Texas Rice Special Section
Highlighting Research in 2006

Agronomic Management

Evaluating Rice Varieties and Hybrids for Texas

Each year new varieties such as the very early maturing variety Spring (center), from Arkansas, are evaluated under Texas growing conditions.

Variety selection is one of the most important decisions a producer has to make. This Texas Rice Research Foundation funded research identifies the weak and strong points of potential and named varieties and hybrids from public and private sources under Texas growing conditions. Each of the 16 entries in this year's test are being evaluated for various agronomic traits on sandy soil at Eagle Lake, and on clay soil at Beaumont. Some of the agronomic data collected will include (1) main and ratoon crop yield and milling response, with and without fungicide when nitrogen is not limiting, (2) the contribution of certain management practices to ratoon crop yield using Cocodrie as the test variety, (3) an economic ranking of each entry's average main, ratoon, and total crop net income, and (4) variety characteristics, tillering potential, and growth stage data for variety-specific management.

New to this year's test is an early planting date (first week of March) which will provide information on main and ratoon crop yield potential when planted under cooler, early season conditions, compared to late March or early April plantings.

Mike Jund, Research Associate

This year we are evaluating twelve non-hybrid or conventional varieties and four hybrids. First time conventional varieties include Pace (Ms), and herbicide resistant CLX177 (Horizon Ag). CLXP729 is the new herbicide resistant entry from RiceTec. Included in our test for the second or more year are the conventional varieties Cocodrie (La), Cheniere (La), Trenasse (La), Presidio (Tx), Sabine (Tx), Spring (Ar), Cybonnet (Ar), Banks (Ar), CL161 (Horizon Ag), and CL131 (Horizon Ag). Hybrids from RiceTec included for the second or more year are XL723 and herbicide resistant CLXL8 and CLXL730.

Management Practices for Texas Rice Production: 2005 Result Summary

1. Main crop yield increases ranging from 200 to 1000 lbs/A were achieved across all conventional varieties when Quadris plus Tilt was applied to main crop at Beaumont. At Eagle Lake, main crop fungicide did not consistently increase main crop yield across all varieties. The yield increase due to fungi-

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Mowing main crop stubble has improved ratoon yield for conventional varieties. This and other management practices are being tested for hybrid ratoon production.

cide at Eagle Lake ranged from 200 to 900 lbs/A, depending on variety. In 2005, fungicide was not applied to hybrids since they are moderately resistant to disease.

2. Using a flailmower to reduce main crop stubble height to 8 to 10 inches contributed nearly 1000 lbs/A to Cocodrie's 3100 lb/A ratoon yield, while splitting the ratoon N contributed another 350 lbs/A. Insecticide applied to ratoon, and fungicide applied to main and ratoon crops, did not significantly improve ratoon yield at Beaumont. At Eagle Lake, Karate applied to ratoon contributed over 800 lbs to ratoon yield, and reducing stubble height contributed another 500 lbs/A to Cocodrie's 2560 lb/A yield. Splitting N and fungicide did not significantly affect ratoon yield at Eagle Lake.

3. On clay soil at Beaumont, the three entries having the highest total net income/A were the hybrids XP732, XP723, and XP729. The three conventional varieties having the highest total net income/A were Cocodrie, Presidio, and CL131. On sandy soil at Eagle Lake, the hybrids XP729, XP728, and XP732 were the top three entries for total net income/A. Banks, Trenasse, and Cybonnet were the top three conventional varieties.

4. Hybrids on clay soil at Beaumont showed a main crop yield increase from 180 lbs/A total N compared to 150 lbs/A total N. On sandy soil at Eagle Lake, 120 lbs/A total N yielded as well as 150 lbs/A total N.

Hybrid Rice Management

Currently RiceTec is supporting research to (1) validate nitrogen rates and timings for hybrids, (2) identify management practices which contribute to improving hybrid ratoon yields and milling, and (3) evaluate the use of banded fluid fertilizer at planting on hybrids.

Nitrogen Rates and Timings: As new hybrids are released, each is evaluated to verify their optimum N requirements and application timing under Texas growing conditions. The hybrids in this year's test are XL723, CLXP729, and CLXL730. Basic treatments are 90 or 120 lbs/A N applied preflood, with an additional 30 or 60 lbs N being applied late season. In addition mid-season N applications are being evaluated.

Hybrid Ratoon Best Management Practices: This research is designed to identify main and ratoon crop management practices that will allow producers to maximize the high ratoon yield potential associated with hybrid rice and is being conducted at Eagle Lake and at Beaumont. Some of the treatments being evaluated in the first year of this test include main crop stubble height, fungicide on main and ratoon crop, gibberellin applied to main crop, ratoon N rates and timing, splitting ratoon N, and insecticide applied to ratoon.

