Texas Rice Special Section

Highlighting Research in 2011

Breeding

Applied Genetics: Speeding the Development of Improved Varieties by Developing Breeding Tools and Genetic Knowledge

Geneticists improve the breeder's ability to create new, improved varieties by finding genes, making the genes more available to breeders by moving them into improved germplasm, and devising improved selection techniques, whether based on visual trait evaluations or linkage between genes and molecular markers.

Dr. Shannon Pinson, Research Geneticist for the USDA-ARS Rice Research Unit in Beaumont, TX, conducts genetic research to help breeders improve available rice varieties for the following traits.

Fig. 1. Even when U.S. rice seedlings are treated with Gibberelic acid to enhance seedling vigor (seedlings of the Lemont variety, on left), the seedlings are not as vigorous as those containing genes from the Chinese variety, TeQing, (LQ:275a, on right).

Early Tillering Enhances Yield Potential (Research funded by TRRF)

Value: Early tillering "locks-in" yield potential before seedling stresses, such as root-pruning by water weevils and reduced tiller production. Tillers also help shade out weeds.

Improved Selection Technique – Marker Assisted Selection: Drs. Pinson and Tabien evaluated seedling tiller numbers within two gene-mapping populations and found markers linked to 7 genes, one gene already contained in most U.S. varieties, plus 6 genes found in foreign rice. Breeders can use the linked markers to select for the tillering genes to incorporate them into U.S. varieties.

Making Genes More Available to Breeders: Six of the tillering genes were first found in the Chinese variety 'TeQing', where the desired genes are unfortunately connected with undesirable traits such as tall height and late heading time. After several generations of backcrossing, progeny lines were created that had the US-adapted genetic background and contained the desired tillering genes (Fig. 1). These lines can be used to introduce just the desired tillering genes from TeQing into their US variety improvement programs.

Putting More Nutrition Into Every Bowl of Rice: (Research funded by the National Science Foundation, NSF)

Value: Consumers pay more for food products fortified with important minerals, such as calcium-fortified orange juice, or vitamin water. Rice is a naturally healthy food, but more could be sold if it could be marketed as "Naturally Fortified".

Finding genes: Drs. Pinson and Tarpley grew 1,600 foreign and US rice accessions at Beaumont and sent seed to Dr. Salt at Purdue University who used an Inductively Coupled Plasma Mass Spectrometer (ICP-MS) to analyze the rice samples for their concentration of 16 elements, namely magnesium, phosphorus, potassium, sulfur, calcium, manganese, iron, cobalt, nickel, copper, zinc, rubidium, strontium, molybdenum, arsenic, and cadmium. A set of 50 rice lines selected for their desirable content of one or more elements were identified, and studies to identify the genes and physiological attributes that underlie their improved nutritional value are now underway. Current investigations are asking if the increased grain mineral content is due to increased root uptake, increased temporary storage in leaves and other plant tissues, or a combination of the two. Segregating cross-progeny will be grown in fields in 2011 to support gene-tagging studies.

Research conducted by Dr. Shannon Pinson (USDA-ARS Research Geneticist, Beaumont, TX), Dr. Rodante Tabien (Texas AgriLife Breeder), and Dr. Lee Tarpley (Texas AgriLife Plant Physiologist). Assisted by Faye Seaberg, Jerri Daniel, Richard Chase, Yao Zhao, Tiffanee Simar, and Randy Valcin. For more information, please contact Dr. Shannon Pinson at shannon.pinson@ars.usda.gov.

Breeding for Rice Fissure Resistance Made Possible Through Development of a New Selection Technique and Identification of Molecular Gene Tags

Value: One of the primary causes of rice grain breakage during milling is fissuring, or cracking, of the rice before it enters the mill (Fig. 1). Any reduction in kernel fissuring can result in direct increases in profit for both producers and millers. For a producer yielding 7,000 lb/A paddy, even a small (5%) improvement in milling yield can increase profits $18/A.

Fig. 1. Fissures in the grain prior to milling causes breakage in the mill. Shining a light through the kernels makes the rice fissures easier to see for counting.

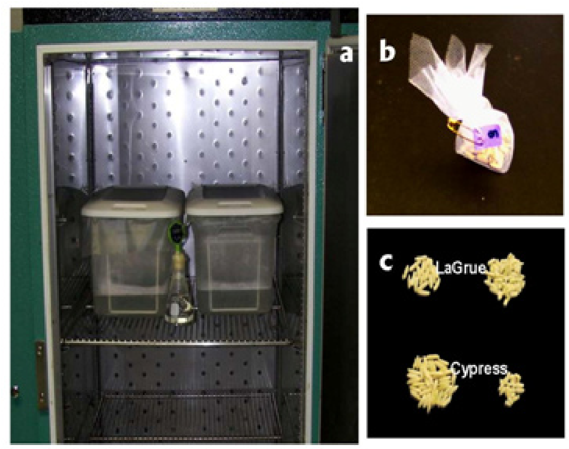

Fig. 2. Evaluation of fissure resistance involves exposing 50-kernel samples to 100% humidity (Fig. 2a). Rice samples are wrapped in tulle (Fig. 2b) to allow their exposure to the humid air. LaGrue (fissure-susceptible) and Cypress (fissure-resistant) are shown in Fig. 2c.

Finding genes: Some rice varieties produce grain more resistant to fissuring than others, and breeders would like to incorporate these genes into improved rice varieties. While most U.S. rice varieties yield around 55% head rice, Cypress, Saber, and Cybonnet typically yield 60 to 65% head rice. Cybonnet inherited its fissure-resistance genes from Cypress, but Saber appears to have a different genetic mechanism allowing its kernels to resist fissuring when exposed to humidity.

Improved Selection Technique: Traits that can be selected for in the early generations of the breeding process are easier and cheaper to select for than traits that cannot be seen until late in the breeding selection process. Recently, successful selection for fissure resistance was accomplished, for the first time ever, using a laboratory evaluation method wherein rates of kernel fissuring are observed after exposure of 50-kernel samples to 100% relative humidity under controlled laboratory conditions (Fig. 2). Dr. Pinson (USDA-ARS, Beaumont, TX), in collaboration with Drs. Jia and Gibbons (both in AR), used this method to select among 300 Cypress x LaGrue F2 progeny. Improved fissure resistance in the following F3 and F4 generations documented the success of the selections, and opens new opportunity for rice breeders to more effectively develop new fissure-resistant US rice varieties.

Tagging Genes with Molecular Markers: The effective phenotyping provided by this lab method was used to identify molecular gene tags associated with fissure resistance genes. One gene from Cypress was found on chromosome 1, another on chromosome 8. Breeders can now use these molecular gene-tags markers to select for Cypress-like fissure resistance. Studies to identify genes for Saber-like resistance are ongoing.

Research conducted by Dr. Shannon Pinson (USDA-ARS Research Geneticist, Beaumont, TX) in collaboration with Dr. James Gibbons (Univ. of AR, Breeder) and Dr. Yulin Jia (USDA-ARS, Stuttgart, AR), and with technical assistance from Faye Seaberg, Jerri Daniel, Richard Chase, Yao Zhao, Tiffanee Simar, and Randy Valcin. For more information, please contact Dr. Shannon Pinson at shannon.pinson@ars.usda.gov.

Development of Locally-Adapted Male-Sterile and Restorer Rice Germplasm

Hybrid rice research in the U.S. is limited and has not been exploited by research institutions. China, India, the Philippines, and an increasing number of countries grow rice hybrids. Farmers in the U.S. have successfully grown hybrid rice, with yield advantages over inbreds ranging from 7 to 21%. Hybrids produced by RiceTec, Inc., are grown on about 24.5% of the Texas rice acreage. Development of hybrids requires several years, but once a variety is developed, significant economic returns are common. Rice (*Oryza sativa* L.) has two subspecies (*indica* and *japonica*), and hybrids produced from *indica*/*japonica* crosses show higher heterosis levels than *indica*/*indica* and *japonica*/*japonica* crosses. In general, available cytoplasmic male sterile (CMS) and restorer lines are *indicas*, and are not adapted to the U.S. environment and production practices. Recently, rice breeders in Arkansas, Louisiana, and Texas have started hybrid breeding programs, and the development of locally-adapted male-sterile and restorer lines required to produce hybrids is one of their main priorities.

At the Texas A&M AgriLife Research and Extension Center at Beaumont, *japonica*-inclined male-sterile lines and *indica*-inclined restorer lines are being developed. Most Texas-bred varieties and elite lines (TX-line) are tropical *japonicas*. These do not possess the restoring factor (Rf) gene, but are good candidates to be developed into locally-adapted CMS lines using backcrossing. This year, potentially new CMS lines, which are in BC3F1, BC2F1, and BC1F1 generations, will be backcrossed to their corresponding maintainer line, which is either a TX variety or an elite line. Widely used restorer lines are *indicas*, such as IR64 and Minghui 63, and 3-way restorer/TX-line//restorer crosses are needed to produce *indica*-inclined restorer lines. In addition, F2 populations of restorer/TX-line crosses will be evaluated, while new F1 seed of restorer/TX line//restorer and TX-line/restorer crosses will be produced. Selected germplasm will be advanced each year until the new *japonica*-inclined CMS lines (at least BC6F1 by 2013) and *indica*-inclined restorer lines (at least F4 by 2013) are produced. The CMS and restorer lines developed from this project will expand AgriLife Research's hybrid rice research potential and allow more and better *indica*/*japonica* hybrids to be made available to our scientists.

Research conducted by Stanley Omar PB. Samonte, Lloyd T. Wilson, and James Medley; Texas AgriLife Research and Extension Center, Beaumont, TX. For more information, please contact Dr. Samonte (sosamonte@aesrg.tamu.edu) or Dr. Wilson (lt-wilson@aesrg.tamu.edu).

Development of Seedling Cold Tolerant Conventional Rice Varieties for Texas

Cold weather affects all stages of rice growth, but early vegetative and reproductive stages are most sensitive. Low temperature at germination and early seedling can cause poor crop establishment that may lead to non-uniform maturation and low grain yield and quality at harvest, while cold temperature at the reproductive stage can lead to high sterility that also lowers grain yield and quality. Seedling cold tolerance is very important in direct-seeded rice that is currently practiced in the U.S., particularly for early-planted fields. In the last five years, 5 to 28% of Texas farmers planted rice before the recommended planting window of March 15 to April 21. Planting before the recommended dates is feasible in Texas based on a 10-year weather pattern study, but none of the Texas-released rice varieties are cold tolerant. Several donors for germination and seedling cold tolerance have been reported, and our Rice Breeding Program, which is supported by the Texas Rice Research Foundation, has identified potential new donors of these traits. Continued screening of breeding materials will facilitate identification of new donors

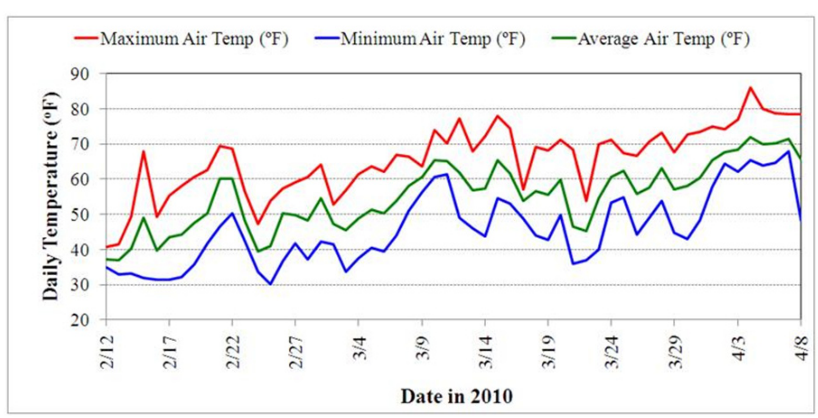

Fig. 1. Outdoor air temperatures during cold tolerance testing.

for cold tolerance and the inheritance studies will help breeders efficiently transfer the trait into new varieties. Our main objective is to develop seedling cold tolerant varieties with high grain yield and quality.

Screening trials for germination and seedling cold tolerance of genotypes reported to possess cold-tolerant lines were conducted in both field and temperature-controlled environments at the Texas A&M AgriLife Research and Extension Center at Beaumont. Two screening trials were conducted in 2010. In the first trial, the effects of three factors on germination and seedling height of rice grown was studied (Fig. 1). The factors were planting date (February, March, and July), genotype (100 entries), and planting material (dry seed vs. pre-germinated seed). In the 2nd trial, the same 100 entries were seeded as dry and pre-germinated seed, but this time in controlled temperatures of 50°F and 77°F, and seedling weights were taken after seven days.

The first trial identified 3 entries that had at least 48% germination, 15 that had seedling height increase, and 7 that had both high germination percentages and low seedling height reduction when exposed to cold February temperatures. Entry # 18, 32, 68, 82 and 86 were identified as the best donors for these traits (Table l). Some entries had early germination in both growing conditions, and are potential donors for high germination rate. Nine entries had consistently low height reduction in dry seeding and seedling tests for cold tolerance, but additional data is needed through further characterization of these genotypes.

Table 1. Effects of early planting (February) and 50°F on germination and plant height or weight of selected genotypes.

Entry	Germination Reduction at Early Seeding (%)	Germination Reduction at 50°F (%)	Plant Height Reduction at Early Seeding (%)	Plant Weight Reduction at 50°F (g)
1	26.0	87.5	6.7	26.1
2	16.0	63.5	-4.2	19.9
5	30.0	42.9	3.9	30.4
6	10.0	58.6	15.0	30.7
8	38.0	40.0	22.7	23.9
18	8.0	72.4	-5.6	17.0
19	14.0	80.0	15.8	20.8
21	6.0	88.9	17.7	-0.6
23	12.0	78.1	11.8	30.9
24	28.0	68.6	10.5	24.8
25	20.0	75.9	15.8	15.9
26	18.0	93.3	5.0	13.4
27	18.0	97.9	-16.7	23.4
29	22.0	84.9	22.2	18.7
31	18.0	85.7	9.1	29.2
32	4.0	52.3	0.0	28.1
42	38.0	80.0	0.0	-3.6
43	30.0	90.3	-5.9	24.7
47	30.0	75.0	8.7	42.9
52	18.0	83.3	0.0	-1.3
54	28.0	97.1	13.3	15.6
59	18.0	36.7	-6.7	40.6
60	28.0	78.4	13.3	31.1
68	2.0	31.2	-7.7	59.5
70	16.0	39.4	7.1	38.3
74	12.0	27.3	8.3	44.7
75	28.0	85.7	7.7	10.0
76	30.0	38.5	13.3	29.7
82	16.0	51.7	0.0	50.8
86	2.0	40.0	-18.8	8.5
90	52.0	93.3	-14.3	7.0
93	16.0	83.1	52.4	34.1

The second trial identified 14 entries that had at most 40% reduction in germination at 50°F. Three genotypes (Entry # 68, 74, and 86) showed cold tolerance in the first trial's February seeding treatment. It took about two weeks for most seed to germinate at 50°F, compared to one week at 77°F. Among the seven entries with the lowest reduction in seedling weight at 50°F, four (Entry # 42, 52, 86 and 90) had the lowest height reduction in the first trial's February seeding treatment.

