near susceptible rice.

Salvage Herbicide Applications: How Late is Too Late?

Bond, J.A., Walker, T.W., Buehring, N.W., and Vaughn, L.C.

Most rice yield losses due to weed competition occur within a few weeks of planting. Every year situations arise where early-season weed control programs fail or cannot be sustained until rice is flooded, and weed control after flooding is problematic. Rice producers have historically had few herbicide options for controlling annual grasses once the flood is established. The herbicides that were available possessed small application windows, caused relatively severe rice injury, and provided inconsistent grass control. In recent years, herbicides targeting annual grasses have received labeling for use before or after rice flooding, and these have increased rice producers' options for postflood, or salvage, weed management. Therefore, three studies were conducted to evaluate weed control and rice tolerance to salvage herbicide applications.

The first study was conducted in 2006 and 2007 to determine the rice tolerance and barnyardgrass (*Echinochloa crus-galli*) efficacy of postflood applications of penoxsulam (Grasp), bispyribac (Regiment), and cyhalofop (Clincher SF). Treatments were arranged as a two-factor factorial in a randomized complete block design with four replications. Factor 1 was herbicide treatments, including penoxsulam at 44 g ai/ha, bispyribac at 34 g ai/ha, and cyhalofop at 310 g ai/ha. Factor 2 included three application timings of 1, 2, and 3 weeks after flooding (WAF). Rice injury and barnyardgrass control were visually estimated on a scale of 0 to 100% at 14 and 28 days after the last application (DAT). The number of days to 50% heading was recorded as an estimate of rice maturity. Rough rice yields were adjusted to 12% moisture content. No visual injury was observed at either evaluation. Pooled across application timings, bispyribac and cyhalofop controlled barnyardgrass better than penoxsulam at 14 DAT, but by 28 DAT, barnyardgrass control with bispyribac was higher than with cyhalofop or penoxsulam. Pooled across herbicide treatments, barnyardgrass was controlled best following applications made 1 or 2 WAF at both evaluations. No differences in the number of days to 50% heading were detected among herbicide treatments or application timings. Herbicide treatment did not influence rough rice yield. Rough rice yield was optimized in 2006 following applications made 1 WAF; however, no differences in rough rice yield were detected for application timings in 2007.

In 2007, a second study was initiated to compare the response of six rice cultivars to postflood applications of quinclorac (Facet). Treatments were replicated four times in a randomized complete block design with a factorial arrangement of six rice cultivars and two quinclorac application timings. Cultivars included Cocodrie, Cheniere, CL161, Bowman, Wells, and XL723. Application timings of quinclorac (560 g ai/ha) were 2 and 4 WAF. A nontreated control was included for each cultivar. Rice injury, number of days to 50% heading, and rough rice yield were determined as previously described. Total and whole milled rice yields were determined from a subsample of rough rice collected at harvest. No visual injury was observed for any cultivar. Pooled across cultivar, maturity was delayed 2 days following applications made 2 WAF and 1 day following applications made 4 WAF. Rough rice yields varied among the six cultivars in response to quinclorac applied 2 and 4 WAF. Compared with the nontreated control for each cultivar, only rough rice yields of Wells and XL723 were reduced by quinclorac applied 2 WAF; however, rough rice yields of all cultivars were reduced at least 10% following quinclorac 4 WAF.

Application rates and timings of bispyribac applied to Cocodrie were evaluated in a third study in 2007. The experimental design was a randomized complete block with a factorial arrangement of bispyribac rate (0, 28, and 56 g/ha) and application timing (2.6-, 5.1-, and 7.7-cm internode elongation). Rice injury, number of days to 50%

heading, and rice yield (rough, total, and whole milled rice) were determined as previously described. No negative impact of bispyribac at any rate or application timing was detected. Although producers realize the best time for herbicide application is early in the season before yield-reducing weed competition occurs, postflood herbicide applications are becoming increasingly common. These data indicate that barnyardgrass was effectively managed when herbicides were applied 1 or 2 WAF, but rice yields varied over two years. Bispyribac was safe for application to Cocodrie as late as 7.7-cm internode elongation. However, cultivars responded differently to quinclorac applied postflood, with yield reductions ranging from 8 to 24%. Therefore, even with new cultivars and herbicides available for postflood application, the overall effectiveness of salvage herbicide programs remains inconsistent and dependent on numerous factors.

Penoxsulam and Propanil Interaction on Alligatorweed (*Alternanthera philoxeroides*) Control as Influenced by Temperature

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Studies were conducted in growth chambers to evaluate the effects of propanil on penoxsulam control of alligatorweed under three temperature regimes. Previous field studies indicated reduction in alligatorweed control when penoxsulam and propanil was tank mixed. Sequential applications were also determined to avoid reduced alligatorweed control. Treatments included penoxsualm alone at 0.034 kg/ha, propanil alone at 3.36 kg/ha, penoxsulam + propanil, penoxsulam followed by (fb) propanil 3 days after treatment (DAT), 5 DAT, and 10 DAT applied to 20 to 25 cm alligatorweed. Three day/night temperature regimes included 30^{o}C/25^{o}C, 27^{o}C/18^{o}C, and 21^{o}C/11^{o}C. Treated plants remained in growth chamber up to 10 days after last propanil application then moved to greenhouse.

Percent biomass reduction of alligatorweed at 42 DAT compared with non-treated was greatest at 21/11^{o}C (day/night) compared to 27/18^{o}C and 30/25^{o}C for all treatments including penoxsulam. Penoxsulam + propanil provided less biomass reduction compared to penoxsulam alone at all temperature regimes. At 21 and 27^{o}C, delaying propanil application at least 3 days after penoxsulam provided % biomass reduction similar to penoxsulam alone. At 27^{o}C, delaying propanil application 10 d was required to achieve biomass reduction greater than penoxsulam alone. At 30^{o}C, delaying propanil application 10 d after penoxsulam was required to achieve biomass reduction similar to penoxsulam alone. Absorption and translocation study tracing ^{14}C Grasp indicated by 48 hours after treatment, propanil reduced absorption of penoxsulam into treated leaf of alligatorweed.

This research indicates propanil antagonizes penoxsulam in alligatorweed. Delaying propanil application at least 10 days after penoxsulam is suggested for alligatorweed control in rice. Cooler temperatures require only 3 days delay for propanil application following penoxsulam.

Weed Management in Louisiana Rice

Webster. E.P., Bottoms, S.L., Hensley, J.B., and Atwal, J.S.

A study was conducted at the Louisiana State University AgCenter Rice Research Station near Crowley in 2006 and 2007 to evaluate the potential use of halosulfuron as a preplant burndown, preemergence, and postemergence herbicide. Halosulfuron was applied at 35, 70, and 140 g ai/ha at 14 and 7 days prior to planting (DPP), at planting, and 3 and 5 days after planting (DAP). Control of barnyardgrass (*Echinochloa crus-galli*), broadleaf signalgrass (*Urochola platyphylla*), and Indian jointvetch (*Aeschynomene indica*) was evaluated in 2007, and crop height and crop yield were evaluated in 2006 and 2007.

When halosulfuron was applied at all rates at 14 DPP, barnyardgrass, broadleaf signalgrass, and Indian jointvetch control was 90 to 98% at 11 days after emergence in 2007. When applied at 7 DPP, halosulfuron at 140 g/ha was needed to achieve 90% control of all weeds evaluated. When the application of halosulfuron was delayed to the at planting timing or later, control was 60% or less for all weeds evaluated. Little to no reduction in crop plant height was observed in both years of the study. Crop injury was less than 20% for all rating dates in 2006 and 2007.

Rice yield in 2007 was higher when treated at 14 DPP for all rates of halosulfuron evaluated, and yields were higher when rice was treated with 70 and 140 g/ha at 7 DPP. However, by delaying the applications to an at planting timing or at 3 to 7 DAP, rice yield was reduced. In 2006, a postemergence herbicide program was applied at midseason to control escaped weeds, and rice yields with halosulfuron applied at planting and 3 to 7 DAP were similar to the earlier application timings.