Evaluating Banded Fluid Fertilizer For Hybrid Rice Production: Recent research with conventional rice varieties has shown that subsurface banding of fluid fertilizer can improve N uptake efficiency and significantly reduce fertilizer application cost. Current N fertilizer recommendations for hybrids are to delay initial N application until pre-flood in order to reduce excessive vegetation early in the growing season. This research will determine if applying fluid fertilizer while planting can be used in hybrid rice production. Several fluid fertilizer N rates are being evaluated and compared with current recommended practices for hybrids using dry urea on clay soil at Beaumont. Texas Liquid Fertilizer has helped support this research by providing fertilizer, equipment, and help in calibration.

For more information contact Dr. Lee Tarpley at 409-752-2741 or email ltarpley@tamu.edu.

Field Performance of Hybrid Rice in 2005

Dr. Garry McCauley, Technician Kyle Cranek

A major decision in rice farming is variety selection. Traditional varieties have dominated the acreage in Texas over the years. Hybrid rice has become more popular in the past few years. Small plot research results has shown that the later generation hybrids can out perform traditional varieties by 3,000 to 5,000 lb/A in main and ratoon crops. There has been some skepticism regarding hybrid performance in large field production. This project was initiated to better understand the relation of small plot and field performance of hybrid rices.

Dry rice yields were obtained from nine rice driers for all available fields and varieties in 2005. Data for limited fields per variety was not included in the analysis. The final analysis was performed on data from 461 fields, totaling 46,598 acres for 7 traditional varieties, 2 Clearfield varieties, 1 Clearfield hybrid, and 2 hybrids for the main crop. For the ratoon crop, analysis was performed on data from 205 fields, totaling 19,129 acres for 4 traditional varieties, 2 Clearfield varieties, 1 Clearfield hybrid, and 2 hybrids. Data collected for each field was dry yield, variety, harvest date and whole and total milled rice for main and RC where possible.

The average MC yield was about 7100 lb/A for the first rice harvested on July 22. The MC yield decreased about 14 lb/A per day until the last MC rice was harvested on October 5. The total decline in the average yield was about 1100 lbs over this 76 day period of harvest. Harvest date had minimal impact on the whole milled grain with an increase of 0.002 % over the same 76 day period. The MC average yield for XP723 was about 8,000 lb/A, which was 1346 lb/A better than Cocodrie, and 1205 better Cheniere. XP723 out yielded Cocodrie by 1666 lb/A and Cheniere by 1205 lb/A in the RC. The total crop advantage for XP723 was 3012 lb/A over Cocodrie and 2704 lb/A over Cheniere. The field yield advantage for XP723 was significant but was at least 1000 lb/A less than the advantage observed in small plots. We hope to continue this comparison in 2006.

Research conducted by Garry N. McCauley and Kyle Cranek. For more information contact Dr. McCauley at 979-234-3578 or email gmccaule@elc.net

Entomology/Weed Management

Section 18 for Orthene Denied

Dr. M.O. Way

Unfortunately, the regional (AR, LA, MO, MS, and TX) Section 18 request for Orthene use on rice was not approved by EPA. We provided economic and environmental data to show that registration of Orthene would increase revenues for southern rice producers by $21 million annually, and decrease the pesticide load in the southern rice growing environment by at least 325,000 lb ai annually. EPA has a problem with registering organophosphate (OP) insecticides and Orthene is an OP. EPA also has a problem with dietary residue issues and economic justification.

Your letters of support and concern regarding Orthene were instrumental in advancing the submission as far as possible. I am very upset and frustrated that our efforts were not successful. However, if you are willing to support another Section 18 submission for the 2007 growing season, we may try again. I think we can improve the submission based on EPA comments. Again, I am so sorry we failed to win approval; I know how important this issue is to the Texas rice industry.

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Icon 6.2FS Seed Treatment Replacements

I have heard from many rice farmers about the need for a replacement for Icon. Many farmers are planting at lower seeding rates (e.g., hybrid cultivars) earlier, and in stale seedbeds, than in the past, which make seedling insect pest problems of greater concern. My project is evaluating several promising experimental seed treatments which target rice water weevil, but these experimentals may have a broader spectrum of activity. I cannot divulge any information about these seed treatments because of confidentiality agreements. However, I can say that some of these experimentals look as good as Icon for control of rice water weevil. We may have a replacement within 1 to 2 years.