This year, the cold tolerant germplasm identified by this project is being characterized, and backcrossing is being used to transfer the cold tolerance trait to genotypes that already have desirable traits. New crosses are also being developed using the genotypes identified by this project, and the populations developed from these crosses will provide germplasm from which to select for cold tolerant varieties. In addition, F1 plants produced from 22 crosses made in 2010 are being advanced for selection and genetic analysis.

We sincerely appreciate the generous funding for this project that was provided by Texas AgriLife Research and the Texas Rice Research Foundation.

Research conducted by Rodante E. Tabien, Stanley Omar PB. Samonte, Chersty L. Harper, and Patrick M. Frank. For more information, please contact Dr. Tabien at (409) 752-2741 ext 2230 or retabien@ag.tamu.edu.

In Search of Genetic Resources for Improvement of Seedling Vigor Under Cold Temperatures

Rice production practices are constantly being modified as a result of the availability of new technologies and the changing economic picture. Farmers are planting rice at least one month earlier than a decade ago. With increasing interest in alternative cropping systems, minimum tillage, and water conservation, there is a need to develop rice varieties that have improved seed germination and vigor under the cold temperatures that can exist during early spring plantings. Such varieties will have improved stand establishment and will better compete with weeds at a time when herbicides are not as effective. In addition, varieties that have good stand establishment under cold temperatures can be planted and harvested earlier in the season, thus reducing irrigation demands during late summer. The objectives of this study were to survey a large diverse set of rice varieties from around the world to identify accessions with improved seedling vigor under cold temperatures that can be used by breeders for varietal improvement. We screened about 2,600 rice accessions, including 1,685 varieties in the USDA "Core" collection, 823 accessions from cold (temperate) regions, and over 100 breeding lines and parents. Each accession was evaluated for germination in growth chambers using three replicates of 30 seed at 54ºF and two replicates at 79ºF. Each seedlot was cleaned, sterilized with 10% Chlorox, placed on paper towels that were uniformly moistened and sealed prior to being placed into the growth chamber. Percent germination was determined approximately 7 days after initiation for the warm treatment and following 30 days of the cold treatment. The accessions were compared to Quilla 66304 (PI 560281), a cold tolerant variety from Central America (70% germination at 54ºF), Lemont (48% germination), and Zhe 733, a tropical variety from China, (40% germination). Results identified 590 varieties (23% of the accessions) that were equal to or better than Quilla 66304 for cold germination. Accession 89-5 (PI 614993) originating from Sichuan, China had plant and grain quality traits comparable to southern US long grains along with 79% germination under cold temperatures. Within the Core and Temperate groups, 31 varieties were identified that had >90% germination at 54ºF. Interestingly, these originated from countries in both tropical and temperate climates. This study demonstrates that genetic resources from around the world can be used to improve seedling vigor under cold temperatures.

Research conducted by Anna McClung, Sara Duke, and Wengui Yan of the USDA ARS, and Zongbu Yan, James Gibbons, and Alisha Stivers of University of Arkansas. The research was supported, in part, by The Rice Foundation. For more information, contact Dr. McClung at 409-752-5221 ext 2232 or anna.mcclung@ars.usda.gov. USDA is an equal opportunity provider and employer.

Herbicide Tolerance Screening and Yield Performance of Selected Germplasms in Herbicide Sprayed Plots

Since 2003, with the start of the mutagen treatment of seeds and the yearly selection of survivors in herbicide-sprayed alleyways of field plots in all of our breeding nurseries and yield trials, the number of Liberty and Roundup herbicide tolerance tests that we have developed has continued to increase due to an increase in the number of seed sources. New entries are tested first in plots sprayed with each herbicide. Survivors are harvested and re-evaluated the following season. In 2010, the Liberty test had 1,400 10-ft rows consisting of 606 entries, including 408 previously identified survivors and 198 new or untested varieties and elite lines. Selection after spraying identified more than 50 lines with good tolerance (ratings of 1-2 on a 1-5 leaf injury rating) and nearly 100 lines with moderate tolerance (rating of 3 on a 1-5 leaf injury rating). The Roundup test had 700 rows, consisting of 117 previously tested lines, 17 new untested elite lines, and 29 untested varieties. Selection among surviving plants identified 33 lines with good tolerance (>50% survivors across the rows), and 8 lines with moderate tolerance (20-50% survivors). In the more than 2,100 accessions and breeding lines that we evaluated, which included 1,074 plants produced after exposure to ethyl methane sulfonate (EMS) mutagen, there were 560 Roundup and 544 Liberty survivors that we selected. In addition, 525 plants (from 323 accessions) and 240 plants (from 132 accessions) of varieties and elite lines survived the first screening for Liberty and Roundup herbicide, respectively. In 2010, over 1,500 herbicide survivors had been advanced for selection and further evaluation, including 164 new breeding lines. Plants surviving Roundup treatment have also been obtained from field alleys sprayed with very high rates of the herbicide, resulting in 119 new lines of Roundup survivors. Numerous crosses of these survivors have been made with elite lines.

A replicated yield trial that evaluated 37 herbicide survivors and 3 checks was conducted in 2010. Liberty was sprayed four weeks after planting using the recommended rate. Results indicated significant variation among entries in plant height, number of days to heading, main crop yield, and percentages of total and whole milled rice. Sprayed and not–sprayed plots were significantly different for these traits. Significant entry x spraying interaction was noted for all traits except heading date. Yield was not significantly reduced in some entries, but the highest yield reduction was 71%. Comparison of means between sprayed and not-sprayed plots showed that some entries were comparable in main crop yield and milling quality (Table 1).

Table 1. Plant height, yield, and milling traits of selected genotypes in response to the application of Liberty herbicide.

Entry No.	Treatment	Plant Height (in)	Main Crop Yield (lb/A)	Total Milled Rice (%)	Whole Milled Rice (%)
702	Sprayed	37	2406	68	37
702	Not Sprayed	37	2199	69	42
705	Sprayed	45	4646	67	56
705	Not Sprayed	45	5124	-	-
706	Sprayed	38	3983	65	23
706	Not Sprayed	41	3713	62	39
708	Sprayed	39	7447	65	37
708	Not Sprayed	43	7592	67	46
713	Sprayed	30	4335	68	54
713	Not Sprayed	33	5310	69	52
714	Sprayed	30	4709	67	55
714	Not Sprayed	34	5663	69	54
717	Sprayed	41	4460	69	65
717	Not Sprayed	45	4833	69	65
718	Sprayed	43	4647	68	63
718	Not Sprayed	46	5622	68	62
719	Sprayed	36	4854	66	24
719	Not Sprayed	42	2655	65	49
720	Sprayed	34	5767	69	54
720	Not Sprayed	39	5103	71	57
724	Sprayed	41	3983	68	56
724	Not Sprayed	42	3900	69	52
727	Sprayed	36	5393	70	58
727	Not Sprayed	37	6638	69	58
731	Sprayed	43	3921	68	65
731	Not Sprayed	45	4522	67	58

We appreciate the generous funding for this project was provided by Texas AgriLife Research and the Texas Rice Research Foundation.

Research conducted by Rodante E. Tabien, Chersty L. Harper, and Patrick M. Frank. For more information, please contact Dr. Tabien at (409) 752-2741 ext 2230 or retabien@ag.tamu.edu.

Not only Conventional Inbred Long Grain Rice is in the Pipeline for Texas Rice Producers

The Texas A&M Rice Breeding Program, which was initiated in 2003, continues to produce new and valuable breeding materials with the potential of releasing new varieties and genetic stock. The major focus of the program is the development of conventional long grain inbred varieties, but with some crosses developed to diversify the varietal release and cater to niche markets. We have made major progress in the development of conventional long grain inbred rice, as two of our elite lines are ready for varietal release. Each of these is described in other abstracts.

In 2010, our breeding program produced over 100 new bi-parental crosses. The pedigree nursery (PN) consisted of 2,800 rows of early generation materials that were grown and evaluated for their phenotype. Among the 936 rows selected from the PN, 57 will be advanced to the 2011 observational nursery (ON) while 879 lines were retained in the PN for further plant selection. From last year's ON, which had 2,700 ten-foot rows, 504 lines were identified for further evaluation and 72 lines were selected as yield trial entries in 2011.

The 2010 preliminary yield trials were considerably lower than normally experienced reflecting the impact of the poor growing conditions experienced across Texas and most of the remaining U.S. rice belt. Our main crop yields ranging from 3,931 to 7,902 lb/A, while the state preliminary yield trial in Beaumont and Eagle Lake had yields ranging from 6,281 to 7,970 lb/A and 4,513 to 6,198 lb/A, respectively. Based on the average grain yields across the two locations, three candidate lines were identified for multi-state evaluation as their yields were higher than that of Cocodrie. The program nominated 38 promising conventional long grain rice lines to the Uniform Regional Rice Nursery (URRN), a nursery that evaluates the top breeding lines from TX, AR, LA, MS and MO. Our Texas elite lines that were in the URRN were also evaluated in yield trials conducted in Eagle Lake and Ganado. Even with the prevalence of panicle blight disease, grain yield in Beaumont ranged from 2,550 to 7,468 lb/A, with the highest yielding TX entry at 7,177 lb/A. Eagle Lake and Ganado's average grain yields ranged from 4,557 to 6,983 lb/A. Figure 1 shows the performance of TX entries in the URRN.

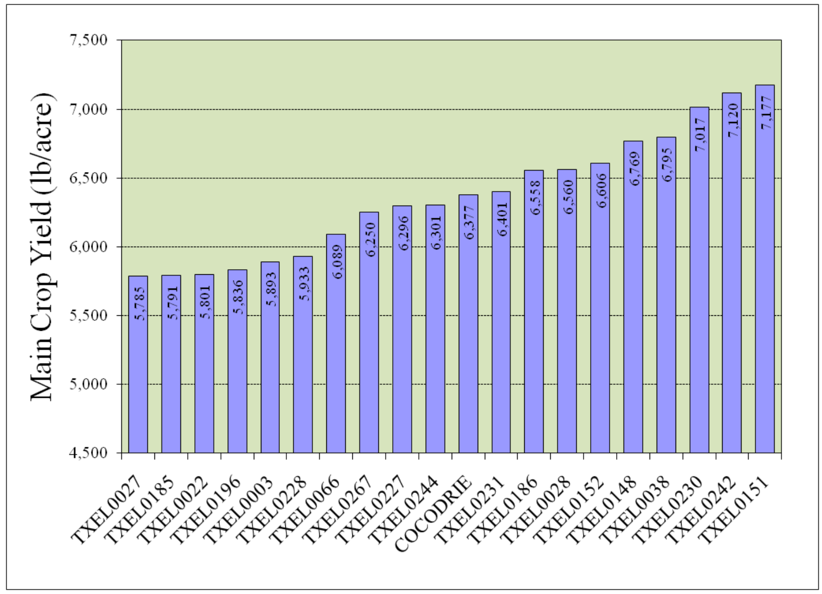

Fig. 1. Performance of elite conventional inbred long grain rice breeding lines at the Uniform Rice Regional Nursery in Beaumont, TX, in 2010.

The program is also developing aromatic rice, Clearfield rice, glufosinate and glyphosate tolerant rice, cold tolerant rice (with Dr. Omar Samonte), and medium grain rice. We have produced crosses that focus on these types of rice. The preliminary yield trial of new aromatic lines was conducted in 2010, with yields ranging from 3,093 to 6,180 lb/A. Most of the advanced lines with Clearfield gene are still in the pedigree nursery, but one line is included in the 2011 preliminary yield trial. A few medium grain are also being evaluated. Liberty and Roundup herbicide tolerance material are still at an early stage and genetic analyses are underway to determine the inheritance of their herbicide tolerance.

We appreciate the generous funding for this project that was provided by Texas AgriLife Research and the Texas Rice Research Foundation.

Research conducted by Rodante E. Tabien, Chersty L. Harper, and Patrick Frank. For more information, please contact Dr. Tabien at (409) 752-2741 ext 2230 or retabien@ag.tamu.edu.

Polyphenols and Antioxidant Capacity: Rice versus Other Common Cereal Grains

The consumption of whole cereal grains has been strongly recommended by many governmental and non-profit health organizations based on epidemiological studies associating whole grain consumption with reduced incidences of chronic diseases such as cancer, diabetes, cardiovascular diseases, and numerous inflammatory diseases. Bioactive phytochemicals, such as polyphenolic compounds, rich in the whole grains are hypothesized to contribute part of the protective effects against these chronic diseases.

Previous study has demonstrated that rice bran of darker color contains higher concentration of polyphenols than some fruits (e.g. blueberry) and vegetables known for their high concentrations. The objective of this study was to compare polyphenols and antioxidant capacity in the extractable and cell-wall bound fractions of whole grain rice differing in bran color (light-brown, brown, red, and purple color classes) with those of other cereal grains, most notably corn, oat, red wheat, white wheat, and barley.

In the extractable fraction, darker bran (red and purple) whole grain rice contained significantly higher total phenolic (4- to 7-fold) and flavonoid (5- to 14-fold) concentrations and antioxidant capacity (2- to 4.5- fold) than most cereal grains except barley (Fig. 1 and 2). The purple bran rice had 50 and 40% higher total flavonoids and antioxidant capacity, respectively, than barley; while the red color bran rice had 70% higher total phenolics than barley. The higher polyphenol concentration (total phenolics and flavonoids) and antioxidant capacity of darker bran rice and barley were primarily attributed to anthocyanins in purple rice and proanthocyanidins (condensed tannins) in red bran rice and barley. Cyanidin-3-glucoside was the predominant anthocyanin and peonidin-3-glucoside was the second highest. The primary food source of anthocyanins is colored fruits. The consumption of anthocyanins in the United States was estimated to be 12.5 mg per day per person. In comparison, the purple rice variety IAC600 contained 140 mg anthocyanins/100 g. Proanthocyanidins are mixtures of molecules differing in number (degree of polymerization) of flavan-3-ol units such as catechin and epicatechin. They are present in some fruits such as apples, cranberries, cocoa, and some cereal grains. Proanthocyanidins in red bran rice were 127 mg/100 g and their composition was 6.5, 33.5, 30.6 and 29.4% as 1-3, 4-6, 7-10 mers (or units), and polymer (>10 mers), respectively. The lighter color bran (light brown and brown) whole grain rice contained 10 to 40% higher total flavonoid content than oat and wheat (red and white). For the polyphenols in the cell-wall bound fraction, whole grain rice contained less than other cereal grains.