Halosulfuron applied at 35 to 140 g/ha can be safely applied to rice and provide residual and postemergence activity on the weeds evaluated in this study. Data indicate both grass and broadleaf weeds can be controlled with the rates evaluated in this study.

Competitiveness of Creeping Rivergrass in Louisiana Rice Production

Bottoms, S.L., Webster, E.P., Hensley, J.B., and Atwal, J.

Creeping river grass [*Echinochloa polystachya* (Kunth) A.S. Hitch] is an invasive weed in the southern rice producing parishes of Louisiana. Studies evaluating the behavior of creeping rivergrass in the Amazon flood plains have shown it to have highly competitive characteristics. Cultural practices associated with rice and crawfish production in south Louisiana increase the invasive potential of this species. Several studies were conducted to evaluate the competitiveness, assess the biological characteristics, and evaluate herbicide efficacy of creeping rivergrass.

A 3-year field study was conducted to evaluate the growth response of creeping rivergrass to rice density; as well as a 2-year field study to evaluate the growth response of rice to creeping rivergrass density. In the first study, Clearfield CL161 rice was drill seeded at seeding rates of 0, 23, 45, 67, 90, and 112 kg/ha. Creeping rivergrass stem segments were planted at a density of 1 plant/m^2 3 days after rice was planted. Creeping rivergrass was allowed to compete with the rice for the entire season. In the second study, Clearfield CL161 rice was drill seeded at a constant rate of 112 kg/ha and creeping rivergrass was planted at 0, 1, 2, 4, 8, 16, and 32 plants/m^2.

A 2-year growth chamber study was conducted to evaluate the effect of temperature on emergence of creeping rivergrass stem segments. Constant temperatures of 11, 15, 19, 23, 27, and 31°C were evaluated with 14:10h light:dark regime. To evaluate herbicide efficacy on control and germination of creeping rivergrass, a 2-year, two-factor factorial greenhouse study was conducted. Two- to 3-leaf seedlings were treated with either glyphosate, cyhalofop, quinclorac, penoxsulam, imazethapyr, or not treated. Nodes that were produced after the herbicide treatment were recorded and replanted either 2 or 4 weeks after application. Growth parameters and node production were recorded.

Creeping rivergrass biomass (fresh weight and total stem length), stem number, and node production were reduced with all rice planting rates compared with no rice planted (nontreated). Although creeping rivergrass total stem length was reduced in treatments with rice planted, the average stem length of creeping rivergrass did not differ between treatments. In the second study, rice yield and growth were reduced by increasing creeping rivergrass densities. Seedling emergence was reduced 27 to 98% from 23 to 11°C in the constant temperature study. Seedling emergence also was reduced with all herbicide applications except quinclorac.

Gene Flow from Weedy Rice Populations to Cultivated Rice Varies by Plant Type

Shivrain, V.K., Burgos, N.R., Smith, K.L., and Gealy, D.R.

Gene transfer from crops to its weedy and/or wild relatives has been the research focal point during the last decade. Little is known about the rate and consequences of gene transfer from wild or weedy relatives to the cultivated crops. Red rice, a weed that infests ~ 40% of the rice acreage in the southern United States outcrosses with cultivated rice. Our objectives were to quantify the gene flow rate from different types of red rice (male) to cultivate rice (female) and consequently determine the morphology and fitness of resulting F_1 outcrosses.

Field experiments were conducted at Stuttgart and Rowher, AR, in 2006 and 2007. Experiments were laid out in a randomized complete block design with three to four replications. Twelve red rice accessions (7 strawhull, 3 blackhull, 2 brownhull) and Clearfield rice cultivar CL161 were used. Twenty-five seeds of an individual red rice accession were planted in the middle row of a 9-row, 5-m long plot, flanked by four rows of CL161 on both sides. Flowering times of red rice and CL161 rice were recorded. At maturity, one row of CL161 on both sides of red rice was harvested, and a sub-sample of 100 g was planted in the field in the subsequent year. Outcrosses resulting from gene transfer from red rice to CL161 were confirmed by DNA analysis. Flowering time, plant height, tiller number, seed production, and seed viability were evaluated in the F_1 plants.

Gene flow rate varied between the two locations, but the trends of the outcrossing rate between CL161 and different red rice types were similar. The highest outcrossing rate (0.2 and 0.06% at Stuttgart and Rohwer, respectively) was observed between CL161 and Phi-1 accession, which was strawhull; whereas the lowest outcrossing rate (0.01%) at both locations occurred between CL161 and Poi-1 accession, which was blackhull. The outcrossing rate varied between and within hull color of red rice accessions that flowered at the same time. In general, the highest outcrossing was observed with brownhull red rice followed by blackhull and strawhull.

F_1 outcrosses between CL161 and all red rice types were uniform in height (145±5 cm). These outcrosses were taller than the CL161 parent and as tall as or taller than their respective red rice parents. All outcrosses had more tillers compared with CL161 parent; however, only 50% of outcrosses had more tillers than their respective red rice parent. The flowering of outcrosses was delayed by 2 to 3 weeks compared with CL161 parent. Seventy percent of the total outcrosses produced seeds equal to the red rice parent and 40 to 50% higher than the CL161 rice parent. Seeds of all the outcrosses were red, pubescent, and shattered at maturity. Seed germination of all the outcrosses was >90%. Gene flow from weedy rice populations to cultivated rice varies by pollen donor plant, and it can produce populations of outcrosses with higher fitness than cultivated rice. This study indicates that strategies for gene flow mitigation from weeds to crops are equally important as gene flow from crops to weeds.

Rising Carbon Dioxide as a Selection Factor in Rice/Red Rice Competition

Ziska, L.H. and McClung, A.

Carbon dioxide (CO_2) is a principle resource for plant growth; as such, the ongoing increase in its concentration may differentially affect the growth of cultivated and wild types of the same species. Red rice in the United States is a weedy relative of cultivated rice that represents a major production constraint in the southern United States. To determine whether recent or projected increases in CO_2 favor cultivated rice or its weedy relative, the initial growth and vegetative characteristics of these two groups were examined using six red rice biotypes (RR) and six commercial varieties (VR) in response to increases in carbon dioxide concentration [CO_2] that correspond roughly to the 1940s, the current [CO_2], and the [CO_2] projected for the middle of this century, (300, 400, and 500 µmol/mol, respectively). Increasing [CO_2] resulted in significant increases in initial leaf area and root weight, but these increases were greater for RR, with significant differences observed as early as 27 days after sowing (DAS) at 500 µmol/mol. By 55 DAS, significant CO_2 by RR/VR interactions were observed for almost all measured vegetative parameters. Overall, these results indicate a greater degree of CO_2 responsiveness among RR as compared with VR. This suggests a greater physiological plasticity and genetic diversity among RR biotypes relative to commercial cultivars that may impact weed/crop competition as atmospheric CO_2 increases. However, this greater variation may also provide a unique genetic resource that could be incorporated into new rice varieties in order to increase their adaptability to climatic change.

Rice Cutgrass: An Emerging Weed in Arkansas Rice

Norsworthy, J.K., Scott, R.C., Smith, K.L., Griffith, G.M., Still, J., and Bangarwa, S.

Rice cutgrass is a perennial, rhizomatous weed that is increasing in occurrence in zero-grade fields where rice is grown continuously. Greenhouse and field trials were conducted to determine what herbicides would provide effective control of rice cutgrass.

The greenhouse trial was a factorial arrangement of 13 herbicides and two application rates applied to 2- to 3-leaf rice cutgrass. Control was visually rated on a 0 to 100% scale at 2 and 4 weeks after treatment (WAT). The herbicides evaluated included thiobencarb, cyhalofop, glyphosate, glufosinate, fenoxaprop, imazethapyr, clethodim, propanil, quinclorac, clomazone, bipyribac-sodium, halosulfuron, and penoxsulam. Adjuvant was applied with each herbicide if needed. A nontreated control was included for comparison.