Stem Borer Research

Mexican rice borer larvae.

Mexican rice borer (MRB) moths have been found this year in all eastern rice belt counties except Orange. Relatively high populations of moths have been captured in pheromone traps in Liberty and Chambers Counties. This moth is moving eastward towards Louisiana at about 15 miles per year. Our data show that MRB and sugarcane borer attack rice near panicle differentiation. The best time to apply a pyrethroid to control stem borers is 1-2 inch panicle + late boot/early heading. Recently, Prolex received a label for stem borers, so Karate Z, Mustang Max and Prolex all have stem borers on their labels. Also, our data show that hybrids are much less susceptible to stem borers than other cultivars.

I would like to thank the rice farmers and TRRF for their continued support. I know that the rice farmers are experiencing very trying times, but please continue supporting research and extension efforts, which help maintain a sustainable rice industry in Texas. For more information contact Mo Way at 409-752-2741 ext. 2231, 409-658-7394, or email moway@aesrg.tamu.edu.

Command Label for Rice Expanded

Dr. Mike Chandler

In 2000, when Command became commercially available to rice producers in Texas, it could only be applied with ground equipment to fine and medium textured soils. The label did not allow for its use on coarse textured soils or aerial application, which greatly restricted its use in Texas. During the past five years, research funded by the Texas Rice Research Foundation has addressed these issues. Based on research conducted across the Texas rice belt, a Section 24C for aerial application of Command in Texas rice was obtained for the 2005 production season on 5,000 acres, and expanded to 40,000 acres in 2006.

The commercial applicators have been excellent stewards in making these applications, which is critical in maintaining the annual Section 24C label. The aerial application label allows applications of Command prior to weed emergence during the period from 14 days pre-plant to 7 days post-plant, or post-plant to rice at the 1-2 leaf stage. If emerged grass is present, a tank mixture with a postemergence grass herbicide will be required. Field research is being conducted at 3 locations in Texas to assess the effectiveness of numerous tank mix partners. The tank mix partners can broaden the spectrum of weed control early season. Sequential pre-plant, followed by post-plant applications of Command, are being evaluated to extend grass control into the growing season.

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Entomology/Weed Management continued...

In 2002 and 2003, extensive field experiments were conducted to determine the optimum Command rate range that maximized weed control and minimized crop injury across a wide variety of soil textures and planting dates. The data suggested that Command was safe to use in Texas rice on sandy textured soils.

Based on this research, FMC Corporation made application to EPA in 2005 to allow the use of Command on sandy textured soils. In June 2006, the federal label was changed that allows a rate for sandy soils of 10 acres per gallon or 0.3 pounds active ingredient per acre. In 2007 producers will be able to make both ground and aerial applications of Command on any rice production field, regardless of soil texture.

For more information, contact Dr. Chandler at 979-845-8736 or e-mail jm-chandler@tamu.edu

Plant Physiology

Physiological Bases For Rice Ratoon Crop Management


Dr. Lee Tarpley

Increase ratoon tiller number. A number of plant growth regulators (PGRs) and management schemes that can enhance ratoon tiller number, and thus stand, have been identified by the Plant Physiology project. This season's focus is on the use of the cytokinin-type PGRs (i.e., MaxCel), which show the most promise.

Increase ratoon tiller vigor. Research is continuing to optimize the rates of a gibberellic-acid treatment applied during grain filling. This gibberellic-acid treatment works by stimulating early growth of ratoon tillers, which can improve ratoon yield. Ratoon yield was increased in 16 of 17 studies at an average 200-300 lbs/A (more for the hybrids), with no decrease in main crop yield. The results from last season indicate that the application of gibberellic acid at mid-grain fill will be effective. We need another year of study, and need to expand the list of confirmed compatible insecticidal (e.g. stink-bug control) tank mixes.

Chemically prune upper ratoon tillers. We are following-up on a preliminary study of last season to develop a procedure for chemically pruning the upper, undesirable ratoon tillers. The technique might allow us to gain some of the advantages from cutting low without the additional step of flail mowing.

Increase N fertility rate without increasing lodging susceptibility of hybrids. We are also examining the combined use of increased nitrogen fertility at mid-season and application of Palisade, a growth retardant, soon after canopy closure. This is to increase main and ratoon crop yields of semi-dwarf hybrid rice, which appear to be nitrogen limited, at least on the heavy clay soils in some seasons. This would also maintain milling quality without increasing lodging susceptibility.