Specific health-benefits suggested for anthocyanins or anthocyanin- and proanthocyanin-rich fractions include prevention of oxidative damage, the provision of anti-inflammation and anticarcinogenic activities, and the prevention of obesity *in vitro* and in animal studies. Darker color-bran whole grain rices have potential to positively impact human health.

Research conducted by Ming-Hsuan Chen. For more information, please contact Dr. Chen at 409-752-5221 ext. 2260 or Ming.Chen@ars.usda.gov. USDA is an equal opportunity provider and employer.

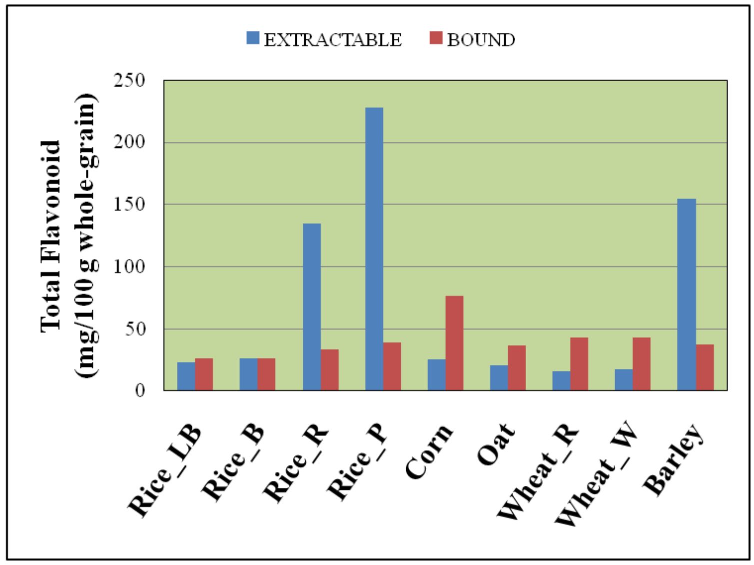

Fig. 1. Total flavonoid content in the extractable and cell-wall bound (bound) fractions of whole grain rice of light brown (Rice_LB), brown (Rice_B), red (Rice_R), and purple (Rice_P) and other whole grain cereals, corn, oat, wheat_R (red), wheat_W (white) and barley.

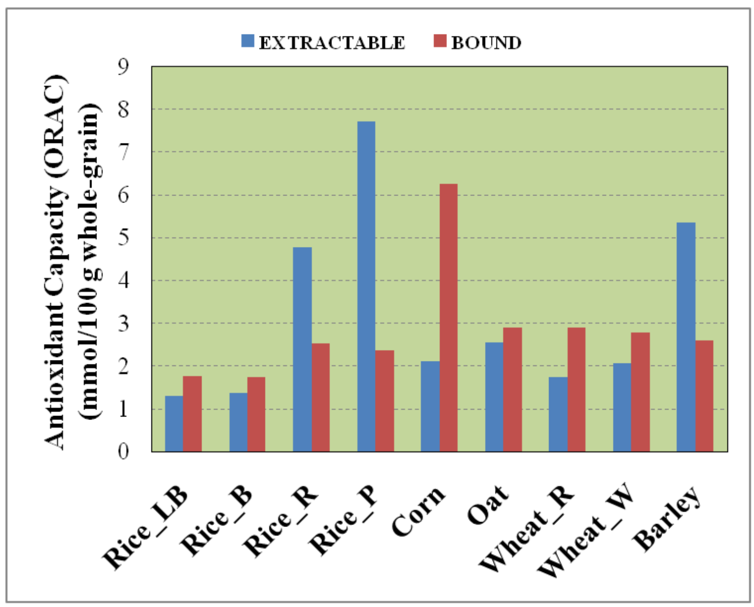

Fig. 2. Antioxidant capacity (ORAC, oxygen radical absorbance capacity) in the extractable and cell-wall bound (bound) fractions of whole grain rice of light brown (Rice_LB), brown (Rice_B), red (Rice_R), and purple (Rice_P) and other whole grain cereals, corn, oat, wheat_R (red), wheat_W (white) and barley.

Release of Four New Breeding Lines Having Resistance to Blast and Sheath Blight Diseases

Sheath blight and rice blast diseases are serious threats to rice production worldwide. High-yielding cultural management practices, such as high nitrogen application and high plant populations, encourage development of these diseases. Complete resistance to sheath blight has not been identified, although there are major genes that offer complete resistance to specific races of the blast pathogen. Resistance to blast disease has not been durable in some regions due to the development of new races of the pathogen that overcome the deployed resistance genes. We have developed four germplasm lines that possess multiple genes for resistance to sheath blight and blast diseases. These lines [LJRIL103 (PI 660982), LJRIL158 (PI 660983), LJRIL186 (PI 660984), and LJRIL220 (PI 660985)] were developed from a cross of Lemont and Jasmine 85. They were selected from a population of 256 progeny and were screened in

Table 1. Sheath blight and blast disease ratings for four germplasm lines and their parental varieties, Lemont and Jasmine 85.

Evaluation Method, Location, Year or Pathogen Race	Disease ratings (0-9 scale)‡					
	LJRIL103	LJRIL158	LJRIL186	LJRIL220	Lemont	Jasmine 85
Sheath blight						
Greenhouse Micro-chamber, CIAT, 2007	3.0*	3.2*	3.7*	4.3*	8.3	4.6*
Greenhouse Mist chamber, CIAT, 2007	3.8*	4.3*	4.3*	5.3*	6.5	4.2*
Field trial, Stuttgart, AR, 2008	4.3*	5.5*	3.5*	4.3*	9.0	3.0*
Field trial, Stuttgart, AR, 2009	5.3*	5.3*	4.0*	4.3*	8.7	3.3*
Field trial, Beaumont, TX, 2008	2.5*	2.5*	4.0*	5.0	7.0	1.5*
Field trial, Beaumont, TX, 2009	5.5*	6.0+	3.0*	4.0*	7.0	2.0*
Field trial, Crowley, LA, 2008	6.0*	6.8+	6.5+	5.8*	7.4	4.2*
Blast race (isolate)						
IB1 (isolate unnamed)	0	5	1	0	4	1
IB49 (ZN61)	0	1	1	0	5	0
IB54 (isolate unnamed)	4	1	0	0	1	5
IC17 (ZN60)	2	2	2	5	5	2
ID1 (ZN42)	1	5	0	0	5	0

‡ Sheath blight was rated on the 0-9 scale, where 0 = highly resistant, 9 = highly susceptible. Blast disease was rated using a method described by Jia and Liu, 2011, where 0-2 =resistant, 3-5=susceptible.

*Significantly different from the susceptible check Lemont at $P = 0.05$ with the Least Significant Difference Test.

greenhouse and mist chamber inoculation tests, and resistance was confirmed in field trials. The greenhouse sheath blight evaluation methods were developed as part of the USDA NRI RiceCAP research project that resulted in mapping novel resistance genes for sheath blight in this and other genetic populations. All four germplasm lines have sheath blight resistance comparable to the resistant parent, Jasmine 85. They contain various combinations of blast resistance genes from both parents, with LJRIL186 having better blast resistance than either parent. They are all long grain varieties with amylose content similar to Lemont, and three of the four lines are aromatic. The germplasm lines are well-adapted for production in the southern USA based upon their plant height, maturity, and plant type. These germplasm lines were jointly released by the USDA-ARS, University of Arkansas Rice Research and Extension Center, Stuttgart, AR, International Center for Tropical Agriculture, Cali, Colombia, and the LSU AgCenter, Baton Rouge, LA. They are being made freely available to the public and will be important in the development of disease resistant aromatic and conventional long grain varieties for the US rice industry.

This research was funded in part by the USDA National Research Initiative "RiceCAP" project.

Research conducted by Drs. Yulin Jia, Rolfe Bryant, Melissa Jia and Anna McClung (USDA-ARS), G. Liu (Texas AgriLife), James Oard (LSU), and F. Correa (CIAT). For more information, please contact Dr. Yulin Jia (Yulin.jia@ars.usda.gov) or Anna McClung (anna.mcclung@ars.usda.gov). USDA is an equal opportunity provider and employer.

'RU0703144': A Promising Conventional Long Grain Rice Worthy as a New Variety for Texas

'RU0703144' was selected from a cross between Cypress (originated from a L-202 x Lemont cross) and Cocodrie (derived from a Cypress x L-202 cross). The F1 was made in 2002, advanced using the pedigree breeding method, and in 2007 was designated as RU0703144 upon entry into the multi-state Uniform Regional Rice Nursery (URRN) evaluations. RU0703144 has a narrow, glabrous, erect flag leaf, and glabrous-awnless grain with straw colored lemma and palea (Fig. 1). The endosperm is translucent, non-glutinous, non-aromatic, very low in chalkiness, and has very early heading and maturity. Across 26 trials, it flowered in 83 days and matured in 118 days. The plant height ranges from 36 to 42 in, and is a non-lodger similar to Cocodrie and Presidio.

RU0703144 consistently out-yields Cocodrie, Cypress, Presidio, Bowman, Catahoula, Cheniere, and Templeton. In six years of yield trials in Beaumont, it had a mean main crop yield of 8,630 lb/A. This is 589 lb/A (7%) more than Cocodrie and 492 lb/A (6%) more than Presidio. The highest yield advantage is 1,070 lb/A (14%) over Francis. In Eagle Lake, it had 816 lb/A (11%) greater grain yield than Cocodrie, and 459 lb/A (6%) more than Presidio, while at Ganado, it had 8% more grain yield than Cocodrie and 4% more than Presidio. In 13 trials conducted in Texas, RU0703144 had an average main crop yield advantage of 641 lb/A (9%) over Cocodrie and 404 lb/A (5%) over Presidio. The highest main crop yield was 11,370 lb/A and was obtained in Eagle Lake followed by 10,628 lb/A obtained at Beaumont. In the Uniform Rice Regional Nursery (URRN) conducted in Arkansas, Louisiana, Missouri, Mississippi and Texas, RU0703144 crop yield was comparable or better than Cocodrie, while ratoon crop yield was lower than Presidio and Wells, but higher than Cocodrie. In four ratoon trials, RU0703144 had a mean ratoon yield of 2,413 lb/A, compared with 2,305 lb/A for Cocodrie. The highest ratoon yield was 4,282 lb/A from Beaumont in 2007. The highest total yield (main crop plus the ratoon) of RU0703144 was 13,644 lb/A obtained in Beaumont. In two years of yield trials, 2008 at Beaumont and in 2009 at Eagle Lake, main crop yield reached 10,467 lb/A.

Fig. 1. Panicles of RU0703144.

The percent head rice (whole milled rice) of RU0703144 averaged 62%, which was higher than Cocodrie (60%) and Wells (57%). Total milled rice ranged from 67 to 75%, while Cocodrie and Presidio ranged from 66 to 75%, and 69 to 75%, respectively. Grain analyses indicated that RU0703144 is a U.S. conventional long grain type, having intermediate amylose content, low alkali spreading value, intermediate gel type, and conventional long grain cooking type. It has intermediate resistance to panicle blight and susceptibility to sheath blight, similar to most U.S. varieties. RU0703144 has some resistance to neck blast, leaf smut, narrow brown leaf spot, brown spot, but not to straighthead. Rice blast tests indicate that RU0703144 has good resistance to blast. Field and greenhouse disease scores show it has a disease resistance package similar to Cocodrie. Preliminary evaluation in Beaumont, TX, showed moderate damage due to rice weevil and low damage due to sugarcane borer and Mexican rice borer. Table 1 shows the yield and agronomic traits of RU0703144 in comparison to

Table 1. Yield and agronomic traits of RU0703144, Cocodrie, Presidio, and Wells in rice growing states in U.S.

Location	RU0703 144	Coco-drie	Presi-dio	Wells	RU0703 144	Coco-drie	Presi-dio	Wells	RU0703 144	Coco-drie	Presi-dio	Wells
	Number of days to Heading				Plant Height (in)				Lodging (%)			
Beaumont, TX	81	79	80	86	37	37	37	40	1	0	0	5
Eagle Lake, TX	81	79	79	81	37	37	37	41	0	0	0	0
Ganado, TX	77	73	74	78	39	38	38	42	0	0	0	0
Mean in Texas	**80**	**77**	**78**	**82**	**38**	**37**	**37**	**41**	**0**	**0**	**0**	**2**
Stuttgart, AK	92	92	91	95	37	37	37	38	0	0	0	0
Crowley, LA	82	81	80	85	39	38	39	43	2	5	0	4
Malden, MO	88	88	87	91	35	37	37	40	2	2	0	3
Stoneville, MS	83	81	83	85	39	37	37	41	0	10	1	0
	Main Crop Yield (lb/A)				Head Rice (%)				Total Milled Rice (%)			
Beaumont, TX	8630	8041	8138	8197	61	60	65	57	70	71	72	71
Eagle Lake, TX	8254	7438	7795	8071	62	60	62	56	72	72	72	74
Ganado, TX	7282	6763	7022	7194	63	61	63	58	73	73	72	73
Mean in Texas	**8055**	**7414**	**7651**	**7821**	**62**	**60**	**63**	**57**	**72**	**72**	**72**	**73**
Stuttgart, AK	7387	7739	6341	7662	60	61	57	56	70	70	70	70
Crowley, LA	8529	8868	7742	8803	64	63	65	57	71	71	70	70
Malden, MO	6432	7596	7634	6948	61	52	46	42	75	74	72	73
Stoneville, MS	9172	9140	9191	9175	53	56	54	50	67	68	68	69

Cocodrie, Presidio, and Wells.

Generous funding for this project was provided by Texas AgriLife Research and the Texas Rice Research Foundation.

Research conducted by Rodante E. Tabien, Chersty L. Harper and Patrick Frank. For more information, please contact Dr. Tabien at (409) 752-2741 ext 2230 or retabien@ag.tamu.edu.