Two-leaf rice cutgrass was transplanted into plots of drill-seeded rice at 2 plants/m^2 at the 2-leaf stage of rice. Six herbicide programs were evaluated that included herbicide applications at the 3-leaf stage of rice and preflood (6-leaf rice). The herbicide programs included: 1) sequential applications of imazethapyr at 70 g ai/ha, 2) sequential applications of imazethapyr at 105 g/ha, 3) clomazone at 670 g ai/ha + thiobencarb at 4480 g ai/ha followed by (fb) propanil at 4480 g ai/ha + fenoxaprop at 86 g ai/ha, 4) clomazone at 670 g/ha + quinclorac at 560 g ai/ha fb propanil at 4480 g/ha + V-10142 at 11 g ai/ha, 5) clomazone at 670 g/ha + V-10142 at 11 g/ha fb propanil at 4480 g/ha + bispyribac-sodium at 47 g ai/ha, and 6) clomazone at 670 g/ha + penoxsulam at 40 g ai/ha fb propanil at 4480 g/ha + cyhalofop at 313 g ai/ha. Nonionic surfactant was applied with imazethapyr, and crop oil concentrate was applied with all other 3-leaf herbicide tank-mixes. Plots were rated for rice cutgrass control and rice injury prior to flooding and at 1, 4, and 9 weeks after the preflood treatment. Rice grain was harvested at maturity.

In an additional field study, the impact of rice cutgrass interference on rice grain yield was determined. Two-leaf rice cutgrass was transplanted at nine densities at the 2-leaf stage of rice. Aboveground rice and rice cutgrass biomass were harvested at rice maturity. Rice cutgrass shoot density at harvest was determined, and the two species were separated, oven-dried, and rice grain yields determined.

The greenhouse study revealed that rice cutgrass is extremely tolerant to most rice herbicides, including quinclorac, clomazone, propanil, fenoxaprop, thiobencarb, and cyhalofop. Rice cutgrass was completely controlled with the 2X rate of glyphosate, glufosinate, and clethodim. In the field, the first application of imazethapyr provided 50 to 60% rice cutgrass control, but control improved to 100% following the second application, regardless of rate. Clomazone + quinclorac provided 67% control of rice cutgrass prior to flooding; however, subsequent applications of propanil + V-10142 did not further improve control. Propanil + bipyribac-sodium were the most effective postflood tank-mix, resulting in 83% control at 9 WAT. Percentage reduction in rice yield loss increased linearly with increasing rice cutgrass biomass, and a hyperbolic response described yield loss as a function of rice cutgrass shoot density. For each 10 g of rice cutgrass biomass, there was a 1% reduction in rice yield. Rice cutgrass at a density of 100 shoots/m^2 was predicted to reduce rice grain yield 50%. Future research is needed to evaluate tillage, preemergence herbicides, bispypribac-sodium timings, and adjuvants and fall-treatment options following rice harvest for control of rice cutgrass.

Encouraging Rice Recovery from Glyphosate Drift Using Fertilizer

Scott, R.C., Wilson, Jr., C.E., and Bond, J.

Glyphosate drift effects numerous rice fields annually in the mid-south. According to the Arkansas State Plant Board, it was second only to 2,4-D drift on cotton in the total number of complaints filed in 2006. Unfortunately, few recommendations can be made to help a field recover once glyphosate drift occurs. This is especially true when drift occurs after the rice reaches the panicle initiation or "green ring" growth stage. At this later season timing, even a very low dose of glyphosate will cause the production of malformed seed heads and a shortened flag leaf. These malformed seedheads will often emerge even when no vegetative visual injury can be documented. Conversely, glyphosate drift in the early stages of rice development (emergence to first tiller) will often produce typical injury symptoms, including chlorosis and necrotic leaf tips. At this early timing, glyphosate drift will often delay the development of the crop which in-turn delays the establishment of a permanent flood and thereby can often increase production costs. Although 2- to 3-leaf rice can recover from significant injury caused by glyphosate drift and yield a relatively normal yield, some grower loss will likely occur. Treatments or recommendations that could shorten this recovery time would be valuable to producers and to those responsible for the drift injury.

Studies were conducted at three locations in 2007 to evaluate the use of ammonium sulfate (AS) and di-ammonium phosphate (DAP) to aid in rice recovery following a glyphosate drift event. Study 1 was conducted at Lonoke, Arkansas, on a Loring silt loam (Fine-silty, mixed, thermic Typic Fragiudalfs) with a pH of 4.8. Study 2 was conducted on a Hillemann silt loam (Fine-silty, mixed, thermic, Albic Glossic Natraqualfs) near Lake Hogue, Arkansas, with a pH of 7.2. Study 3 was conducted on a Sharkey clay (Very-fine, smectitic, thermic Vertic Haplaquepts) with a pH of 8.0, near Stoneville, MS. These fields were not deficient in any nutrients and were fertilized following University recommendations, with the exception of the treatments made following the simulated glyphosate drift treatments. Studies were conducted using a randomized complete block design with a factorial arrangement of treatments. Factors included cultivar (Wells for both Arkansas locations, Cocodrie in Mississippi, and XP723 at all locations) and fertilizer [0, 112 kg/ha AS, 112 kg/ha DAP, 56 kg/ha AS + 56 kg/ha DAP (0, 100 lb/A AS, 100 lb/A DAP, 50 lb/A AS + 50 lb/A DAP)]. These fertilizer treatments were applied to rice plots that had received [0, 163, or 326 ml/ha (0, 2.2, or 4.4 oz/A)] Roundup WeatherMAX herbicide for the Arkansas studies and [0, 107, 215 ml/ha (0, 1.45, and 2.9 oz/A)] of Roundup WeatherMAX for the Mississippi study. Fertilizer treatments were applied approximately 10 days after the simulated drift. Rice was in the 2- to 3-leaf growth stage at the time of herbicide application. Visual estimates of injury and yield data were obtained.

The degree of glyphosate injury observed varied greatly by location. At Lonoke, little visual injury was observed and the fertilizer treatments did not enhance yields. At Lake Hogue, there was significant herbicide injury, ranging from 11 to 71%. At this location, yield was lowered by glyphosate when applied to Wells at 326 ml/ha (4.4 oz/A). No fertilizer treatments enhanced yield at the Lake Hogue location. Similar visual injury was observed at the Mississippi location; however, the addition of fertilizer did not enhance yields. Yield of XP723 actually increased at this location following the higher rate of glyphosate. In addition to not providing an overall increase in yield, little evidence exists to demonstrate that the addition of fertilizer following a glyphosate drift event will enhance rice recovery. Several factors, including environment, may affect this finding. These studies will be repeated in 2008.

Efficacy of Cyhalafop-Butyl and Quinclorac for Grass Control in Arkansas Rice (*Oryza sativa* L.)

Doherty, R.C., Smith, K.L., Bullington, J.A., and Meier, J.R.

A trial was conducted in 2007 at Rohwer, AR, on a Sharkey clay soil to evaluate grass control in conventional rice (*Oryza sativa* L.) utilizing cyhalafop-butyl and quinclorac combinations. Wells rice was drill seeded at 101 kg/ha in 19 cm rows in an area known to have natural populations of barnyardgrass (*Echinochloa crus-galli*) and Amazon sprangletop (*Leptochloa panicoides*). Rice was planted May 21, 2007, and flood established June 28, 2007 (1 day after herbicide application). Herbicide applications were made at 1- to 3-tiller rice for all treatments.