Rice Crop Response To Various Stresses

Hot nights. In the Texas ricebelt, temperatures can be high enough to hurt yield. We are studying the mechanism to help direct the efficient development of new genotypes, management schemes, or agrochemical treatments to address the situation. The main effects are probably due to high night temperatures because the sensitive reproductive events usually occur at night. The Plant Physiology project designed and constructed a novel way of heating the plants with near-continuous adjustment to precisely maintain temperatures for the day/night pattern, without enclosing the plants in any sort of chamber, thus minimizing any change in humidity or light. The apparatus has been used in several studies this season.

Cool soil. Cool soil temperatures can limit rice seed germination and early seedling growth. The earlier we can plant and obtain vigorous seedling growth the better because this allows plant development to occur before the hottest periods of the season, and increases the probability of a favorable season for the ratoon crop. Four novel seed treatments have been identified that provided higher and more consistent germination rates in cool soil, and equal plant development and growth, but avoided the lanky growth pattern due to gibberellic-acid seed treatment.

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Plant Physiology continued...

Factors shared among stresses. An environmental stress can lead to a decline in yield or quality through disruption of the plant's ability to deliver photosynthate to the developing grain. A likely weak link in this delivery system is being examined for its role in yield response to stress. Simultaneously, potential plant growth regulators with ability to alter the activity of the weak link are being evaluated because, if this is the weak link, an agrochemical treatment specifically addressing it would be useful. Research on this project conducted by Abdul Razack Mohammed, Elliott W. Rounds, and Dr. Lee Tarpley.


Elliott Rounds, Texas A&M graduate student working in the Plant Physiology Project.

Hybrid Rice Main Crop And Ratoon Crop Requirements During Hotter Than Normal Seasons


Abdul Razack Mohammed, Texas A&M graduate student working with Dr. Tarpley.

The yield loss in hotter than normal seasons is noticeable, and is probably either due to increased respiration or disruption of nutrient transfer within the plant. Both of these can be partially alleviated through maintenance of photosynthesis and adequate storage of reserve carbohydrates and N in the plant prior to major developmental periods. To maintain adequate photosynthesis and deposition of reserves for later use requires adequate N and P nutrition. Because of shifts in how photosynthate is allocated during chronic high temperature exposures, additional fertilizer might be needed, the timing of fertilization might need to be altered, and measures to temporarily alter how the plant allocates its photosynthate might be needed.

Our reseach addresses all three of these. The approach is two-fold: ensure adequate accumulated reserves of carbohydrates and nitrogen going into heading and grain fill (by achieving quick canopy closure followed by Palisade-assisted growth retardation), and by promoting the ability of the developing grain to attract the reserves needed in filling, and thus minimize blanking (through application of an auxin-type PGR shortly before flowering). This research will be split between delayed-planting and controlled-environment studies. Generous funding for these projects provided by the Texas Rice Research Foundation and the Texas Rice Belt Warehouse. For more information contact Dr. Tarpley at 409-752-2741 or email ltarpley@tamu.edu . Additional information is also available at http://beaumont.tamu.edu/eLibrary/TRRFReport_default.htm .

Genetics

Incorporating Foreign Sheath Blight Resistance Genes into US Rice Germplasm


Dr. Shannon Pinson

Sheath blight disease, caused by the *Rhizoctonia solani* fungus, has been the most economically significant rice disease throughout Texas, Louisiana, and Arkansas since the early 1970's. While diseases such as blast and straighthead can also devastate yield, sheath blight disease occurs more consistently with several hundred thousand acres of U.S. rice requiring fungicide treatment each year to control this disease. Chemical control is costly and incomplete. While several fungicides can slow the progression of *R. solani* infection, multiple applications repeated every 10 to 14 days are generally required. The cost of chemical control can be as much as $25 per acre.

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Genetics continued...

Fig. 1. "Bird's nest" caused by sheath blight disease.

The most economical and effective method for controlling crop disease is to plant genetically resistant varieties. This is a common strategy for reducing incidence of rice blast disease. Sheath blight resistance, however, differs from that of blast resistance in several key ways. Unlike rice blast where complete resistance to several races or forms of the fungus can be conferred by individual resistance genes, all known sheath blight resistance (SBR) genes have small individual impact and even the most SBR rices known to scientists can be infected by *R. solani* and develop mild to severe symptoms, depending on the environmental conditions. To achieve field-useful levels of sheath blight resistance (SBR), breeders must combine several SBR genes into a single rice line. Some varieties, such as 'Jasmine 85' and 'TeQing', contain enough resistance genes, however, to allow them to develop only minor sheath blight symptoms and no measurable yield losses under typical Texas field conditions. Earlier studies supervised by Dr. Shannon Pinson (USDA-ARS, Beaumont, TX), showed that TeQing, a highly SBR variety from China, contains 15 SBR genes (Table 1). Interestingly, these same studies showed that Lemont, a highly susceptible US variety grown widely in the 1990's, also contains three SBR genes.