'RU0703190': A Potential New Rice Variety in 2011

Water is a limited and expensive resource, and both the urban sector and rice (*Oryza sativa* L.) growers compete for it. An inbred rice improvement program was initiated by Dr. Ted Wilson at the Texas A&M AgriLife Research and Extension Center at Beaumont in 2001 to develop commercially acceptable varieties that produce high main crop grain yields along the Texas Gulf Coast, while using significantly less water due to eliminating a ratoon crop. RU0703190 is the first variety produced by this project and its application for commercial release is scheduled for 2011. RU0703190 was derived from a 'Cocodrie x L202' cross, and selected through the pedigree and observational nurseries, Preliminary Yield Trials, Texas Statewide Yield Trials, and the Uniform Rice Regional Nursery (URRN). RU0703190 possesses most of the traits identified to increase grain yield based on both simulation analyses and field studies. Based on URRN results from Texas for 2007 through 2010, RU0703190 is very early-maturing (116 d to maturity), semi-dwarf (93.0 cm), and produces long grain (9.62 mm length; 2.71 mm width). RU0703190 has a high main crop yield (average of 8,849 lb/A), which is higher than Cocodrie, Templeton, Bowman, Catahoula, Cheniere, Francis, Wells, and Presidio. RU0703190 has high whole (grain 62.3%) and total (74.0%) milled rice yields; it possesses resistance to several blast races (IB54, IB45, IH1, and IG1), and has the same cooking quality as Cocodrie, Cheniere, Catahoula, and Francis. Relative to Cocodrie, RU0703190 produces more leaves on the main culm, has a higher tiller density, produces a greater amount of above biomass, larger leaf area, more spikelets and filled grain, heavier panicles, and higher nitrogen uptake efficiency. These traits contribute to its high grain yield. RU0703190 would be an excellent high yielding main crop variety to grow in the Texas Gulf Coast, especially when water supply is limited during the ratoon crop.

Fig. 1. RU0703190 (on right) next to the 'Texas Patna' (released in 1942, on left).

Fig. 2. Rough, dehulled, and milled grain of RU0703190.

We sincerely appreciate the generous funding for this project that was provided by the Lower Colorado River Authority (LCRA) and the San Antonio Water System (SAWS).

Research conducted by Rodante E. Tabien, Stanley Omar PB. Samonte, Lloyd T. Wilson, Chersty L. Harper, James C. Medley, and Patrick Frank. For more information please contact Dr. Tabien (retabien@ag.tamu.edu), Dr. Samonte (sosamonte@aesrg.tamu.edu), or Dr. Wilson (lt-wilson@aesrg.tamu.edu).

Variation in Rice Silica Content and Its Use as an Industrial Feedstock

Rice can accumulate silicon (Si) from the soil and although it is not an essential nutrient, it plays an important role in the growth and health of rice plants. Silica is concentrated in the hulls, which are a by-product of the milling process, and in straw which remains in the field after harvest. Some rice hulls are burned to produce steam or electricity and the silica-rich rice hull ash is usually disposed of in landfills where it remains for years due to its chemical stability. Due to the high silicon concentration, rice hulls and ash can also be used as raw materials in the production of Si-based industrial materials with high economic value. These compounds are used in a wide variety of products including glass, ceramics, cement, pharmaceuticals, cosmetics, detergents, chemical catalysts, and as coatings for electronic and optical materials. This study was conducted to determine the genetic variability present in the USDA world collection of rice for Si content that could be used in the development of new varieties that have dual purpose for use as a food crop and as an agricultural feedstock for high value industrial products. One hundred and seventy-four diverse rice accessions were characterized for hull silica concentration in trials conducted at Beaumont, TX, and Stuttgart, AR, and with 164 genome-wide DNA markers. The average silica concentration ranged two-fold among the accessions with a mean of 200 mg g^{-1}. Most of the accessions from Central America had a higher silica concentration while those from the Mideast and Eastern Europe had lower silica concentrations compared to accessions from other parts of the world. Accessions from the Tropical *japonica* subpopulation had some of the highest Si concentrations. This is the same genepool that most of the U.S. long grain rice is developed from, suggesting it is a rich resource for modifying Si in new US rice varieties. Location effects were important, indicating the necessity of having multiple test sites for silica evaluation. Several genetic markers were identified that were linked to Si concentration in the hulls with five of these having been verified in other studies. This research demonstrates the potential of using genomics to develop rice varieties for use as an industrial feedstock, without competing with its use as a globally important staple food.

Research conducted by Anna McClung, Rolfe Bryant, Aaron Jackson, Wengui Yan, and Robert Fjellstrom of the USDA ARS. For more information, contact Dr. McClung at 409-752-5221 ext 2232 or anna.mcclung@ars.usda.gov. USDA is an equal opportunity provider and employer.

Varietal Stability and Soil Variability in Large Yield Trials

High yield and stability of traits across environments (location, year, or their combination) are two of the desired characteristics of a rice variety for use in commercial production and for use as a check in large yield trials. Stable varieties, when used as checks, can be planted in fewer blocks or paddies of a large yield and performance trial because their trait values do not differ significantly among blocks. A large trial that requires stable check varieties is the Uniform Rice Regional Nursery (URRN), which consists of 280 yield plots planted at 40 plots per block. The objective of this study was to estimate the variation in yield-related traits and grain yield within variety and the variation in soil nutrient levels in a large yield trial.

At the URRN conducted at the Texas A&M AgriLife Research and Extension Center at Beaumont in 2010, four rice varieties (Francis, Spring, Trenasse, and Wells) were added to each of the seven blocks and planted at two replicated plots per block. Yield-related traits and grain yield were determined from each of the plots, while soil samples were taken from each block at pre-plant and at heading for soil analyses.

Results of soil analyses indicated that there were no significant differences among the 7 blocks of the URRN for pH and concentrations of N, P, K, Ca, Mg, S, Na, Fe, Zn, Mn, and Cu. Varietal performance in 8 traits estimated in 2010 showed that Spring was the most stable, as there were no significant differences among blocks in terms of tiller and panicle densities, number of days to heading, plant height, grain yield, whole grain yield, and whole and total milled rice percentages (Table 1). Francis was the next most stable, as it differed among blocks only in whole milled rice percentage. Trenasse showed significant differences among blocks in whole and total milled percentages, while Wells showed differences among blocks in tiller and panicle density. All four varieties were stable

Table 1. Significance of variation within varieties planted in seven blocks of the URRN at Beaumont in 2010.

Trait	Variation in Trait Values Across the 7 Blocks of the URRN			
	Francis	Spring	Trenasse	Wells
No. of tillers/m	ns	ns	ns	*
No. of panicle/m	ns	ns	ns	**
No. of days to heading	ns	ns	ns	ns
Plant height (cm)	ns	ns	ns	ns
Grain yield (lb/ac)	ns	ns	ns	ns
Total milled rice (%)	ns	ns	**	ns
Whole milled rice (%)	*	ns	*	ns
Whole grain yield (lb/ac)	ns	ns	ns	ns

ns – no significant differences at the 5% level.
*, ** – significant differences at the 5 and 1% level, respectively.

in terms of grain yield among the seven blocks. In comparison, in last year's (2009) yield trial, Spring was the most stable while Wells was the least stable. Still to be estimated and analyzed from the 2010 yield trial are top- and bottom-half panicle weights and 100-grain weight.

Research conducted by Stanley Omar PB. Samonte, Rodante E. Tabien, Lloyd T. Wilson, and Chersty L. Harper. For more information, please contact Dr. Samonte at sosamonte@aesrg.tamu.edu.

Volatile Profiles of Aromatic and Non-Aromatic Rice

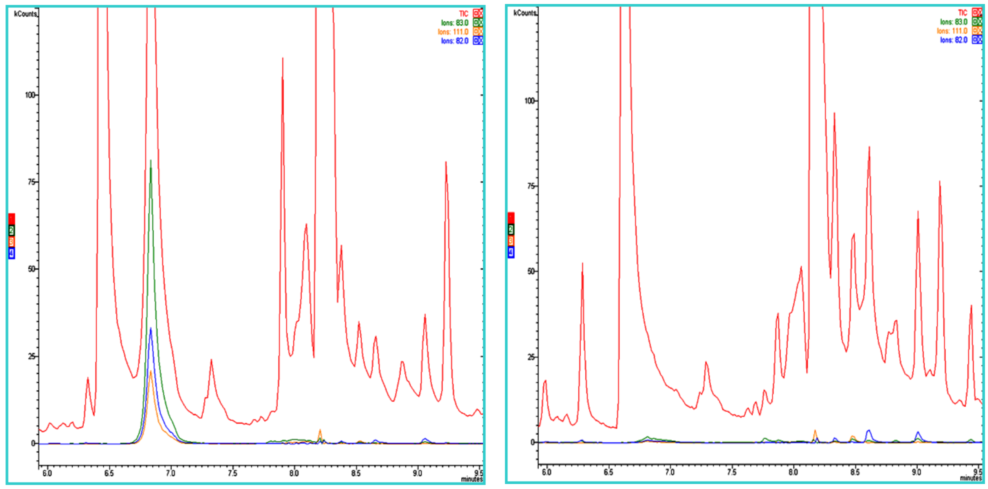

Fig. 1. Demonstration of the difference in volatile profiles of aromatic rice (left) and non-aromatic rice (right) with overlay of selected ions (yellow, blue, green) used to identify the 2AP peak. Peaks elsewhere on the chromatogram indicate other volatile compounds present.

Rice is enjoyed by many people as a staple food because of its flavor and texture. Some scented varieties command a premium in the marketplace because of their distinctive aroma and flavor. The compound most commonly associated with the popcorn or nutty scent of aromatic rice is 2-acetyl-1-pyrroline (2-AP). This compound can be detected in the leaves and grain of the aromatic rice plant. Although there has been considerable research on 2-AP in rice, it is not known if different aromatic rice varieties produce other flavor volatiles that may influence preference by consumers. In this study, seven aromatic and two non-aromatic varieties were examined for their volatile profiles both before and after storage using solid phase microextraction (SPME) fibers in conjunction with gas chromatography/mass spectrometer (GC-MS). The aromatic varieties were derived from different sources of 2-AP, originating from India, Thailand, China, and the USA. Ninety-three volatile compounds were identified, 64 of which had not been previously reported in rice. Differences were found in volatile compounds of aromatic and non-aromatic rice other than 2-AP. Most of the volatile compounds were present in freshly harvested rice and rice following storage, with very few new compounds being identified only after storage. This indicated that rice does not need to be "aged" to determine its volatile profile. Dellrose, an aromatic variety, and Cocodrie, a non-aromatic variety, had the most complex volatile profiles (over 64 volatiles). Sixteen compounds were found only in aromatic varieties and some volatiles were found to be unique to specific aromatic varieties. However, no distinctive pattern was observed that would identify a variety as being derived from Basmati, Khao Dawk Mali 105 (i.e., jasmine), or other sources of aroma. This study showed that there is a great diversity of volatiles in both aromatic and non-aromatic rice varieties and, with further research, this may lead to a better understanding of the combination of compounds that gives a variety a unique flavor.

Research conducted by Anna McClung and Rolfe Bryant of the USDA ARS. For more information, contact Dr. McClung at 409-752-5221 ext 2232 or anna.mcclung@ars.usda.gov. USDA is an equal opportunity provider and employer.

Physiology

Can Seedling Mineral Composition Predict Rice Grain Nutritional Value?

This study investigated the possibility of using the mineral (ionomic) composition of rice (*Oryza sativa* L.) seedling leaves to predict varieties that accumulate large amounts of specific minerals in their grain. This information will be used for genetically improving the nutritional value of rice grain and for improving our understanding of mineral uptake, transport, and accumulation in rice. In 2007 and 2008, flooded and unflooded field trials were conducted on a core subset of 1,640 rice varieties from the USDA National Small Grains Collection to identify varieties with varying levels of grain mineral composition. The present study investigates correlation between seedling leaf and grain mineral contents of 16 minerals within this diverse set of varieties to determine if seedling leaf data could be used to predict grain content. Such correlations could greatly accelerate breeding efforts aimed at developing rice varieties with improved grain mineral composition (nutritional value). The 40 rice accessions selected for their extreme grain mineral composition were grown in an outdoor potted plant study in 2010. All 40 varieties were planted in 7-10 day intervals to provide, on a single sampling date, plants of a wide range of developmental stages. Leaf tips (2 inches) were collected from the most recently fully emerged leaf per plant for ionomic analysis. The results for Molybdenum (Mo) illustrate the potential of this approach to comparing leaf and grain mineral contents. Rice accessions from Malaysia (GSOR accessions 310354, 310355, 310356, 311643 and 311743) with high grain Mo also displayed high leaf Mo indicating that seedling leaf data can be used to predict grain Mo.

Research conducted by Ratnaprabha, Dr. Shannon R.M. Pinson, Dr. David E. Salt (Purdue University) & Dr. Lee Tarpley. Funded by NSF DBI 070111. For more information, please contact Dr. Pinson at 409-752-5221 ext 2266 or Shannon.pinson@ars.usda.gov or Dr. Tarpley at 409-752-2741 ext 2235 or ltarpley@tamu.edu.

Effects of High Night Temperature and 1-Methylcyclopropene on Rice Production

Higher night temperatures negatively effect plant metabolic processes and decrease crop yield and grain quality. High temperatures can also up-regulate ethylene (naturally-occurring gaseous plant hormone) production, which can increase production of reactive oxygen species (ROS). The ROS can trigger oxidative-stress responses in plants thereby decreasing membrane stability. Destabilized membranes can disrupt water, ion, and organic-solute movement across membranes, thus affecting carbon production (photosynthesis), consumption (respiration), transport, and accumulation. The 1-methylcyclopropene (1-MCP) is an ethylene perception inhibitor that acts by binding to the ethylene receptor, thereby blocking the ethylene binding sites and repressing the plant's response to ethylene. The objective of this study was to determine the effects of high night temperature (HNT) and 1-MCP on the physiology and yield of rice plants.