Barnyardgrass and sprangletop control 6 days after application (DA-A) was 80% or less with all treatments. At 13 DA-A, all treatments provided 98 to 100% control of barnyardgrass, while Amazon sprangletop control was 13% or less with quinclorac at 0.21, 0.277, 0.32, and 0.42 kg ai/ha plus 2.34 L/ha MSO. All other treatments provided 98 to 100% control except for cyhalafop-butyl at 0.28 kg ai/ha, which provided 83%. Cyhalafop-butyl and quinclorac combination treatments all provided 91 to 100% control of barnyardgrass and Amazon sprangletop, while quinclorac at 0.21, 0.277, 0.32, and 0.42 kg ai/ha plus 2.34 L/ha MSO provided 33% or less control of Amazon sprangletop at 22 DA-A. Cyhalafop-butyl at 0.28 kg ai/ha provided 100 and 80% control of barnyardgrass and Amazon sprangletop, respectively. All treatments provided 100% control of barnyardgrass, while Amazon sprangletop control was 100% except for cyhalafop-butyl at 0.28 kg ai/ha, which provided 83 and 30% or less with quinclorac at 0.21, 0.277, 0.32, and 0.42 kg ai/ha plus 2.34 L/ha MSO. Due to timely permanent flood establishment, cyhalafop-butyl at 0.28 kg ai/ha provided 100 and 83% control of barnyardgrass and Amazon sprangletop, respectively 75 DA-A. Grain yield was equal between all treatments.

In conclusion, cyhalafop-butyl alone controlled barnyardgrass and Amazon sprangletop equal to tank mixtures of cyhalafop-butyl and quinclorac. Quinclorac alone controlled barnyardgrass and Amazon sprangletop less than tank mixtures of cyhalafop-butyl and quinclorac.

Abstracts of Posters on Rice Weed Control and Growth Regulation
Panel Chair: A. Fischer
Poster Session Chair: C.A. Greer

Herbicide Options for Ducksalad (*Heteranthera limosa*) Management

Atwal, J.S., Webster, E.P., Bottoms, S.L., and Hensley, J.B.

Ducksalad is a common annual weed in rice fields. Mature plants of ducksalad can be 15 to 30 cm tall, with thick spoon-shaped leaves and a thick waxy cuticle. The leaves can be above or submerged below the water surface. Ducksalad poses problems by competing with rice during the early season in flooded rice fields.

A study was established at the Louisiana State University AgCenter Rice Research Station near Crowley. The experimental design was a randomized complete block with four replications. There were 31 treatments consisting of 14 herbicides. The test area was not planted with rice to ensure a solid stand of ducksalad and to limit interspecific competition. The entire study area was flooded in order to simulate a water-seeded rice production system. Forty-eight hours after initial flooding, the area was drained for 7 days. The initial treatments were applied 6 days after draining to simulate a pegging application (PEG), and the permanent flood was established 24 hours later. Prior to the cotyledon and late postemergence application (LPOST), the area was drained 24 hours prior to treatment and reflooded 24 hours after treatment. The cotyledon application was applied 7 days after PEG (DAPEG) and the LPOST was applied 42 DAPEG.

Imazethapyr, clomazone, and V-10142 controlled ducksalad 91 to 99% at 14 DAPEG. Imazethapyr and V-10142 applied at PEG and cotyledon stage, and bispyribac-sodium and penoxsulam applied at the cotyledon stage controlled ducksalad 88 to 99% at 35 DAPEG. 2,4-D acid, bentazon, bispyribac-sodium, imazethapyr, and orthosulfamuron applied at LPOST and penoxsulam applied at cotyledon and LPOST controlled ducksalad 90 to 98% as compared with less than 78% for all other treatments 49 DAPEG.

This study indicates that clomazone, Imazethapyr, and V-10142 can be applied at PEG to provide early-season control of ducksalad that allows the growth of rice to get an early-season competitive advantage. Late-season applications of 2,4-D acid, bentazon, bispyribac-sodium, imazethapyr, orthosulfamuron, and penoxsulam can be made to control late-season escapes.

Clearfield Rice Hybrids Respond Differently to Late-Season Imazamox Applications

Bond, J.A., Walker, T.W., Buehring, N.W., and Vaughn, L.C.

New Clearfield (imidazolinone-tolerant) rice cultivars (CL161, CL131, and CL171AR) with enhanced tolerance to imidazolinone herbicides have been released in recent years. The enhanced tolerance of these Clearfield cultivars over their predecessors (CL121 and CL141) has contributed to a tremendous increase in hectarage planted to Clearfield cultivars in the Midsouth. Hybrid Clearfield rice cultivars, however, exhibit somewhat lower tolerance to imidazolinone herbicides than the newer inbred Clearfield cultivars. Because of the differences in tolerance, the maximum allowable imazethapyr (Newpath) rate is lower for hybrid Clearfield cultivars than for inbred Clearfield cultivars. Imazamox (Beyond) is currently labeled for application to Clearfield rice following two imazethapyr applications to control escaped red rice (*Oryza sativa*). Imazamox can be applied to inbred Clearfield cultivars as late as 14 days after panicle initiation (PI+14 d), but applications to hybrid Clearfield cultivars are restricted to PI. Research was initiated in 2007 at the Mississippi State University Delta Research and Extension Center in Stoneville to compare the response of three hybrid and one inbred Clearfield cultivars with application rates and timings of imazamox.

The hybrid Clearfield cultivars CLXL729, CLXL730, and CLXP745, and the inbred Clearfield cultivar CL161 were drill seeded on May 1, 2007, at rates of 39 kg/ha for hybrids and 89 kg/ha for CL161. The experimental design was a randomized complete block with four replications. Imazethapyr at 71 g ai/ha was applied to all cultivars in sequential applications when rice reached the one- to two-leaf stage and the one- to two-tiller stage. Treatments included imazamox at 44 and 87 g ai/ha applied at PI and PI+14 d and imazamox at 44 g/ha applied at mid-boot. Crop oil concentrate at 1% v/v was included with all imazethapyr and imazamox applications. Treatments were applied when a majority of plots in the experiment reached the designated growth stage. A nontreated control (no imazethapyr or imazamox applications) was included for each cultivar. Rice injury was visually estimated on a scale of 0 to 100% (0 = no injury and 100 = total plant death) at 14 and 28 days after each imazamox application. The number of days to 50% heading was recorded as an estimate of rice maturity. Rough rice yields were adjusted to 12% moisture content, and whole and total milled rice yields were determined from a subsample of rough rice collected at harvest. Data were subjected to ANOVA with means separated by Fisher's Protected LSD test at P = 0.05.

Visual injury was <3% for all cultivars at each evaluation. No differences in maturity or rough, whole, or total milled rice yields were detected among imazamox treatments for CL161. Maturity and rough rice yields of the three hybrid Clearfield cultivars varied with imazamox application rate and timing. Maturity of CLXL729 was delayed 8 days following imazamox at 44 g/ha applied at mid-boot and 6 days following imazamox at 87 g/ha applied at PI+14 d compared with the nontreated control. Rough rice yield was reduced 21 and 33% for CLXL729 following imazamox at 44 g/ha applied at mid-boot and imazamox at 87 g/ha applied at PI+14 d, respectively. The same application rates and timings of imazamox delayed maturity of CLXL730 and CLXP745 4 and 3 days, respectively. Rough rice yield of CLX730 was reduced following all imazamox treatments except 44 and 87 g/ha applied at PI. Rough rice yield of CLXP745 was reduced 11 to 31% by all applications of imazamox. Total milled rice was not negatively impacted by imazamox treatment for any hybrid cultivar. Only imazamox at 44 g/ha applied at mid-boot to CLXL729 reduced whole milled rice yield.

Hybrid Clearfield cultivars were less tolerant to imazamox than CL161, and the response to imazamox applications varied among hybrid cultivars. Current labeling only allows imazamox at 44 g/ha to be applied at PI to hybrid Clearfield cultivars. However, in commercial fields, variability in growth stages and irregularities in imazamox application may occur that would make treatments in the current research possible under some circumstances. Consequently, red rice populations should be carefully considered when planning where to plant hybrid Clearfield cultivars. Based on these data, inbred Clearfield cultivars should be planted where red rice densities are high and an imazamox application likely will be required.

Response of Rice to Low Rates of Glyphosate and Glufosinate

Davis, B.M., Scott, R.C., and Smith, K.L.