Fig. 2. The light circles in this mature rice field are areas affected by sheath blight.

The desired SBR genes in foreign varieties like TeQing and Jasmine 85 are unfortunately intermingled and/or physically linked with genes coding for undesirable traits such as late maturity, tall height, a propensity to lodge, poor milling quality, and atypical grain shape and cooking quality. It is difficult for breeders to disentangle the desired SBR genes from the undesired genes when using the foreign rice lines as breeding parents. Three SBR genes from TeQing were fortuitously maintained, though not purposely selected for, during the development of the variety 'Saber'. Saber is indeed less susceptible to sheath blight disease thanks, in part, to these three introgressed SBR genes (Table 1)

Six additional TeQing SBR genes have since been isolated from the undesirable foreign genes - making them more available to US rice breeders. Molecular evaluation of three newly-developed germplasm lines show that they each contain from one to four TeQing SB QTLs now introgressed into a genetic background similar to that of Lemont. The foreign SBR genes are now associated with acceptible levels of plant height, heading, and grain qualitities (Table 1) – giving breeders a 'head start' in efforts to incorporate these SBR genes into improved US rice varieties. The single TeQing SBR gene contained in TIL:642 is of particular interest in that the introduction of this one foreign SBR gene imparts SBR equal to that seen in Saber, which contains three foreign SBR genes (Table 1).

For more information contact Dr. Shannon Pinson, emial shannon.pinson@ars.usda.gov. Participants: Shannon Pinson, Bob Fjellstrom, and A. Robert Shank from USDA-ARS, Beaumont, TX; Jim Oard and Don Groth with LSU, Crowley, LA; Yulin Jia and Melissa Jia, USDA-ARS, Stuttgart, AR.

	Lemont	Cocodrie	TeQing	Saber	TIL:642	TIL:455	TIL:514
Average Sheath Blight Severity	Highly Susceptible	Highly Susceptible	Resistant	Moderately Resistant	Moderately Resistant	Moderately Resistant	Moderately Resistant
0 = highly resistant, 9 = devastated	6.8	6.7	3.7	5.5	5.2	4.9	5.1
Total number of SBR genes	3	3	15	6	4	7	6
number = those in Lemont	3	3		3	3	3	3
no. of TeQing SBR genes			15	3	1	4	3
plant height in inches	34	38	43 = tall	38	38	38	40
days to heading	97	92	100 = late	94	95	96	96
grain shape	long	long	medium	long	long	long	medium
apparent grain amylose in 2005	intermed.	intermed.	high	intermed.	intermed.	intermed.	intermed.
hull & leaf character	smooth	smooth	Hairy	smooth	smooth	smooth	smooth

Sheath Blight Resistance in Southern Rice

Dr. Bob Fjellstrom

Sheath blight is a serious fungal disease problem in southern U.S. rice production, making it necessary for rice farmers to diligently use fungicides for its control. There are no long grain rice varieties adapted to commercial production in the southern U.S. that have adequate resistance to sheath blight disease. DNA markers that indicate the presence of sheath blight resistance genes would be quite valuable for plant breeders in developing improved rice varieties for production throughout the South.

Though the molecular location of some foreign resistance genes have been reported, no studies had yet focused on identifying the genes already contained in the U.S. adapted rice. Superior sheath blight resistance was identified in the medium grain variety 'Pecos', and our lab has been working hard at finding DNA markers associated with Pecos' disease resistance genes. In our studies, we determined that the tall height of Pecos has a lot to do with its sheath blight resistance. Since most long grain rice varieties have semi-dwarf height (which keeps them from falling down easily from medium or high winds), we wanted to identify Pecos genes for sheath blight resistance unrelated to plant height.

Fortunately, we were successful in finding two gene regions and DNA markers associated with them that explain a significant portion of the sheath blight resistance found in Pecos. The fact that these same genetic regions were previously found associated with sheath blight resistance in foreign rices adds to the confidence and excitement in our results. Because these resistance genes are already contained in rice adapted to the Southern U.S. they will be more readily available and easier for U.S. rice breeders to work with than the previously reported foreign genes.