Rice plants were subjected to ambient night temperature (ANT) (77°F) or HNT (86°F) through the use of continuously, precisely controlled infrared heaters, starting from 2000 h until 0600 h, starting 30 day after emergence (DAE). Half of the plants in each temperature regime were treated with 1-MCP granules 30 DAE at the rate of 10 g active ingredient per hectare. Leaf-level photosynthesis and respiration were measured using a LI-6400 portable photosynthesis system (LI-COR Inc., Lincoln, NE, USA) 10 days after treatment (DAT). Membrane injury was measured 10

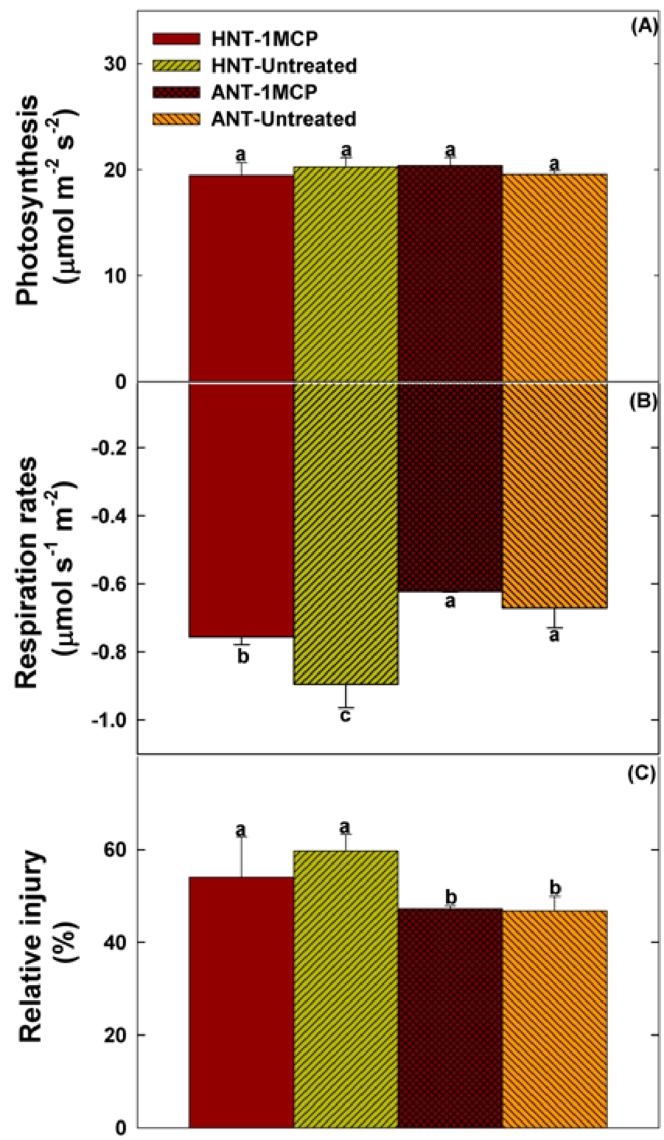

Fig. 1. Effects of high night temperature and 1-MCP on rice physiology.

DAT. Pollen germination, spikelet fertility, and yield were determined.

Our results indicated no effects of HNT on leaf photosynthesis. However, compared to ANT-treated plants, HNT increased respiration (28%) and relative membrane injury (21%) (Fig. 1), and decreased pollen germination (50%), spikelet fertility (11%), and yield (6%) (Fig. 2). The 1-MCP-treated plants grown under HNT showed decreased respiration (-16%) and relative membrane injury (-10%) and increased pollen germination (100%) and yield (7%), compared to untreated plants grown under HNT (Fig. 1 & 2). A decrease in respiration increased membrane stability can aid in transfer of photosynthates from leaves to grain, thus promoting grain filling of fertilized spikelets. Increased pollen germination can increase the number of fertilized spikelets available for filling. Hence, less respiration and more stable membranes, along with greater pollen germination, can increase spikelet fertility and yield.

Research by Dr. Abdul Razack Mohammed, Mr. Leon Carl Holgate, and Dr. Lee Tarpley. Generous funding for the plant physiology projects was provided by AgroFresh Inc. For more information contact Dr. Mohammed (abdulrazack@neo.tamu.edu.) or Dr. Tarpley (ltarpley@tamu.edu).

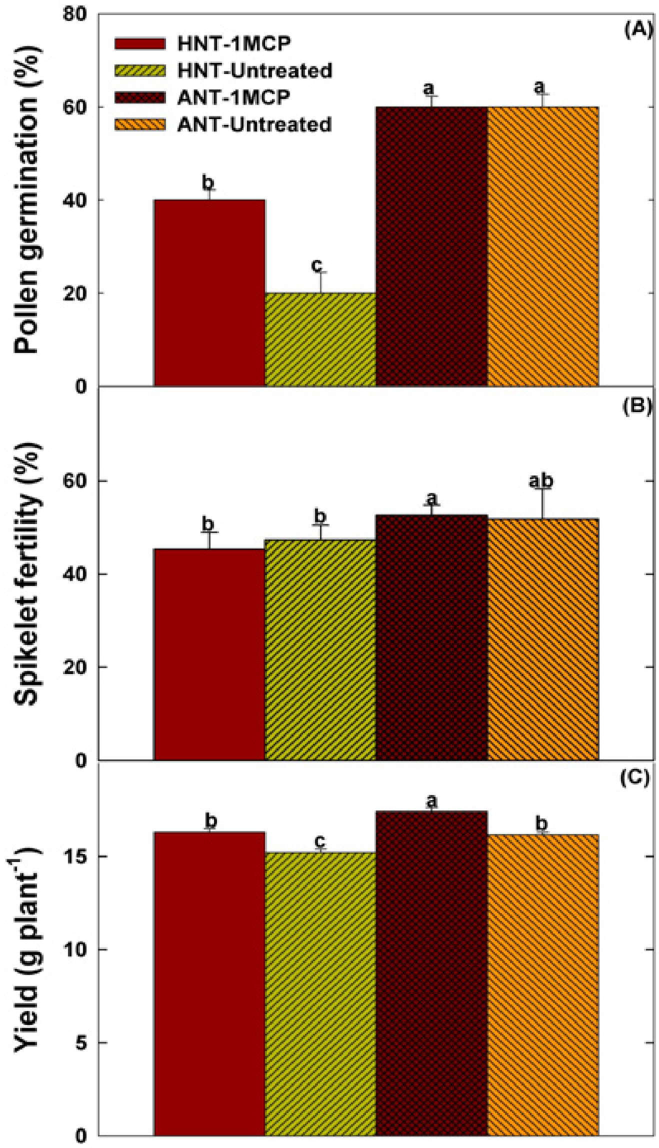

Fig. 2. Effect of high night temperature and 1-MCP on pollen germination, spikelet fertility and yield.

Light Interception and Plant Architectural Modeling

The efficiency with which different rice varieties intercept light is a fundamental starting point for a myriad of processes involved with rice crop growth, development, maturation, and yield. Research by our team has shown that the architecture of the rice plant has a tremendous impact on the efficiency with which a rice variety intercepts light. Four major factors that impact light interception efficiency are the angle of tillers within a plant, the position of tillers with respect to mother plants and other daughter tillers, the average distance between nodes on each tiller, and the curvature of leaves within the canopy. Genotypes whose leaves are less erect intercept a greater amount of light in the upper part of the canopy during times of day near solar noon, while genotypes that have leaves that are more erect intercept a relatively greater amount of light further down into the canopy. The upper leaves are better at converting light into usable energy due to their higher concentration of chlorophyll. As a result, unless the light intensity that strikes the leaf surface is higher than what is referred to as a variety's light saturation point, higher light interceptions by upper leaves can result in a higher rate of plant photosynthesis.

Canopy structure also affects a variety's ability to compete with weed species for light, while the distribution of roots in the soil affects their efficiency at taking up nutrients from the soil. Rice varieties that are more efficient at capturing light, either via leaf or stem tissue, reduce the amount of light reaching the ground, in the process "shading-out" slower developing weed species more effectively.

One area of our research involves incorporating the 3-D dimensionality of plant organs in determining how a rice variety intercepts light, captures nutrients from the soil, and competes with other organs and adjacent plants during the course of growth and development. The major characteristics possessed by each organ include organ age, stage, biomass, and amount of structural and non-structural carbohydrates (CH_2O) and nitrogen (N). The architectural components include organ shape, organ spatial position in the plant, and the hierarchical relationships of individual organs to other organs in 3-dimensional space.

Our 3-D rice model simulates the growth, development, spatial location, and light capture by each organ on the plant. Research is under way to extend the model to estimate microenvironment data such as organ temperature, light quality, and CO_2 concentration, to more accurate capture detailed physiological processes involving the initiation of tiller buds and the transition from vegetative development to panicle differentiation, flower initiation, and grain development. Research addressing how insects and disease injure different parts of the rice plant will soon be addressed using this approach. A physiologically detailed but simpler version of our rice model , in terms of architectural detail, was used in identifying the combination of plant traits to produce high-yielding water-efficient main crop rice varieties. The first variety developed through this effort with the Lower Colorado River Authority will be released in 2011. We anticipate being able to use the 3-D rice model to further improve our ability to identify which combination of plant traits have the greatest impact on rice yield.

Research conducted by Lloyd (Ted) Wilson, Yubin Yang, Stanley Omar PB. Samonte, Xiaobao Li, Jim Medley, S. Jiale Lv, and Jenny Wang. For additional information, please contact Ted Wilson at lt-wilson@aesrg.tamu.edu.

Photosynthetic Rates of Hybrid Rice and their Parents at Reduced-Feedback Inhibition Conditions

The yield advantage of hybrids over inbred rice varieties is usually attributed to heterosis. Some studies state that hybrids have higher photosynthetic rates than inbred varieties. However, in these studies, the interactions between photosynthetic rate and nitrogen concentration and content have not been analyzed. Hence, it is not definite that hybrids have higher intrinsic photosynthetic ability, because one of the alternate possibilities is that hybrids have higher N content and larger leaf areas that contribute to increased photosynthesis. The generally heavier biomass and larger leaf area of hybrids can also result in higher photosynthetic demand and lower photosynthetic feedback inhibition, which very likely contributes to increased photosynthesis. Reducing the leaf area of rice plants by partially removing leaves should minimize feedback inhibition and allow the remaining leaves to photosynthesize at higher rates to support the metabolic demand especially during grain filling. The objective of this study is to analyze and determine the relationship among photosynthetic rates, plant biomass, leaf area, and nitrogen concentration of hybrids and their parents under normal growing conditions and under conditions of reduced-feedback inhibition.

Fig. 1. Field experiment consisting of 3 hybrids and their parents at Beaumont, TX, in 2011. Each plot consists of 6 rows, with the borders planted with Banks.

This year, a 3-factor field experiment was established at the Texas AgriLife Research and Extension Center at Beaumont (Fig. 1). The factors are sampling date, variety, and leaf injury. Plants will be sampled on 6 dates during the main crop and 3 dates during the ratoon crop. Seven varieties will be evaluated, consisting of 3 hybrids and their parents (3 male-sterile lines to be represented by their maintainer line, and 1 pollinator parent). During each sampling date, 50% of the leaves in one treatment of each variety will be removed, i.e., 1/2 of each leaf will be cut off, while a second treatment will serve as a control plot (no leaf injury). During each sampling date, canopy photosynthesis and respiration rates, light interception, leaf area, masses of structural parts (roots, leaves, stems, and panicles), numbers of tillers and panicles, numbers of filled and unfilled grain in main culm panicles, and number of nodes on the main culm will be measured. Nonstructural carbohydrates and total nitrogen in each structural part will also be estimated after the plant samples are dried and ground.

The first sampling date is set for this June, when the rice plants are in the early tillering stage.

Research conducted by Lloyd T. Wilson, Stanley Omar PB. Samonte, James C. Medley, and Jenita Thinakaran, Texas AgriLife Research and Extension Center, Beaumont, TX. For more information, please contact Dr. Wilson (lt-wilson@aesrg.tamu.edu) or Dr. Samonte (sosamonte@aesrg.tamu.edu).

Plant Nutrition

Developing Best Management Practices for Rice Ratoon Crop Production

In Texas, rice ratooning plays an important role in increasing net income for rice growers. Therefore, it is necessary to develop management practices to enhance ratoon crop (RC) production. As with the main crop, the production of the RC is affected by rice variety and different management factors. At the Texas A&M AgriLife Research & Extension Center at Beaumont, the Soil and Plant Nutrition group has continuously studied management practices to improve RC production. Such studies included varietal evaluation, nitrogen rate and timing, disease and pest control, early and normal planting date, sandy or clay soil, cutting height, and plant growth regulators. Here we discuss the effects of variety, planting date, location, and N rate.

Rice varieties showed a differential response to planting date (Fig. 1). Inbreds planted early had greater RC grain yield than those planted at normal dates. The greatest difference in grain yield between early planting and normal planting was 98% for Clearfield XL 729 planted at Eagle Lake in 2008. However, there was no consistent pattern for hybrids between early and normal planting dates at both sites.

Experimental sites affected RC grain yield. Ratoon crop yield at Eagle Lake was 32% greater than at the Beaumont when averaged across variety and year. The maximum difference in RC grain yield (averaged across sites and years) was 39%, which was observed comparing Presidio and Cocodrie.

The rate and timing of RC N application affected grain yield (Fig. 2). For Clearfield XL 729, a single application of 135 lb/A N prior to RC permanent flooding produced significantly greater grain yield than did 100 lb/A N. However, this

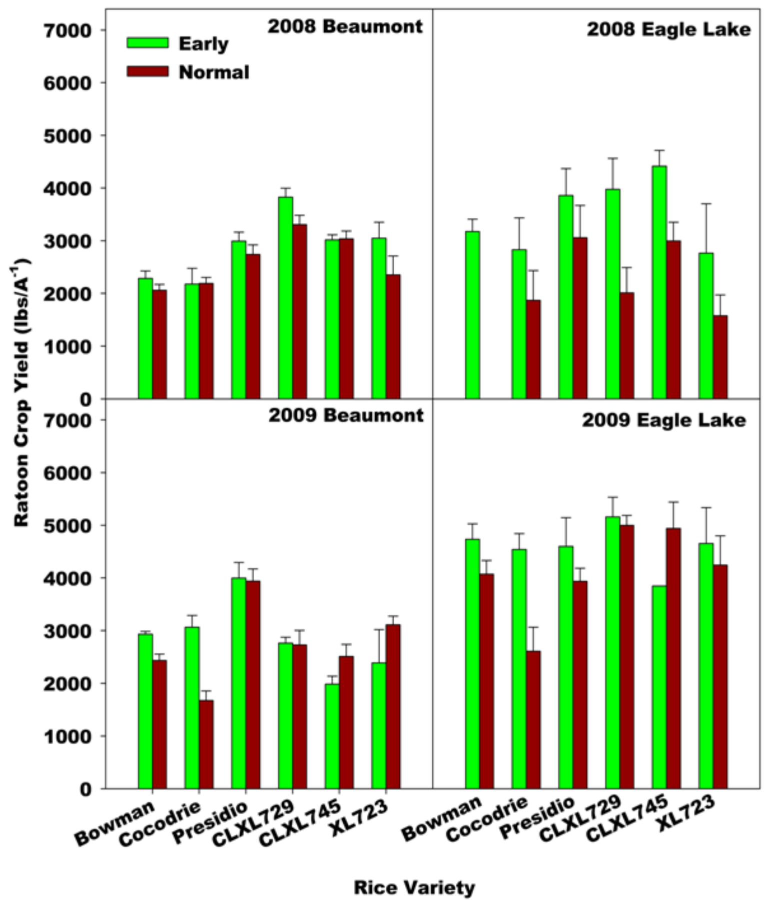

Fig. 1. Effects of variety and planting date on ratoon crop yield at Beaumont and Eagle Lake in 2008 and 2009.