A study was conducted to assess the injury caused by low rates of glufosinate and glyphosate on rice. The experiment was conducted near Lonoke, AR, in 2007. Wells and XP723 varieties were grown using conventional tillage practices. Herbicide treatments consisted of glyphosate applied at 0, 0.13, 0.26, and 0.53 kg ae/ha. Glufosinate was applied at 0, 0.07, 0.15, and 0.31 kg ai/ha. These represent 0x, 1/2x, 1/4x and 1/8x rates, respectively. Treatments were applied at the 3- to 4-lf, ¼-inch panicle initiation (PI), and boot stages using Roundup Weathermax (glyphosate) and Ignite280 (glufosinate). Applications were made using a pressurized CO_2 backpack sprayer with a four-nozzle boom delivering a spray volume of 93 l/ha. The study design was a randomized complete block with four replications. Visual injury, visual stunting, canopy heights (cm) (taken at heading), heading dates, flag leaf length, and days to heading were recorded for all treatments. Yields were obtained using a small plot combine and adjusted to 12.5% moisture.

In general, both varieties responded similarly to glyphosate and glufosinate. Visual injury from the 3- to 4-lf timing for glufosinate ranged from 0 to 83% depending on rate at 2 weeks after treatment (WAT). Glyphosate injury at the 3- to 4-lf timing ranged from 0 to 45% injury. At the PI timing, glufosinate injury ranged from 16 to 78% and glyphosate injury ranged from 5 to 10% at 2 WAT. Injury at the boot timing for glufosinate ranged from 15 to 85%. Glyphosate at the boot timing did not show any increase in injury at any rate. By comparison glufosinate caused 15 to 85% more visual injury at the boot timings than glyphosate.

Canopy height was reduced the greatest when both herbicides were applied at the PI timing. Glyphosate reduced canopy height at the PI timing from 5 to 26 cm. Glufosinate applied at the PI timing reduced canopy heights from 7 to 24 cm. Flag leaf length was not affected by either herbicide when applied at the 3- to 4-lf timing. Glufosinate reduced flag leaf length from 12 to 30 cm when applied at PI. Glyphosate reduced flag leaf length from 3 to 21 cm when applied at PI. Both herbicides did not affect flag leaf length when applied at boot due to the emergence of the flag leaf prior to application. Days to heading were not affected by either herbicide when applied at the 3- to 4-lf timing. However, days to heading was delayed by both herbicides when applied at the PI and boot timings. The greatest delay in heading occurred at the boot timing with glufosinate delaying heading from 34 to 44 days. Glyphosate delayed heading at the boot stage from 27 to 44 days.

Glufosinate applied at 0.31 kg ai/ha reduced the yield of Wells by 37% and XP723 by 29% when applied at the 3- to 4-lf timing. Glyphosate applied at 0.53 kg ae/ha reduced yields at the 3- to 4-lf timing of Wells by 65% and XP723 by 91%. When herbicides were applied at the PI timing, yields were reduced from 9 to 70%. Glufosinate at 0.31 kg ai/ha reduced the yield of Wells by 55% and XP723 by 39%. Glyphosate applied at 0.53 kg ae/ha reduced yields of both cultivars by 70%. Yields were reduced the greatest when herbicides were applied at the boot timing. Glufosinate applied at 0.31 kg ai/ha reduced the yield of Wells by 93% and XP723 by 91%. When glyphosate was applied at 0.53 kg ae/ha, yields were reduce by 93% for Wells and 95% for XP723.

Use of SSR Markers to Discern Reciprocal Outcrossing Rates between Weedy Red Rice Types and Rice Cultivars Having Different Degrees of Flowering Synchronization

Gealy, D.R. and Estorninos, Jr., L.E.

Red rice in southern U.S. rice fields has remained widespread despite recent successes in controlling this con-specific weed in herbicide-resistant rice systems. Outcrossing and gene flow between rice and red rice remain a potential complication for long-term efficacy of these systems. Synchronization of flowering can influence outcrossing rates between rice and red rice. These studies were conducted to determine the effect of flowering synchronization on maximum outcrossing between rice and red rice under field conditions. In 1999 and 2000, commercial rice cultivars with a broad range of flowering dates were grown with Stuttgart Strawhull red rice in drill-seeded field plots (2 m wide by 5 m long and three replications) at Stuttgart, AR. From the earliest to the latest flowering date, these were L204, Jefferson, Kaybonnet, Lemont, and Starbonnet. Stuttgart Strawhull red rice flowered several days before L204 and had an extended flowering period due, in part, to its high tiller production. Rice and red rice plants were grown in adjacent rows (18 cm apart) to ensure maximum outcrossing. Seed from the rice and red rice plants in these plots were harvested separately, and ~4000 to 5000 seedlings per replication were evaluated in the field in 2006 to determine the presence of hybrids that had been formed via outcrossing in 1999 and 2000. DNA samples were obtained from leaves of plants exhibiting the expected phenotype for rice-red rice hybrids (typically tall, late-maturing, ‘bull’ type plants with rough leaves) and were subject to PCR. Five SSR markers (RM5, RM232, RM234, RM253, and RM488) were visualized on an ABI3730 automated DNA sequencer using DNA isolated from leaf tissues and analyzed in Genemapper software. Only plants for which at least four of the five SSR marker profiles were consistent with the rice cultivars and red rice line present in the original plots were considered to be true hybrids. Outcrossing from red rice to rice was greatest for the earliest flowering rice cultivar, L204 (0.25%), which flowered nearly synchronously with the red rice, was intermediate (0.11%) for the intermediate flowering Kaybonnet, and was lowest for the latest flowering cultivar, Starbonnet (0.007%). Outcrossing from rice to red rice was typically much lower than in the reverse direction. In a similar study, red rice and rice plants were grown together in plots as described above, except that 1 to 4 weeks after emergence, Stuttgart Strawhull red rice plants were mowed to ground level. This was done in an attempt to alter red rice flowering dates to the degree that one or more treatments would achieve highly synchronous flowering with Kaybonnet rice, which normally flowers about 2 weeks after Stuttgart Strawhull red rice. These treatments were largely ineffective because mowing up to 4 weeks after emergence delayed red rice flowering no more than 2 or 3 days. Outcrossing from red rice to rice was similar for all treatments and averaged ~0.125%. Outcrossing in the reverse direction averaged only 0.020%. These studies indicate that flowering synchronization between red rice and rice can affect outcrossing rates greatly. Even moderately synchronized flowering periods can result in reduced but sizeable outcrossing rates if red rice begins to flower earlier and has an extended flowering period compared with rice.

Evaluation of Texasweed (*Caperonia palustris*) Emergence and Growth in Response to Shade

Godara, R.K., Williams, B.J., and Burns, A.B.

Texasweed (*Caperonia palustris*) is an annual broadleaved plant belonging to Euphorbiaceae family. Texasweed has existed in the United States as a wetland plant and has not been a major problem in crop production, but lately, it has become increasingly more common in rice, cotton, and soybean fields in the states of Arkansas, Louisiana, Mississippi, and Texas. Experiments were conducted at Northeast Research Station near St. Joseph, LA, to study the effect of shade on Texasweed emergence and growth. Shade levels of 0, 30, 50, 70, and 90% were achieved using with cubical (1.82-m side) shade cloth. The experiments were conducted under field conditions using 3-L capacity plastic pots. The emergence study involved five shade levels: 0, 30, 50, 70, and 90% as treatments and a randomized complete design with four replications and four pots per tent were used. Seventy-five Texasweed seeds were planted 1 cm deep in pots filled with Sharky clay soil taken from a rice field with no Texasweed infestation history. Texasweed emergence was recorded weekly over a 1-month duration. Total emergence was tested for differences using ANOVA. The growth response experiment involved planting 15 seeds per pot. Three uniform sized plants were retained per pot at first thinning (3 days after emergence), which after 30 days of emergence were further thinned to one plant per pot. Treatments for the experiment were different shade regimes obtained by transferring plants (pots) to an increasing shade level every 2 weeks. For plants emerging under 0% shade, the different shade regimes were R1: 0%, R2: 0% - 30%, R3: 0% - 30% - 50%, R4: 0% - 30% - 50% - 70%, R5: 0% - 30% - 50% - 70% - 90% shade. Similarly, there were different shade regimes for plants emerging under 30, 50, 70, and 90% shade. Once transferred to the highest shade level of the respective shade regime (treatment), Texasweed grew undisturbed for the rest of the duration. The experiment was laid out as a randomized complete block design with four replications. Plant height, leaf area, and dry weight were recorded every 2 weeks. Growth parameters for each shade regime were tested for differences using ANOVA.