Now that genetic regions containing sheath blight resistance genes within U.S. rice have been found, we are now in the process of 'fine mapping' these regions. Through detailed mapping efforts we will be able to find markers very *closely* linked to the desired genes in order to provide rice breeders with accurate and reliable DNA markers for selecting sheath blight resistant rice varieties.

For more information contact Dr. Bob Fjellstrom, email: bob.fjellstrom@ars.usda.gov. Participants: Arun Sharma, Shannon Pinson, Bob Fjellstrom, A. Robert Shank, Joseph Kepiro, Anna McClung, and Rodante Tabien. This research was primarily supported by the RiceCAP NRI grant from the USDA-CREES, administered through the University of Arkansas.

Studying the Inheritance of High Milling Yield in Cypress

Milling yield, also called "head rice yield", is the percentage of whole grain obtained from rough rice (paddy rice) after milling. Milling yield is a critically important trait in rice because it is a major factor determining the price farmers are paid for their crop. Developing genetic markers that are associated with milling yield will help breeders to develop new rice cultivars that have high farm gate value. Data are collected for each step of the milling process, hulling, milling and separating, and these measurements are reported as brown rice (BR) recovery, milled rice (MR) recovery, and head rice (HR) recovery, respectively. However, rice milling yield is a complex trait with multiple components, each under the control of numerous genes that may be affected by environmental (non-genetic) factors, including the weather conditions prior to harvest and post-harvest handling of the grain. Breeding for improved milling yield is difficult because of the numerous sub-component traits, their quantitative inheritance and the difficulty of duplicating commercial

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farming practices and environments on a small scale.

Milling yield was evaluated in a segregating population (F_{11}) derived from a Cypress x Panda cross. Although both are early maturing long grain tropical *japonica* cultivars, Cypress has gained wide recognition for having high and stable milling yield (~64%) over a variety of harvest moisture levels, whereas Panda is characterized by low milling yield (~ 52%). The offspring of this cross were evaluated for traits regularly used as selection criterion by breeders of Southern U.S. long grain rice, such as grain chemistry, appearance, BR, MR and HR. Development of innovative techniques allowed us to identify molecular markers for kernel length, width and thickness; as well as markers for percentage of chalkiness and green area in kernels, factors associated with immature grains. Statistical analysis uncovered 14 different traits affecting milling yield. We have identified molecular markers for these traits and are developing statistical regression models to prioritize each trait's usefulness in selecting superior high milling cultivars.

Variety Improvement

Dr. Rodante Tabien

Finding a Needle in a Haystack: The Case of Rice Tolerance to Roundup and Liberty Herbicides

The project to identify tolerant rice germplasm to either Roundup or Liberty started in 2003. Two activities were initiated; first, the screening of germplasm from the gene bank collection, and second, inducing mutation using chemicals. The test entries, composed of Cocodrie as susceptible check and 29 entries grown in flats, were knapsack sprayed at 4-5 leaf stage using the recommended dosage. Three weeks after spraying, reaction of each entry was evaluated and the plants that survived the first screening were transferred to pots, grown to maturity and re-evaluated to remove potential escapes during the first screening.

In the 2004-2005 screening, over 1500 germplasm lines were evaluated for Roundup or Liberty tolerance and several accessions are currently seeded. Among the survivors, 352 plants from 196 accessions produced seeds after treatment with Liberty. Plants grown from these seeds and retested with Liberty resulted in 52 plants from 23 accessions. Seeds from these second generation plants produced 14 third generation plants from 7 accessions after a third application of Liberty. With Roundup treatment, 112 plants produced seeds from 44 accessions. Second generation testing produced 68 plants from 34 accessions, with third generation testing producing one plant. In addition, 35 plants from 5 accessions survived after being treated with Roundup, followed by a second generation treatment of Liberty. Selected survivors from all herbicide testing were replanted for seed increase, resulting in 120 fertile plants.

Mutation induction was done using ethyl methane sulfonate (EMS) and methyl nitrosourea (MNU). There were more than 300 surviving plants for each herbicide from TX 9092, Cocodrie and TX-8181 that were seed-bearing. Some unique mutations were noticed, such as chlorina and variegated chlorophyll production, and are currently under evaluation. To assure further seed testing, 23 survivors from Round-Up testing and 174 from Liberty testing were seed increased. Currently, seeds generated from all surviving plants are planted for field screening and further evaluation.

Current Updates On The Development Of High Yielding Rice Varieties For Texas

Rice varietal development for Texas continuously aims for high yield, good grain and milling quality, herbicide tolerance and seedling cold tolerance. Weeds are perennial production problem and early season plant establishment has been critical to farmers in all rice production areas in Texas. Availability of herbicide

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Albino and its variants at seedling stage. Note the all white single row.

and cold tolerant rice varieties will have tremendous impact in current production practices.