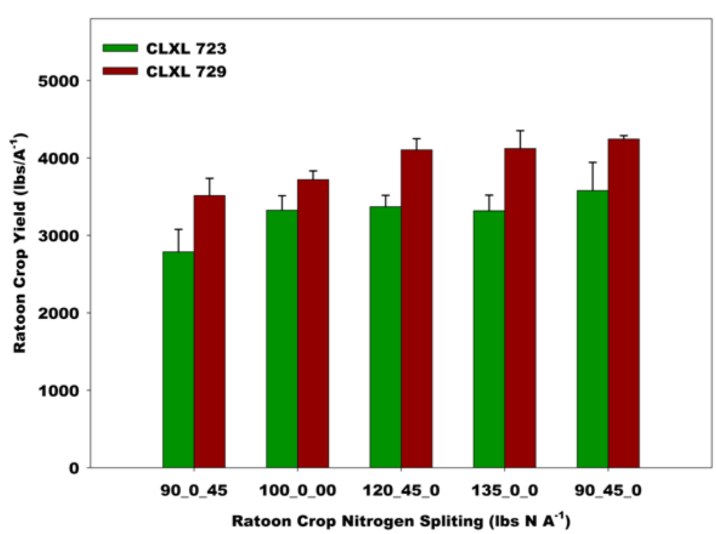

Fig. 2. Effects of variety and nitrogen rate on rice ratoon crop yield at Beaumont, TX, in 2008.

effect was not observed for XL 723. For split N application, 90 lb/A N at preflood plus 45 lb/A N applied 14 day later produced the greatest RC yield for both varieties. The split fertilization of 90 lb/A N applied prior to permanent flooding and 45 lb/A N applied 28 days later had the lowest RC yield. Main crop (MC) N application had carryover effects on RC yield, with higher MC N rates significantly increasing RC yield. For Clearfield XL 729, the RC yield when MC received 180 lb/A N or higher was 15% greater than those of MC receiving 105 or 120 lb/A N. Additionally, Clearfield XL 729 had significantly greater RC yield than Clearfield XL 745 and Clearfield XL 746. Our multiple year and site studies have demonstrated that varietal selection and nitrogen management are critical to ratoon crop production.

Research conducted by Fugen Dou, Lee Tarpley, Mike Jund, Darrell Hagler, and Jack Vawter. This project was supported by the Texas Rice Research Foundation. For more information, contact Dr. Dou at 409-752-2741 ext 2223 or f-dou@aesrg.tamu.edu.

Effects of Phosphorus and Potassium Fertilization on Rice Main and Ratoon Crop Yields

Application of phosphorus (P) and potassium (K) to rice is beneficial for increasing yields. However, the re-evaluation of the annual fertilizer P and K application requirements for rice is needed due to increased fertilizer costs. The focus of this study is on evaluating P and K fertilization effects on rice main and ratoon crop yields in a loamy soil near El Campo, Texas and in a clayey soil at the Beaumont Center.

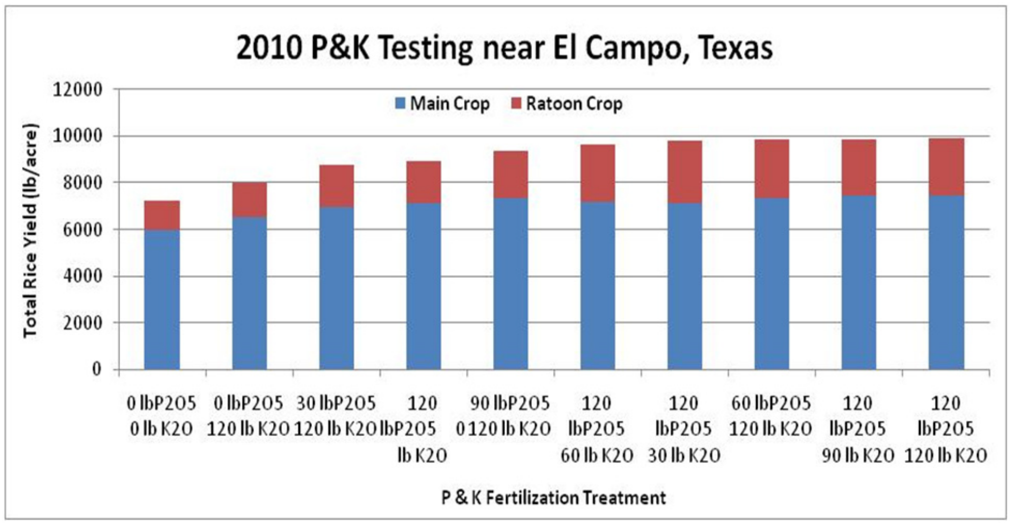

Fig. 1. Main and ratoon crop rice yields at variable P and K fertilization. The study was conducted at El Campo, TX, in 2010.

At the El Campo site, P and K were applied at five levels: 0, 30, 60, 90, and 120 lb P_2O_5/A and 0, 30, 60, 90, and 120 lb K_2O/A, respectively. Rice (Clearfield 111) was planted by dry seeding in mid-March 2010. A single fertilization of P and K was applied via broadcasting to each plot on March 24. The main crop received a total of 199 lb N/A, and the ratoon crop received 92 lb N/A in the form of urea. Soil and rice plant tissue for main crop were sampled on July 6. Main (MC) and ratoon (RC) rice crops were harvested on July 26 and October 11, respectively. The second soil sampling was conducted after ratoon crop harvest on October 21, 2010. The total rice yield (TC = MC + RC) ranged from 7,237 to 9,916 lb/A (Fig. 1). The main crop yield ranged from 73% to 82% that of in the total crop yield. The greatest yield was produced by the 120 lb P_2O_5/A + 120 lb K_2O/A treatment and the lowest by the unfertilized control (0 lb P & K). Phosphorus application significantly increased main, ratoon, and total rice yields. Total rice yield at 60 lb P_2O_5/A was greater than at 0 and 30 lb P_2O_5/A. Similar results were observed for the ratoon crop yield. For main crop, P fertilization increased yield compared to the untreated control. Only ratoon crop yield responded to K fertilization. The 30 lb K_2O/A treatment had the greatest ratoon yield. Based on this one-year primary study, our results indicated that application of P at 30 lb P_2O_5/A was adequate for the main crop (variety CL111), which is consistent with existing soil test recommendations. Application of K at 30 lb K_2O/A increased ratoon crop yield. Currently, we are evaluating the seasonal dynamics of P and K in soil and the effects of P and K application rates on plant tissue P and K levels. Furthermore, we are using the P and K study at the Beaumont Center to determine the effects of P and K application on rice yield for varieties Clearfield 162, Presidio, REX, and CLXL 745 at 45 lb P_2O_5/A, 45 lb

K_2O/A, and in an unfertilized control.

Research conducted by Fugen Dou, Kirill Kostyanovsky, Garry McCauley, Lee Tarpley, Darrell Hagler, Jack Vawter, and Peter McGuill. We want to thank Mr. LG Raun for collaboration and field management. For more information, contact Dr. Dou at 409-752-2741 ext 2223 or f-dou@aesrg.tamu.edu.

Agronomy

Beaumont Wireless Weather Monitoring System

Wireless sensor networks (WSN) are being used in a variety of applications in diverse industries, including agriculture. They are used to monitor livestock, grazing patterns, and in some cases environmental parameters for crop production. Achieving accurate measurement of environmental parameters such as temperature and moisture of the air and soil can be difficult. However, WSN can provide an easy way of monitoring and recording environmental parameters in situ.

At the Texas A&M AgriLife Research and Extension Center at Beaumont, Texas, a WSN was set up to monitor temperature and moisture of the soil and air in a flax field. The network consists of sensors, nodes, a repeater, a receiver, and a computer (Fig. 1). The sensor transmits real-time data to the node. The node sends the signal wirelessly to the receiver via the repeater. The receiver is directly connected via a USB cable to the computer where the data is recorded and stored for retrieval and analysis when needed. The network operates on the Industrial, Scientific, and Medical (ISM) radio band on a 2.4 GHz frequency. At close range (1,400 ft or less), the nodes communicate directly with the receiver. However, at greater distances, the repeater is needed to link the communication between the nodes and the receiver. With a clear line of site, the repeater is able to communicate with the receiver up to 1.6 km (1 mile).

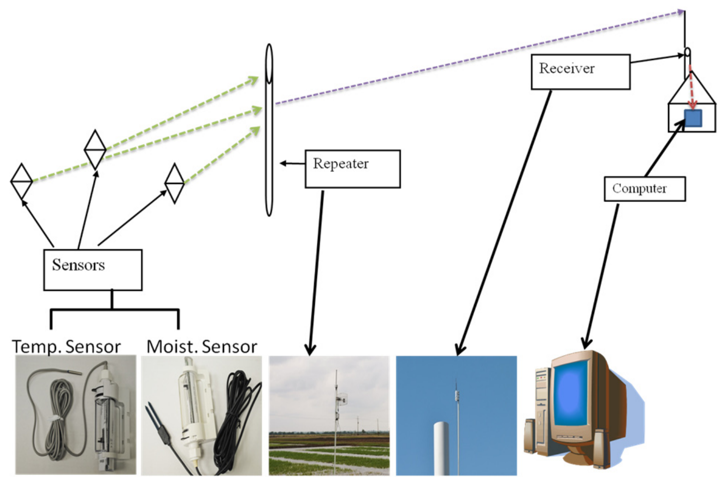

Fig. 1. Wireless Sensor Network in the flax field at Beaumont, Texas, in 2011.

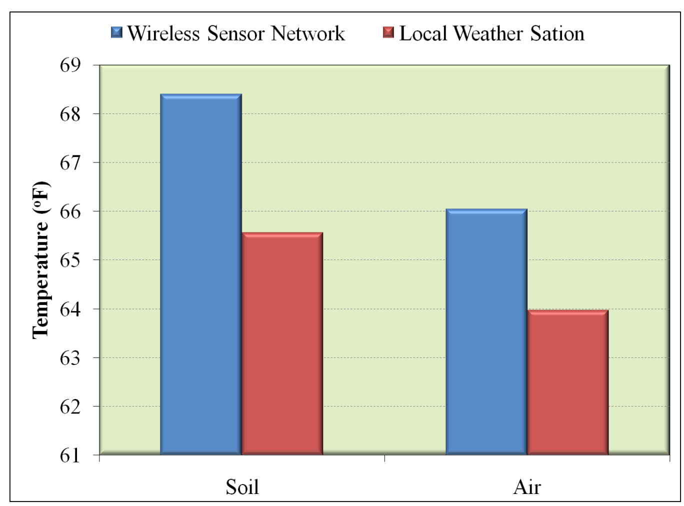

Fig. 2. Soil and air temperatures from the wireless sensor network set up on the flax field and a local weather station located 1,094 meters from the flax field for the month of March 2011.

Weather data of a target location (i.e., the flax field) is more accurately measured with a WSN that is located on that field than when measured from a nearby local weather station. Located 0.7 miles (~1100 meters) from the flax field, the local weather station at Beaumont recorded temperatures lower than the WSN for the soil (3°F) and air (2°F) during the month of March (2011). This accuracy is very important for making decisions such as frequency and intensity of irrigation for large or small fields. The WSN set up is fairly simple and can be easily relocated to other areas at minimal cost and in quick time. The network can also be easily expanded by simply adding other temperature and/or moisture sensors.

Research conducted by Leon C. Holgate, Dr. Abdul Razack Mohammed, and Dr. Lee Tarpley of the Texas A&M AgriLife

Research and Extension Center at Beaumont, TX.

Decreased Seeding Rate is Economically Beneficial for Texas Rice Production

Fig. 1. Seeding rate study at Beaumont in 2009.

Interest in the effect of seeding rate on main crop yield has increased because of the relatively high cost of seed for some varieties. Several presentations on this topic were made at the 2006 Rice Technical Working Group meetings by researchers from Arkansas and Missouri. Research conducted by the Plant Physiology project has shown that yield of the main and ratoon crops of conventional varieties was either positively affected or not affected by 40 and 70 lb/A seeding rates at Eagle Lake and Beaumont during the last several years, while milling was not affected. Main crop grain moisture content and the ratoon grain moisture content in 2007 were significantly greater at harvest indicating a higher amount of tillering at the lower plant density.

In 2009, Cocodrie, CL151, and CL161 were compared at 40 and 70 lb/A seeding rates at Eagle Lake and Beaumont (Fig. 1). The results generally supported previous research. At Eagle Lake, the Cocodrie main crop yield (9,682 lb/A) for the 70-lb seeding rate out-yielded the 40-lb seeding rate (9,409 lb/A). In contrast, the CL151 main crop yield (9,439 lb/A) at the 40 lb/A rate out-yielded the 70 lb/A rate (9,131 lb/A), while seeding rate did not effect the CL161 main crop yield. Neither milling yield nor ratoon crop yields differed between seeding rates for any of the varieties. At Beaumont, the only difference was for the main crop of Cocodrie which yielded 712 lb/A greater at the 70 lb/A seeding rate compared to the 40 lb/A rate. Given that the 40 lb/A rate out-yielded the 70 lb/A rate as frequently as the reverse over the course of several years of study, the conclusion is that a lower seeding rate (40 lb/A) can be economically beneficial for Texas rice producers growing Cocodrie or the Clearfield inbred varieties.

Grain moisture contents were greater for Cocodrie and CL151 main crops at Beaumont for the 40 lb/A seeding rate but did not differ in 2009. These results are consistent with the moisture content typically being higher at harvest for the lower seeding rate, reflecting a greater amount of tillering at the lower plant density.

Summary: A lower seeding rate (40 lb/A) can be economically beneficial for Texas rice producers through decreased seed cost and a slight increase in average yield.