Texasweed emergence under all shade levels was 60 to 70%, and no significant differences in emergence were observed among various shade levels. Leaf count and dry matter production per plant decreased with increasing shade level. Plant growth in shade regimes starting at 30 and 50% shade was comparable with those starting at 0% shade but was greatly reduced in the case of shade regimes starting at 70 and 90% shade. Plant height was significantly increased in 70% as compared with other shade levels. Maximum canopy width was recorded in plants under 0% shade. Seed production per plant decreased with increasing shade level and was severely affected by 90% shade. These studies indicate that Texasweed emergence is not affected by shade, and it can grow satisfactorily in shade up to 70%.

Effects of Adjuvants on the Efficacy of Penoxsulam and Cyhalofop-Butyl in Southern U.S. Rice

Lassiter, R.B., Haygood, R.A., Mann, R.K., Richburg, R.S., and Walton, L.C.

Studies were conducted across the mid-South rice-growing region from 2005 to 2007 to evaluate various adjuvant systems with Grasp SC herbicide (penoxsulam) in field trials for weed efficacy and crop tolerance. Clincher SF herbicide (cyhalofop-butyl) was evaluated with different adjuvant systems during 2006 in postflood applications. All studies were conducted utilizing typical small plot research methodology.

Adjuvant systems evaluated as tank mixes with Grasp SC were no adjuvant, crop oil concentrate (COC) at 1.25 and 2.5% v/v, methylated seed oil (MSO) at 1.25 and 2.5% v/v, nonionic surfactant (NIS) at 0.5% v/v, and COC + 28% urea ammonium nitrate (UAN) at 2.5% v/v each. Also evaluated in 2006 were several commercially available proprietary adjuvant blends representing MSO + organosilicone surfactant (OSi) at 1 and 2.5% v/v, and MSO + OSi + UAN at 2.5% v/v. These same adjuvant systems were evaluated with Clincher SF during 2006.

Results of these studies with Grasp SC demonstrated better efficacy on barnyardgrass (*Echinochloa crus-galli*), hemp sesbania (*Sesbania exaltata*), and Pennsylvania smartweed (*Polygonum pensylvanicum*) when adjuvant rates are 2.5% v/v; adjuvant rates less than 2.5% v/v were not consistent regardless of the adjuvant type used. Across the years, MSO (2.5% v/v) and COC (2.5% v/v) have been the most efficacious adjuvant systems for use with Grasp SC. Under the more challenging growing conditions (i.e., larger weed size), the use of MSO with Grasp SC has resulted in weed control better than COC. In tank mix studies with Grasp SC and other broadleaf and sedge herbicides, the use of MSO did not increase rice phytotoxicity compared to COC in these tank mixes, except with propanil products. The use of MSO with these tank mixes proved to be more efficacious in many instances than COC.

No adjuvant system evaluated with Clincher SF dramatically improved control of barnyardgrass or *Leptochloa* species over COC at 2.5% v/v. Any of the adjuvant systems evaluated at less than 2.5% v/v with Clincher SF were less consistent with regards to weed control. All COC, MSO, and proprietary adjuvant blends containing MSO that were used at the rate of 2.5% v/v provided equal performance on the grass species.

This research confirms the current label recommendations on Grasp SC and Clincher SF to use MSO or COC at 2.5% v/v for optimum performance. However, MSO appears to be a somewhat better adjuvant system for use with Grasp SC under certain conditions.

The Effect of Phosphorus Fertilizer Placement on Weed and Algae Growth in Rice Systems

Lundy, M., Fischer, A., van Kessel, C., Ruark, M., Pedroso, G., Hill, J.,
Spencer, D., Mutters, R., Greer, C., and Linquist, B.

Weed control is a major challenge in California rice systems. Ninety-eight percent of growers depend on herbicides for weed control, and control via herbicides represents as much as 20% of the overall cost of producing rice. Due in part to the widespread use of herbicides, there are more herbicide-resistant weeds in California rice systems than in any other crop or geographic region in the United States. Thus, greater weed control without an escalation of herbicide regimes could potentially decrease production costs and improve the long-term sustainability of California rice. The effect of fertilizer management practices on weed growth and abundance in California rice systems is not known. The objective of this study was to evaluate the effect of phosphorus (P) fertilizer and its placement in the soil on weed growth, cover, and abundance. Two studies were conducted.

In an on-farm study of 10 fields, the effect of surface applied P to zero P on weed cover at mid-tillering was compared. Depending on the field, in plots with surface applied P there was greater cover of waterhyssop (300%), ducksalad (100%), smallflower (100%), bulrush (90%), watergrass (130%), and redstem (100%) as compared with plots with no P fertilizer. In a controlled pot study, we compared weed abundance and biomass in pots under two water management conditions, flooded and unflooded (to simulate drill seeding), and with three P treatments: zero P, surface applied P, and P buried 2.5 cm. Algae, harvested from the flooded pots 8 days after planting, yielded greater biomass in pots with surface P (100%) and buried P (30%) than in pots with no P.

Weeds were harvested between 21 and 26 days after planting. Comparing weed counts in the two water management systems, in the initial harvest, there were 57% more weeds in the unflooded system than the flooded system, and the dominant weed species varied. In both flooded and unflooded pots, P placement affected weed abundance. Weed counts from the initial harvest in the flooded system resulted in significantly higher percentages of smallflower (257%), waterhyssop (82%), the grouping of ducksalad, monochoria, and arrowhead (150%), and the grouping of redstem and smartweed (363%) in the surface P treatments relative to treatments with zero P. Weed counts in the buried P treatment were between the zero P and surface P treatment counts. With the exception of watergrass, the weed species that responded to P fertilizer in the flooded pots were similar to the weeds observed in the on-farm study, where all the fields sampled were water seeded and flooded. In the unflooded pots, weed counts from the initial harvest resulted in significantly higher percentages of waterhyssop (333%), bulrush (60%), the grouping of ducksalad, monochoria, and arrowhead (140%), and the grouping of redstem and smartweed (185%) in surface P treatments relative to treatments with zero P. As in the flooded system, weed counts in the buried P treatment were between the zero P and surface P treatments. While there were 420% more grasses in the unflooded system than in the flooded system at the initial harvest, P placement had no observable effect on grasses in either the flooded or unflooded system.

In conclusion, the placement of P fertilizer in the soil has a large effect on weed populations based on both pot and field studies. This study has begun to identify which weed species demonstrate a response to P. However, whether these responses are due to germination, vigor, competition, or some combination of these is not clear and should be examined further. Pinpointing the effect of P fertilizer on weed populations has the potential to indicate management practices that reduce weed populations in California rice without an escalation of herbicide use.

Grasp SC Tankmixes for Broad Spectrum Weed Control in Rice

Mann, R.K., Richburg, J.S., Lassiter, R.B., Walton, L.C., Haygood, R.A., and Siebert, M.W.

Field trials were conducted from 2005 to 2007 in the southern U.S. rice growing area to evaluate penoxsulam (Grasp SC herbicide, 240 g ai/l) as a postflood application alone and tankmixed with other herbicides. Postflood applications are defined as applications made after the permanent flood has been established in the rice crop. Postflood applications are necessary to clean up rice fields for harvest when preflood herbicide treatments fail and significant numbers of weeds escape that may negatively impact yield or harvest of the rice crop.

Field trials were conducted in the major rice growing states in the southern United States using standard small plot research techniques and application equipment. Clomazone was applied preemergence at reduced rates of 25 to 50% of the recommended soil rate, and when necessary, propanil was applied postemergence at reduced rates during preflood. These research testing procedures were utilized to ensure weeds were not completely controlled and that weeds were present for the postflood timing application, simulating weed escapes that often occur commercially.