The third year of the breeding project continued the identification of available germplasm and evaluation of genetic resource for herbicide tolerance. In the absence of donor for herbicide resistance, germplasm with cold tolerance (15°C), new plant type traits and/or progenies of indica x japonica crosses from the Philippines, elite lines for US breeding programs, wild rice derived lines from WARDA, and selections from the U.S. collection that constitutes germplasm from Italy, Korea, China and Russia were planted and used for crosses. A total of 134 new single crosses were generated. Some EMS-derived donors were also used to make crosses that resulted in 28 single crosses. One to three seedlings from each cross were planted in 2006 for generation advance.

The 2005 nurseries included the pedigree nursery (PN), observational nursery (ON) and first preliminary yield trial (PYT), with 4428, 1333, and 33 entries, respectively. The PN consisted of newly developed lines and lines that were segregating in phenotypes, mostly in F_2 to F_6 generations while ON and PYT included lines in F_4 to F_7 generation that were nearly uniform in appearance. Before hurricane Rita hit Beaumont, 1586 rows were selected at PN while 93 of the best rows elevated to 2006 ON. In ON, 255 were retained and 60 lines advanced to PYT. Twenty lines were retained at PYT and 11 were selected for the 2006 statewide trials. All lines from the pedigree nursery selected for advancement were advanced in Puerto Rico and the harvest was planted one panicle to a row in the 2006 Beaumont nurseries.

The development of Clearfield rice for Texas will commence this year with the approval of the agreement between Texas A&M University and the owner of the herbicide resistance gene associated with Clearfield Technology, BASF.

Very high tillering and dwarf mutant rice.

X-rice: Texas Mutant Rice That May Answer Query For Function Controlled By Specific Dna Sequence

Mutants are odds since these usually have unusual appearance. These mutants rarely occur but are highly visible in a population or field, being so different from the rest. In most cases, these were being ignored because of their appearance or general weakness. With the completion of the rice genome sequencing project, the current question is what are the biological functions in these sequences? Mutants are useful germplasm in assigning function to DNA sequences and these are the challenges ahead for functional genomics. The International Rice Research Institute (IRRI) has initiated large scale mutant generation project using radiation and chemicals as mutagenic agents and rice cultivar IR64.

Mutants can be spontaneous or induced. Field mutants are naturally occurring but very rare while induced mutants are more frequent due the mutagenic effect of the chemicals or radiation used. Breeding popu-

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lations or big rice production areas are good sources of natural mutants, but these mutants are usually not identified and kept.

Current efforts to generate herbicide tolerant germplasm and the large breeding populations have given us a chance to identify mutants. Remnant seeds after screening for herbicide tolerance were grown in big plastic tubs and were observed for unusual phenotypes. Visible mutants in the breeding nurseries were tagged and evaluated. Some of the mutations found were albino variant, mosaic, orange leaf, spotted leaf, streaking and variegation. These can be useful in studying chlorophyll and chloroplast formation, stay green trait, and leaf senescence. Another mutant, a very high tillering dwarf, was derived from the early generation line of L202 x Saber cross. This is currently being characterized and will be analyzed genetically.

For more information, contact Dr. Rodante E. Tabien at 409-752-2741 ext 2210 or email retabien@ag.tamu.edu.

Development of a High-Yielding Water-Efficient Cultivar

Fig. 1. Statewide Preliminary Yield Trial (SPYT) at Beaumont, planted last 20 April 2006. Eight LCRA lines are entered into the SPYT alongside entries from other Texas rice breeding projects.

Rice production in Texas currently involves growing both a main crop and ratoon crop. A new rice cultivar that has a significantly higher main crop yield than the current short season cultivars would be economically profitable even without the second crop. This ultra-high yielding rice cultivar, which would eliminate the need for a ratoon crop, would reduce Texas rice water use by about 147,000 to 304,000 acre-feet of water per year, compared with the current requirement for the main crop and ratoon crop of short-season cultivars.

The determination of the best plant growth parameters for an ultra-high yielding cultivar for the Gulf Coast Environment was based on 6 years of field trials that showed the superior yield of ultra-high yielding prototypes over conventional short-season plant types, comprehensive simulation analyses that identified the potential impact of different plant traits on rice yield performance, and detailed literature research on high yielding rice plant types. The breeding for a commercially acceptable ultra-high yielding cultivar was initiated by the Texas A&M University System Agricultural Research and Extension Center in 2002, with financial support from the Lower Colorado River Authority and San Antonio Water System.