Research conducted by Drs. Lee Tarpley and Abdul Razack Mohammed. This project was supported by the Texas Rice Research Foundation. For more information, contact Dr. Tarpley at 409-752-2741 ext 2235 or ltarpley@tamu.edu.

Development of Sustainable Aerobic Rice Production Systems

Water shortage for crop production is increasingly tied to escalating population pressures, and may be challenged by increasing temperatures attributed to climate change. With increasing competition for limited water resources, there is a need to adopt water-efficient rice production practices. Aerobic rice, which is produced without flooding, can greatly decrease water use and reduce greenhouse gas emissions. While research has shown that methane emissions from flooded rice fields may be declining, emissions of the more damaging nitrous oxide may have increased (Farooq et al., 2009). Illukpitiya et al. (2009) showed that weeds pressure and low grain yield pose major challenges to adopting aerobic rice production in the U.S. Although rice varieties have been found that yield comparable to or slightly lower under aerobic condition compared to flood rice in the tropics (Peng et al., 2006), these yields do not compete economically with what is obtained with flooded rice production in the U.S. Currently, information on varietal selection and nutrient and weed management is lacking for aerobic production in the U.S. To fully determine whether aerobic rice production can work in the U.S. requires development of economically and environmentally sustainable management practices.

The project will examine the influence of water management, soil texture, and rice varieties on 1) the agronomic and yield performance of different rice varieties for a range of water regimes and soil textures, and 2) water use efficiency and methane emissions. To accomplish these objectives, a completely randomized design with three replications will be conducted in 2011. Two rice varieties, Presidio and Rondo, with potential contrasted water resistance, and soils from Eagle Lake and Beaumont will be used. Rice plant tissue and greenhouse gas samples will be regularly collected until maturity. Tissue samples will be used to measure nitrogen content and biomass accumulation. This study will develop critical information on varietal response and water management under aerobic rice production.

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Peng, S.B., B. Bouman, R.A. Visperas, A. Castaneda, L.X. Nie, and H.K. Park. 2006. Comparison between aerobic and flooded rice in the tropics: Agronomic performance in an eight-season experiment. Field Crops Res. 96: 252-259.

Research conducted by Junel Soriano, Fugen Dou, and Rodante E. Tabien. Generous funding for the Aerobic Rice Production System project will be provided by the Fulbright Visiting Scholar Program in Philippine. For more information, contact Dr. Dou at 409-752-2741 or f-dou@aesrg.tamu.edu.

Variety, Nitrogen, and Fungicide Effects on Rice Main Crop Production

Rice varieties perform differently under different soil, climate, and production practices. As a result, research to develop rice production practices for Texas needs to be conducted in Texas. New varieties with contrasting characteristics frequently require different management for optimum yield. Our studies showed that rice variety has a significant effect on rice main crop yield, and that the varietal performance varies with soil properties, nitrogen and disease management. For example, data generated by our Soils and Nutrition Project show that conventional semidwarf varieties respond minimally to N applied near main crop heading, but hybrid varieties that are currently in use in Texas frequently show positive main crop yield and milling increases in responses to N application near heading. Moreover, our results indicate that even the same variety needs different amounts of N fertilizer when planted in different soils due to differences in soil nutrient supply. Our 2010 results indicated that hybrids generally are taller and had greater main crop yield than most inbreds at Beaumont and Eagle Lake. The average yield differences between hybrids and inbreds were 29% and 38% for Eagle Lake and Beaumont, respectively (Figs. 1 and 2). Increasing the N rate slightly increased main crop yield for most hybrids. Besides nutrition, disease management is another concern in rice production. Fungicide application slightly increased main crop yields for most inbreds. Milling quality of hybrids was slightly lower than of inbreds, and it was only slightly affected by nitrogen rate or fungicide application. In 2011, 13 rice genotypes including Catahoula, CL111, CL151, CL162, Clearfield XL729, Clearfield XL745, Cocodrie, Milagro, Presidio, Rex, TXEL0022, TXEL0038, and XL723 are being evaluated at Eagle Lake and Beaumont, in response to nitrogen rate and

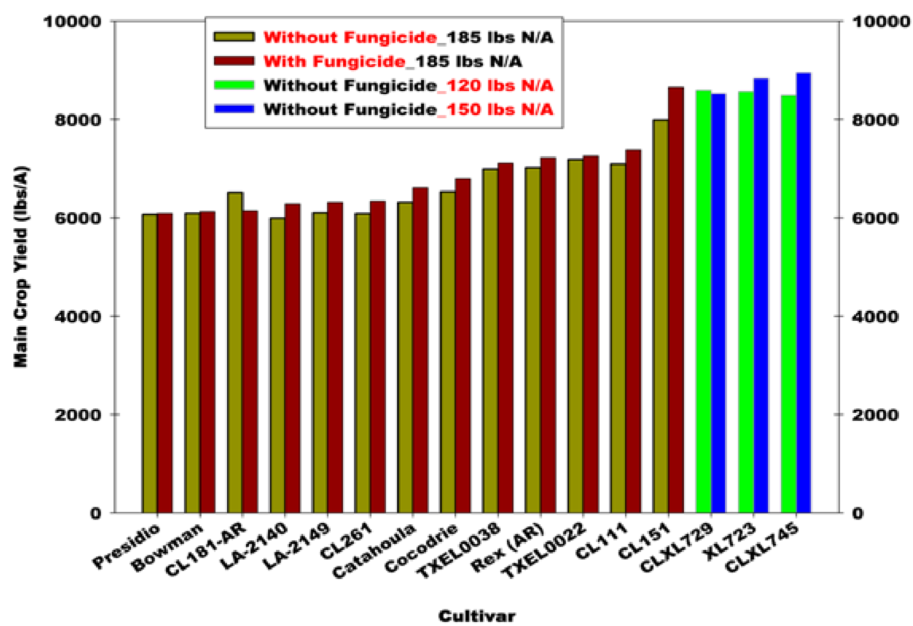

Fig. 1 Main crop yields of various rice varieties as affected by fungicide or nitrogen rates at Eagle Lake in 2010.

fungicide application.

Research conducted by Fugen Dou, Lee Tarpley, Kirill Kostyanovsky, Darrell Hagler, and Jack Vawter. This project was supported by the Texas Rice Research Foundation. For more information, contact Dr. Dou at 409-752-2741 ext 2223 or f-dou@aesrg.tamu.edu.

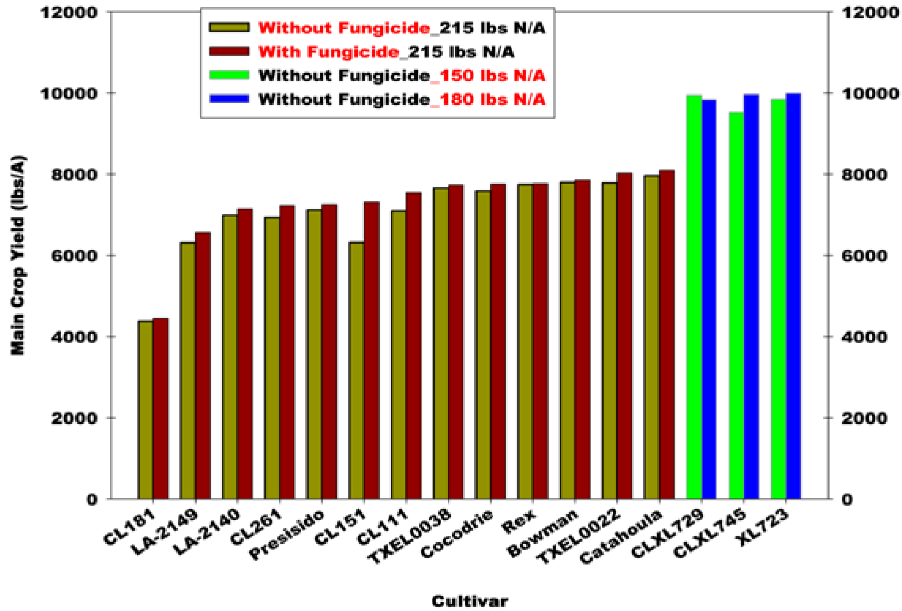

Fig. 2 Main crop yields of various rice varieties as affected by fungicide or nitrogen rates at Beaumont in 2010.

Pest Management

Absorption and Translocation of Newpath in Red Rice as Affected by Sharpen and Light Intensity

Sharpen (Saflufenacil) is a member of the pyrimidinedione family of herbicides, which inhibits the protoporphyrinogen oxidase (PPO) enzyme. Sharpen could be used in combination with herbicides such as Newpath in rice production where additional activity on dicotyledonous weeds is needed. However, Sharpen, a light-dependent membrane-disrupting herbicide, could affect Newpath absorption and translocation depending on light availability. The objective of this study was to investigate the effects of Sharpen postemergence application on Newpath absorption and translocation in red rice plants under four light intensities.

This study was conducted near Beaumont and Eagle Lake in 2009 and 2010. Treatments included two herbicide combinations (Newpath alone and Newpath plus Sharpen) and four levels of light intensity (1066, 677, 259, and 106 µmol/m/s). Newpath was applied at 4 oz/A and Sharpen at 0.010 lb/A. Methylated seed oil (MSO) at 1% v/v was included in all herbicide treatments. Light intensity treatments were obtained by placing shade cloths over the top of the plants inside of the growth chamber. No shade, 30%, 70%, and 90% shade cloths were used in the study. Red rice seeds (TX4 ecotype) were seeded in deep cones containing potting mix. Red rice plants were grown in growth chambers under a 14-h photoperiod and 86°F day and 77°F night temperature regime. Herbicide applications were made at the 3-leaf stage of red rice plants. Within 0.5 hours after application of the formulated products, 5 µL of 14C-Newpath solution with 835 kBq/µmol of specific activity was applied in three positions of the middle section of the leaf surface. Red rice plants were placed and maintained under light regimes according to treatments until harvest. Plants were harvested at 1, 6, 24, 72, and 168 hours after treatment with 14C-Newpath. Plants were sectioned into 1) treated leaf, 2) portion of plant above the treated leaf, 3) aerial portion of plant below the treated leaf, and 4) roots. Plant sections were dried in an oven at 131°F for 72 h. Dried samples were combusted with a biological sample oxidizer. Sample radioactivity was quantified by liquid scintillation spectrometry.

Absorption and translocation of 14C-Newpath increased over time, but less than 15% of radioactive Newpath was absorbed and less than 10% was translocated at 168 hours after treatment. Newpath plus Sharpen treatment provided a higher uptake and translocation of 14C-Newpath than Newpath alone. From the radioactive Newpath absorbed, a higher percentage was translocated to the portion above the treated leaf section at 72 and 168 hours in the Newpath plus Sharpen combination. Harvest timing and light intensity affected translocation of Newpath to the portion below the treated leaf. At higher light intensity, translocation of absorbed 14C-Newpath to the portion below the treated leaf was faster than under lower light intensity. Sharpen enhances absorption and translocation of Newpath in red rice plants.

Research conducted by Edinalvo Camargo (Texas A&M University, College Station, TX, and Conselho Nacional de

Desenvolvimento Científico e Tecnológico, Brazil), Scott Senseman (Texas A&M University, Texas AgriLife Research, College Station, TX), Garry McCauley (Texas AgriLife Research, Eagle Lake, TX), Steven Bowe, John Harden (BASF Corporation, Research Triangle Park, NC), and John B. Guice (BASF Corporation, Winnsboro, LA).

Beneficial Bacteria: A New Potential Management Option for Bacterial Panicle Blight in Rice

Bacterial panicle blight, caused by *Burkholderia glumae*, is thought to be an increasingly important disease of rice in the southern United States and in rice-growing countries of Central and South America and Asia. However, losses in rice grain yield and milling quality caused by the disease is poorly understood. Until detailed data are developed that separate the effect of high temperature induced panicle blight that causes reduced metabolic efficiency from the effects of bacterial panicle blight, the importance this bacteria will remain unclear. Bacterial panicle blight was widespread in Texas, Arkansas, and Louisiana in 2010. Currently, there are no rice varieties with high levels of resistance and no registered chemicals to control the disease in the U.S. Therefore, we initiated a biocontrol study with the aim of utilizing antagonistic bacteria as one component in an integrated management program for bacterial panicle blight on rice.

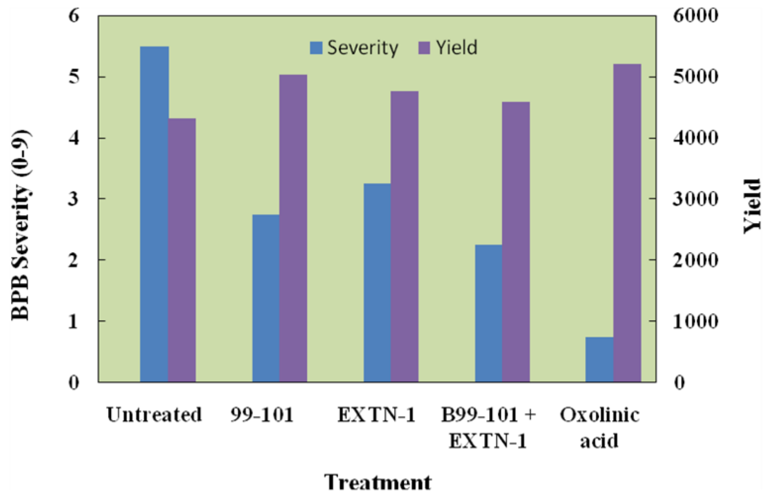

Fig. 1. Efficacy of the beneficial *Bacillus* strains 99-101 and EXTN-1 and the antibiotic oxolinic acid for bacterial panicle blight (BPB) control and yield increase.

In this study, beneficial plant growth-promoting rhizobacteria (PGPR) were evaluated for suppression of bacterial panicle blight in rice under field conditions. Two strains of *Bacillus subtilis, 99-101 and EXTN-1,* that have shown strong antagonistic activity against *B. glumae* in previous in vitro and greenhouse studies were selected for this field experiment. The strains were sprayed individually or in combination into plots of rice plants at the flowering stage. Plots treated with and without oxolinic acid (antibiotic) served as positive and negative controls, respectively. Plots were spray inoculated with *B. glumae* at the flowering stage. Disease severity on rice panicles was assessed on a scale of 0 to 9, where 0 represents no symptoms and 9 represents most severe. Yield was determined at maturity.

The two *Bacillus* strains reduced the severity of bacterial panicle blight by 41 to 50%, respectively, and increased yield compared to the untreated control by 11 to 17% (458 to 715 lb/A) (Fig. 1). A mixture of the strains did not further increase yield compared with each strain alone. Treatment with oxolinic acid reduced disease severity by 86% and increased yield by 21%, relative to the untreated control. Use of PGPR strains may provide a practical solution to minimize damage by bacterial panicle blight in rice.