Penoxsulam applied at 44 to 50 gr ai/ha provided barnyardgrass (*Echinochloa crus-galli)* control that was equal to/or greater than cyhalofop-butyl (310 gr ai/ha), propanil + quinclorac (4480 + 560 gr ai/ha), and bispyribac-sodium (30-34 gr ai/ha) applied alone. Tankmixing penoxsulam plus cyhalofop-butyl (310 gr ai/ha), triclopyr (280 gr ai/ha), halosulfuron (26 gr ai/ha), or propanil (4480 gr ai/ha) did not reduce barnyardgrass control. Tankmixing penoxsulam plus bentazone (840 gr ai/ha) or carfentrazone (28 gr ai/ha) resulted in slightly reduced barnyardgrass control. Penoxsulam tankmixed with cyhalofop-butyl provided greater sprangletop (*Leptochloa* spp) control than penoxsulam, quinclorac + propanil, or bispyribac-sodium.

Penoxsulam at 50 gr ai/ha provided hemp sesbania (*Sesbania exaltata*) control that was equivalent to propanil + quinclorac and bispyribac-sodium. Penoxsulam at 44 gr ai/ha tankmixed with triclopyr, quinclorac, halosulfuron, bensulfuron (52 gr ai/ha), carfentrazone, or propanil provided hemp sesbania control equivalent to propanil + quinclorac or bispyribac-sodium. Penoxsulam tankmixed with bentazone caused slight antagonism of hemp sesbania control.

Penoxsulam at 44 to 50 gr ai/ha provided alligatorweed (*Alternanthera philoxeroides)* and smartweed (*Polygonum* spp) control that was equivalent to bispyribac-sodium and greater than quinclorac + propanil. Tankmixing penoxsulam plus quinclorac, triclopyr, or bensulfuron improved alligatorweed control, whereas tankmixing with propanil reduced alligatorweed control. Tankmixing penoxsulam plus cyhalofop-butyl, triclopyr, bentazone, or halosulfuron improved smartweed control, whereas tankmixing penoxsulam with propanil or carfentrazone slightly reduced (5-20%) smartweed control.

Penoxsulam at 44 to 50 gr ai/ha provided eclipta (*Eclipta alba*) control that was equivalent to propanil + quinclorac and bispyribac-sodium. Tankmixing penoxsulam plus quinclorac, triclopyr or halosulfuron resulted in slightly improved eclipta control, whereas tankmixing penoxsulam with propanil resulted in slight antagonism. Penoxsulam at 44 to 50 gr ai/ha provided excellent control of annual flatsedge (*Cyperus irria*), equivalent to quinclorac + propanil and bispyribac-sodium. Only penoxsulam tankmixed with propanil caused a slight reduction (<10%) in flatsedge control.

Rice (*Oryza sativa*) injury from postflood applications of penoxsulam at 1, 2, and 4 weeks after application was less than or equal to the other commercial standards tested (cyhalofop-butyl, quinclorac + propanil, and bispyribac-sodium).

Landscape Analysis and Management Influence over Resistant Echinochloas in California Rice Systems

Marchesi, C.E., Greer, C.A., Hill, J.E., Jasieniuk, M.A., Canevari, M., Mutters, R.G., Plant, R.E., and Fischer, A.J.

Late watergrass (*Echinochloa phyllopogon,* LWG), early watergrass (*E. oryzoides,* EWG) and barnyardgrass (*E. crus-galli,* BYG) are the most competitive and difficult weeds to control in rice. Herbicide resistance in some of these species was confirmed in California in 1998. Resistance results from an evolutionary process in which preexisting mutants are allowed to evolve under selection pressure. Selection pressure is determined by herbicide factors, weed characteristics, and management factors. Resistance can result from a mutation on the herbicide's binding site, from an enhanced ability to detoxify herbicides or impairments to reach the target site. It is crucial to understand not only how resistance evolves but also how it spreads. Resistance can spread with seed dispersal, and seed of these Echinochloas can disperse mainly by water, soil attached to machinery, and birds. Resistance may involve a fitness penalty (lower ecological success) to resistant biotypes when compared with susceptible wild type, although meaningful differences have been reported only in few cases. Establishing fitness differences under specific selection forces would allow designing management tactics to control resistant biotypes.

Factors that shape the incidence, evolution, and spread of herbicide resistance weeds are closely associated with rice management and landscape properties. Crop and herbicide rotation can reduce the selection pressure in favor of resistant mutants. Reducing the densities of weed infestations also diminishes the probabilities of resistant mutants to be found and selected for. This can be achieved through alterations in the recruitment environment with changes in tillage, rice seeding, and water management. Changes in herbicide use or implementations of mechanical control strategies will reduce selection for resistance. The use of high rice quality seed could prevent spreading seed of resistant weeds. In addition to this, landscape properties, like soil characteristics and water source dynamics, can also affect seed dispersal.

Resistance of various Echinochloas to herbicides with different modes of action has been reported in California and worldwide. Further research has shown the prevalence of metabolic cross resistance in California watergrasses, which have evolved and spread differently for each species. While LWG has spread from a single introduction source, resistance may have evolved through the occurrence of independent mutations in EWG. Water-seeding rice on heavy clay soils where crop rotations are difficult to implement has limited the scope of herbicide options available for use in California rice. Moreover, the prohibition of straw burning leads to its incorporation, enriching the weed seed banks. Some alternatives to control weeds are being investigated, such as tillage alternatives and stand establishment methods to break weed cycles, as well as the use of different strategic herbicides. The relative contribution of resistant gene-flow through seed dispersal or the localized evolution through independent mutations to the current resistance spread patterns will affect the success of these mitigation practices. Crop management practices will be more successful in delaying the evolution of resistance where resistance-gene flow through seed dispersal is not the main vector of spread and vice-versa.

Different studies have associated the occurrence of resistance with management practices and the effect of gene flow in the temporal distribution of resistant biotypes. No studies have put together the above mentioned factors, as well as landscape properties, in order to develop an integrative approach. The objective of this study is to establish what is the relative contribution of crop management practices, landscape variables, mechanisms of resistance dispersal and their interactions, towards defining the patterns of resistance currently observed throughout the area where rice is grown in California. The research involves field survey and herbicide screening tests in controlled environment studies. Detailed field histories were collected via written questionnaires, and molecular data is available from previous studies. Fields have been geo-referenced, and all data were loaded into a geographic information system. Statistical multivariate analysis (Log Regression and CART) is used to determine if resistance is associated with specific management practices, landscape variables, and dispersal ability.

California Weedy (Red) Rice

Ortiz, A., Fischer, A.J., Greer, C., Schaal, B., Eckert, J., Osuna, M.D., and Laca, E.

California red rice accessions were characterized molecular and morphologically. In another study, those accessions were compared with cultivated rice (and with red rice from southern United States at the DNA level). Seed characteristics of the weedy rice from California were variable across the different accessions collected, but differ from those of commercial rice varieties. From the molecular study we concluded that California weedy rice may be more related to straw hulled red rice from the southern United States. It also appeared to be genetically distant from other non-weedy red bran rice types found in California.

Penoxsulam Faces Metabolic Resistance in California's Late Watergrass

Osuna, M.D., Yasuor, H., De Prado, R., and Fischer, A.J.

A population of *Echinochloa phyllopogon* with suspected resistance to penoxsulam was found in rice growing areas in California. The ratio (R/S) of the GR_{50} values of the resistant to susceptible plants was 9.8 for penoxsulam. Studies using cyt P450 inhibitors showed that cyt P450 contributed to penoxsulam resistance in R *E. phyllopogon*. ALS assays demonstrated that resistance in R *E. phyllopogon* is not due to reduced ALS sensitivity.

Distribution and Origin of Herbicide-Resistant *Echinochloa oryzoides* in Rice Fields of California

Osuna, M.D., Okada, M., Ahmad, R., Fischer, A.J., and Jasieniuk, M.

To provide insight into the origins and spread of resistance in *Echinochloa oryzoides* (early watergrass), 434 individuals from 23 populations (12 resistant, 11 susceptible) in rice fields across California were genotyped at seven microsatellite loci. Results showed a lack of geographic and population structuring, suggesting that resistant biotypes in California have spread by seed dispersal and by independent mutation events.