For the 2006 cropping season, the pedigree nursery consists of 7,312 rows, while the observational nursery consists of 560 rows. There are 66 lines being evaluated in the preliminary yield trials at Beaumont, and 8 lines being evaluated in the statewide preliminary yield trials at Beaumont (Fig. 1) and Eagle Lake. Marker-assisted selection is being used to evaluate 529 lines, to identify which lines have the genes for desired cooking quality, semi-dwarf stature, and blast resistance. Hybridization blocks have also been established with lines and cultivars that will serve as parents in this season's hybridization work.

Research on this project is conducted by Lloyd T. Wilson, Rodante E. Tabien, Stanley Omar PB. Samonte, and James C. Medley. For more information, contact Ted Wilson at 409-752-3045 ext. 2210 or e-mail lt-wilson@aesrg.tamu.edu.

Rice Functionality, Starch Structure and the Genes

Dr. Ming-Hsuan Chen

Through collaborative efforts among USDA scientists at Beaumont, Texas, we have gained in-depth knowledge of how rice functionality, i.e. the texture of the cooked rice, rice processing properties, and starch gelatinization temperature, are associated with starch-synthesis genes and starch structure. Ninety percent of milled rice is starch, which is made up of two kinds of large molecules, amylose and amylopectin. Amylose content is a key determinant of cooked rice texture and processing properties.

The *Waxy* gene is primarily responsible for amylose synthesis. The synthesis of amylopectin is a concerted effort of multiple forms of starch-synthase enzymes, branching- and debranching-enzymes. We have identified four DNA sequence changes in the rice *Waxy* gene that are strongly associated with grain amylose content. These DNA sequence differences discriminate low-, intermediate-, and high-amylose classes of rice apart from each other and also identify pasting properties separating Dixiebelle-type from Jodon-type rice.

Detailed study of starch structures indicated that not only the quantity of amylose, but also its molecular structure might contribute to the functional attributes of rice. The *Alk* gene, which is associated with rice gelatinization temperature (GT), encodes the starch synthase IIa enzyme, which is one of the enzymes responsible for amylopectin synthesis. Several DNA sequence changes in the *Alk* gene were identified that strongly associated with the GT of rice. Analysis of amylopectin fine structure demonstrated that high- and intermediate-GT rice (Dellmont) has higher percentage of longer exterior-chains of amylopectin than does the low-GT rice (Bengal). DNA sequence specific markers of the *Waxy* and *Alk* genes were developed, and have been incorporated into the marker assisted breeding program. Currently, we are investigating other functional attributes of rice that have not yet been explained through functional and starch-structural studies. For more information contact Dr. Ming-Hsuan Chen email: ming.chen@ars.usda.gov. Participants: Christine Bergman, CMing-Hsuan Chen, Bob Fjellstrom, Anna McClung and Shannon Pinson.

Whole Grain Rice and Health Benefits

The bran layer of the whole-grain rice contained various health-beneficial phytonutrients including phenolics (simple phenolics and tannins), vitamin E (tocopherols and tocotrienols), and oryzanols. These phytonutrients are bioactive compounds that provide protection against degenerative diseases, including cancer and cardiovascular diseases. This protective ability has primarily been attributed to their antioxidant activity. In addition, tocotrienols and oryzanols were reported to reduce cholesterol synthesis and lower serum cholesterol level, respectively. They are also one of the principal ingredients that protect food quality by preventing oxidative deterioration of lipids.

Results from two field studies of rice bran or whole grain of colored rice cultivars demonstrated that the cultivars, in general, with red and purple bran have higher (up to 20 times) total phenolics content and antioxidant capacity than does the light-brown rice, i.e. typical US consumed rice. Variation does exist among rice accessions with similar colored bran. In a separate study, approximately 200 rice accessions of diverse origin were used to study the concentrations of vitamin E and oryzanols in the bran. More than two-fold differences in vitamin E and oryanol contents were found. Among them, two US cultivars, A201 (long grain rice) and Vista (medium grain rice), contained higher contents of both total vitamin E and oryzanols. Improvement of these phytonutrient contents through traditional and marker-assisted breeding methods is feasible. The Cereal Chemistry Lab will continue studying these phytonutrients to enhance the health-beneficial properties of whole-grain rice. For more information contact Dr. Ming-Hsuan Chen, email: ming.chen@ars.usda.gov. Participants: Christine Bergman, Ming-Hsuan Chen and Fernando Goffman.