Interactions between Rice Straw and Copper: Implications for Algae Management

Spencer, D.F., Lembi, C.A., Liow, P.S., and Lubelski, D.D.

Algae present problems in California rice fields. Growers have reported that algae are less inhibited by copper treatments than previously. Measurements of the copper-binding capacity of rice straw indicate that 25 to 75% of a copper treatment would be bound to straw and, thus, not be available to inhibit algae.

Seed Treatments for Planting Rice into Cool Soil

Tarpley, L. and Mohammed, A.R.

Interest in early planting is increasing among U.S. rice producers. The estimated yield advantage from planting earlier is 280 to 340 kg/ha (250-300 lb/A) per week. With early planting, crop development can often occur before the hottest periods of the season, and the probability of a favorable season for the ratoon crop is increased. However, cool soil temperatures at rice planting can result in poor germination (both the ability to germinate and the rate of germination) and slow seedling growth, sometimes with reduced growth extending into the season. A gibberellic acid seed treatment is commonly used in the southern United States to stimulate seedling vigor for semidwarf rice cultivars. The gibberellic acid treatment, if rates are not controlled carefully, can sometimes lead to tall stemmy seedlings prone to lodging with spring breezes.

The objective of the study was to identify plant growth regulator seed treatments that can increase seed germination without the chance of tall stemmy seedling growth. Two planting procedures were used. In 2006 and 2007, seeds were planted to a 2.5-cm depth into field soil in pots situated outdoors at the Texas A&M Agricultural Research and Extension Center in Beaumont. Plantings were made every 4 to 7 days starting in early February for a number of plantings to promote the chances of at least one planting being subjected to cool soil conditions. The soil temperature at a 2.5-cm depth was monitored throughout the study. In each study, the time to emergence, emergence percentage, plant height, number of tillers, and aboveground dry weight at harvest were recorded. A planting was harvested at a set date. At harvest, most plants had one tiller apparent. The seeds (*Oryza sativa* L. cv. Cocodrie) were treated with a standard seed treatment excluding gibberellic acid. The seed treatment was supplemented with one of the novel plant growth regulators, gibberellic acid, or no added plant growth regulator. Four to five seeds were planted per pot. All seeds in a pot received the same treatment. There were four to six replicate plots per treatment. Treatments were randomized.

In 2007, a device was constructed to provide controlled cooling of the soil. Water chilled to a set temperature is circulated among the pots. The pots were constructed from material that transmits heat easily, but not carbon dioxide or oxygen. This allowed the soil temperature to be controlled without drastically altering its redox potential. The apparatus was situated in the greenhouse to avoid air temperature effects. The three soil temperatures were 10°C (50°F), 16°C (60°F), and ambient.

In 2006, ten seed treatments were evaluated, with five retained for additional testing. In 2007, another treatment was eliminated because of inferior seedling phenotype (too tall). Four novel seed treatments have been identified that provide higher and more consistent germination rates, while also providing at least as much leaf and tiller development and plant biomass but a shorter seedling relative to gibberellic acid treatment when seeds were planted into soil with an average 3 AM soil temperature of 10°C (50°F) or less for at least the first 10 days after planting.

Traits for Field Identification of *Monochoria vaginalis* and Species of *Heteranthera* at Different Growth Stages

Eckert, J.W. and Fischer, A.J.

Heteranthera species and *Monochoria vaginalis* are frequently misidentification in California rice fields. Well defined morphological characteristics for field identification of these weeds would benefit control strategies. Two species of ducksalad (*Heteranthera*) are currently described as being present in California rice fields. *Heteranthera limosa* is found in California as the white-flowered form of this species although other color variants exist in other regions. *Heteranthera rotundifolia* is found in California as the blue-flowered form although other colors exist in other regions. These two species have often been grouped together as *H. limosa*. Added to this confusion between species of *Heteranthera* is the long-term misidentification of *H. rotundifolia* as *Monochoria vaginalis* by most rice professionals and growers. It is unclear when this began but is likely due to having a blue flower color. This poster helps clarify the differences between these three species and also adds a third *Heteranthera* being present in California.

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INSTRUCTIONS FOR PREPARATION OF ABSTRACTS FOR THE 2010 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 33rd 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 33rd RTWG meeting in 2010, or earlier as stated in the Call for Papers issued by the 33rd RTWG meeting chair and/or panel chairs.

   The respective panel chairs for the 2010 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 33rd RTWG meeting. The appropriate due date will be identified in the Call for Papers for the 33rd 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 33rd RTWG meeting and submitted to M.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 2010 PANEL CHAIRS

Breeding, Genetics, and Cytogenetics:

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Plant Protection:

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Fax: (662) 686-7336
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Processing, Storage, and Quality:

Elaine Champagne
USDA-ARS-SRRC
1100 Robert E. Lee Blvd.
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New Orleans, LA 70124

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Fax: (504) 763-4419
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Rice Culture:

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LSU AgCenter Rice Research Station
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Rayne, LA 70578

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Rice Weed Control and Growth Regulation:

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Mississippi State University
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Stoneville, MS 38776

Phone: (662) 686-3282
Fax: (662) 686-7336
Email: jbond@drec.msstate.edu

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	C.C. Bowling	L. Drew	R.J. Smith, Jr.	B.A. Huey
Hot Springs, AR	J.P. Craigmiles		F.L. Baldwin	
1984	M.D. Morse	E.A. Sonnier	California Rice Varietal Improvement Team	
Lafayette, LA	L.C. Hill	D.L. Calderwood	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	D.S. Mikkelsen	J.B. Baker	Texas Rice Breeding and Production Team	
Houston, TX			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	B. Wells	S.D. Linscombe	
	S.-T. Tseng			
			Advances in Rice Nutrition Team	
2000 Biloxi, MS	D.M. Brandon	R.K. Webster	P.K. Bollich	C.E. Wilson
	J.W. Stansel		R.J. Norman	
			Bacterial Panicle Blight Discovery Team	
2002 Little Rock, AR	F.L. Baldwin	M.A. Marchetti	M.C. Rush	D.E. Groth
	R.H. Dilday	J.F. Robinson		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	J.A. Musick	F.N. Lee	M.A. Marchetti
	A.D. Klosterboer	J.E. Street	A.K. Moldenhauer	
	F.N. Lee	J.F. Williams	Individual	
	W.H. Brown	S.L. Wright	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	
			Bakanae Team	
			J. Oster	R. Webster
2008	M.C. Rush	R. Dunand	C. Greer	
San Diego, CA	C. Johnson			
			Individual	
			D. Groth	

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

- 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

2008

RICE TECHNICAL WORKING GROUP
MANUAL OF OPERATING PROCEDURES
2008

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 Cooperative State Research, Education, and Extension Service (CSREES), 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) Processing, Storage, and Quality; 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.

Revised Memorandum of Agreement

The previous Memorandum of Agreement is published in the 31st RTWG Proceedings in 2006. The following is a revised Memorandum of Agreement accepted by the 32nd RTWG membership in 2008.

REVISED MEMORANDUM OF AGREEMENT

FEBRUARY 2008

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 COOPERATIVE STATE RESEARCH, EDUCATION, AND EXTENSION SERVICE

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.

4. **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.

5. **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.

6. **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)

Old Business

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.

New Business

i) The Necrology Report read by Chair.
ii) The Chair announces RTWG award recipients and asks the Executive Committee to keep this information secret until after the Awards Banquet.
iii) 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)

Old Business

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) Processing, Storage, and Quality; 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. If the funds are used as start up money by the host state, it must be repaid by the host state when a sufficient amount of money has been secured to repay the loan. If the funds are used by the host state due to debt incurred in hosting the biennial meeting, no repayment is required. Use of the Contingency Fund by a host state is subject to approval by the Executive Committee.

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.

<u>Sunday:</u> 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. The Distinguished Rice Research and/or Education Award

   i) 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 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) Team category – 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. The Distinguished Service Award - 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.

32nd RTWG ATTENDANCE LIST

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