This research was funded in part by the Texas Rice Research Foundation. We thank Dr. Joseph W. Kloepper at the Auburn University for providing the *Bacillus subtilis* strains for this study.

Research conducted by Drs. Xin-Gen Zhou and Guangjie Liu. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu.

Biocontrol of Sheath Blight and Narrow Brown Leaf Spot in Organic Rice

Organic rice production has significantly increased in Texas over the last decade. Texas organic rice acreage exceeded 16,000 acres in 2007, 2008, and 2009. Production is driven by the increased organic rice market and the unique position of Texas that has the ability to rotate large tracts of fallow lands certified for organic production with cattle operations. Due to prohibition from using synthetic pesticides in organic rice, control of pests including diseases is a particular challenge. Sheath blight (ShB) caused by *Rhizoctonia solani* and narrow brown leaf spot (NBLS) caused by *Cercospora janseana* are among the major diseases found in organically produced rice. The purpose of this study was to evaluate the efficacy of commercially available biocontrol products for management of these diseases.

Table 1. Efficacy of biofungicides for sheath blight and narrow brown leaf spot control and yield increase in organic rice.

Biocontrol Agent, (rate/A)	Sheath Blight (0-9)^z		Narrow brown leaf spot (0-9)^z		Yield (lb/A)	
Serenade Max, 3 lb	2.0	a^y	3.7	b	4,826	a
Serenade ASO, 6 fl qts	2.0	a	4.7	ab	4,115	b
Ballad Plus, 4 fl qts	2.3	a	4.7	ab	4,340	b
Untreated control	3.0	a	5.7	a	4,197	b
$P > F^x$	0.1416		0.0491		0.0092	

^{z}Severity was rated on a scale of 0 to 9 where 0 represents no symptoms, and 9 represents most severe.

^{y}Means in a column followed by the same letter are not significantly different ($P = 0.05$) based on LSD test.

^{x} P values ≤ 0.05 indicate significant differences exist among treatments.

An experiment was established in a field under organic management for many years at Beaumont, TX. Durana white clover and Tam 90 ryegrass were planted in fall 2009 and mowed in spring 2010. Rice variety Jazzman was drill-seeded. Plots were inoculated with the ShB pathogen at the time of panicle differentiation. Narrow brown leaf spot developed from natural inoculum. Plots were sprayed at the booting stage with Serenade Max (*Bacillus subtilis* strain QST713, 14.6% active ingredient), Serenade ASO (*Bacillus subtilis* strain QST713, 1.34% a.i.), Ballad Plus (*Bacillus pumilus* strain QST2808, 1.38% a.i.), or left untreated as the control. Severity of ShB and NBLS was rated near rice maturity on a scale of 0 to 9, where 0 represents no symptoms, and 9 represents most severe in symptoms and damage. Plots were harvested and grain yield adjusted to 12% grain moisture.

Sheath blight developed slowly following inoculation, resulting in low levels of the disease at rice maturity. Narrow brown leaf spot became severe toward rice maturity. Serenade Max reduced NBLS severity, while Serenade ASO and Ballad Plus did not. Among the three biofungicides evaluated, only Serenade Max significantly increased grain yield (Table 1).

This research was financially supported in part by the Texas Rice Research Foundation. We appreciate the biofungicide material support from AgraQuest, Inc.

Research conducted by Drs. Xin-Gen Zhou and Anna A. McClung. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu. USDA is an equal opportunity provider and employer.

Biocontrol-Based Sheath Blight Management to Reduce Fungicide Use on Rice

Sheath blight (ShB) caused by *Rhizoctonia solani* is one of the most important rice diseases in Texas, Arkansas, Mississippi, and other southern states. The lack of complete ShB resistance in the most commonly planted varieties and the severity of this disease results in southern U.S. rice farmers applying more than 1 million pounds of fungicides annually. Hence, there is an urgent need to develop alternative or complementary management options. Combined use of biocontrol agents with reduced rate fungicides can be a viable solution toward this goal. The results of our previous studies suggest that the *Bacillus subtilis* strain MBI-600 was effective in suppressing ShB and was compatible or tolerant to azoxystrobin and other fungicides. Azoxystrobin is one of the most effective and commonly used fungicides for control of ShB. The objectives of the present study were to determine the optimum rates of combined application of the biocontrol agent and azoxystrobin under greenhouse conditions, and evaluate their efficacy for ShB control and impact on yield in the field.

A greenhouse experiment was conducted as a 5 x 7 factorial with 5 concentrations of MBI-600 (0, 103, 106, 109 and 1011 CFU/ml) and 7 rates of azoxystrobin (0, 17, 33, 50, 67, 83 and 100% of the full recommended rate). Sclerotia of *R. solani* were placed on the sheaths of treated plants. Applications of MBI-600 at 109 and 1011 CFU/ml to both seeds and plants at the 3-leaf stage were effective in reducing disease severity with the highest concentration completely eliminating the disease (Fig. 1). ShB severity was significantly reduced with applications of azoxystrobin at 67, 83, and 100% of the full recommended rate to 3-leaf plants. The optimum rates of MBI-600 and azoxystrobin for combined application to achieve maximum ShB control were 109 CFU/ml and 50% of the recommended rate, respectively.

A field trial was conducted in Texas with *R. solani* inoculum introduced into plots at the time of panicle differentiation. MBI-600 was applied as a seed treatment and as a foliar spray, while azoxystrobin was applied as a foliar spray only. Foliar applications of MBI-600 and azoxystrobin (Quadris 2.08 SC) individually and in combination were made at the boot stage. MBI-600, applied to both seed and to foliage at 109 CFU/ml, resulted in a significant reduction in ShB severity over the untreated control (Fig. 2). The combined use of MBI-600 with azoxystrobin at 4.5 fl oz/A further reduced disease severity. The efficacy of this combined treatment was comparable to that of azoxystrobin at 9.0 fl oz/A (the full recommended rate). The combined treatment tended to have higher grain yield than the untreated control and have similar yield to azoxystrobin at 9.0 fl oz/A. The combined use of the biocontrol agent with a reduced rate fungicide may provide a practical means to minimize yield losses caused by ShB, while reducing 50 percent of fungicides use on rice.

We acknowledge the financial support provided by USDA/NIFA SRIPM Grant (2010-34103-21156) for this study.

Research conducted by Drs. Xin-Gen Zhou, K. Vijay Krishna Kumar, Munagala S. Reddy, Guangjie Liu, Joseph W. Kloepper, Yulin Jia, Thomas W. Allen and Shien Lu. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu.

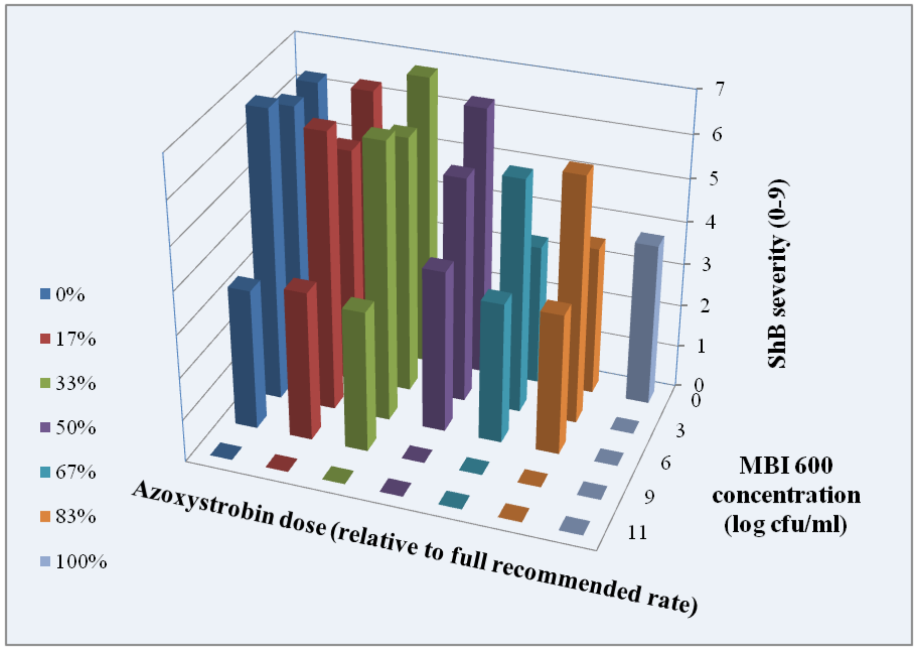

Fig. 1. Individual and combined effects of bacterial biocontrol strain MBI-600 and fungicide azoxystrobin (Quadris) on sheath blight (ShB) severity under greenhouse conditions.

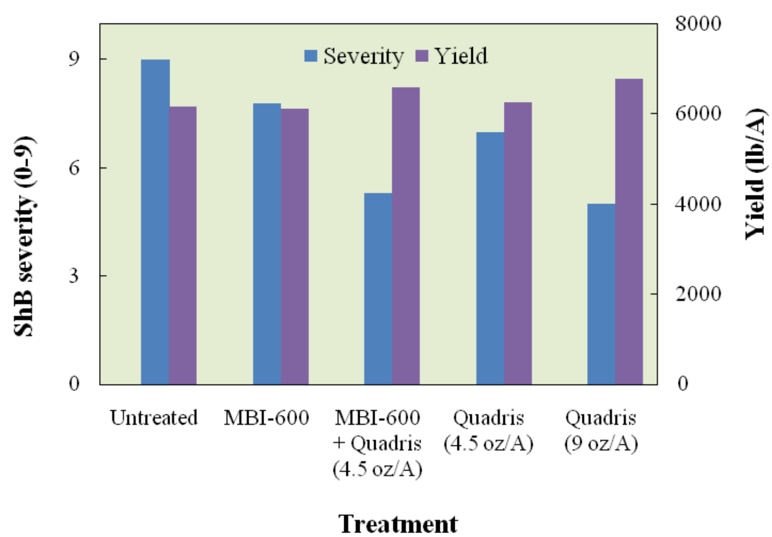

Fig. 2. Effects of bacterial biocontrol strain MBI-600 and fungicide azoxystrobin (Quadris) on sheath blight (ShB) severity and rice yield in the field.

CLEARFIELD* Hybrid Rice Injury as Affected by Application Timing and Rate

CLEARFIELD* rice technology has been available for several years and has helped farmers battle red rice problems since its introduction. Recently, CLEARFIELD* hybrid rice varieties were introduced to maintain the desired herbicide-resistant traits while having the added heterotic benefits of a hybrid. Soon after the hybrid varieties were released, farmers noticed herbicide injury to these new varieties even while following the label recommendations. Texas AgriLife Research was able to perform preliminary trials to test the effect of planting date, planting density, and Newpath application rate on visual plant injury at Beaumont and Eagle Lake, TX. A secondary experiment was designed to test the effect of Newpath application timing and rate on plant visual injury and yield. CLXL 745 was planted at Beaumont, and Eagle Lake Each study had one early post-emergence herbicide application (at the 1 to 2-leaf stage) and one of two different late post-emergence applications, either a 3- to 4-leaf or a 5- to 6-leaf treatment. The three rates included in the early application were 0, 2 and 4 oz a.i./A, while the four rates included in the late application were 0, 4, 6, and 8 oz a.i./A. Plots were evaluated for visual injury at two-week intervals after the second application. Plants showed no significant differences in grain yield or quality. There were no significant differences in visual injury; however, significant differences were recorded in height. According to these data, hybrid rice seems to be tolerant to Newpath applications and timings.

Research conducted by Aaron L. Turner (Texas AgriLife Research, College Station, TX), Dr. Scott A. Senseman (Texas AgriLife Research, College Station, TX), and Dr. Garry N. McCauley (Texas AgriLife Research, Beaumont, TX).

Comparison of Disease Severity and Yield Potential of Rice Varieties in Two Organic Cropping Systems

The market demand for organically produced rice has driven the steady increase in acreage of organic rice in the U. S., with Texas and California having the most acreage. Yield potential and disease management are among the principal challenges associated with organic rice production. Organic rice can be produced in different production systems, and disease severity and yield potential may vary from one system to another.

The objectives of this research was to evaluate 27 rice varieties and breeding lines to determine their response to diseases under two different organic cropping systems in 2010. For the first cropping system, Durana white clover was planted in fall 2009, plowed down in spring 2010, followed by tillage, and water-seeding. For the second system, Durana white clover was planted as in the 1st cropping system but mowed prior to planting rice. Dry rice seed was directly seeded using a no-till drill into the mowed clover. Diseases were monitored throughout the cropping season. Diseases severity was assessed using a scale of 0 to 9, where 0 represents no symptoms and 9 represents most severe. Grain yield was determined near maturity.

Fig. 1. Symptoms of straighthead Note the “parrot beak” shaped hulls of grains. (Photo by Dr. X. G. Zhou).

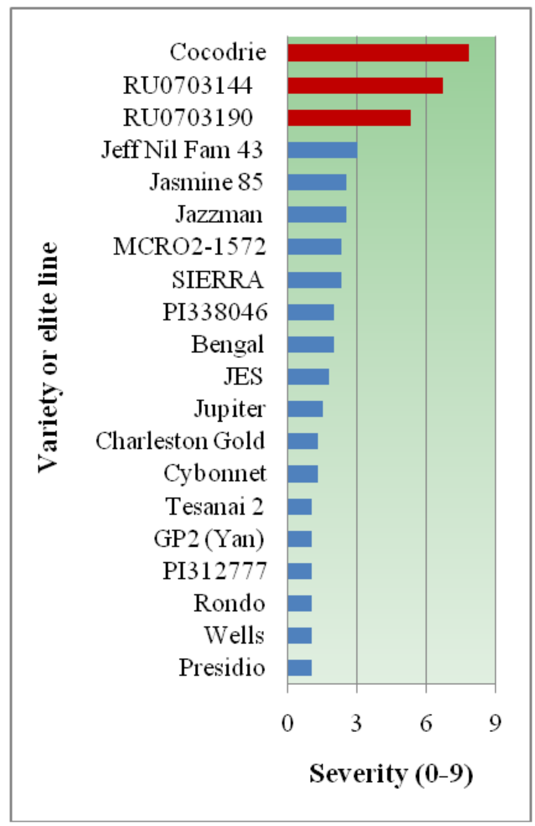

Fig. 2. Severity of straighthead in 20 rice varieties and elite lines under the no-till organic cropping system.

Narrow brown leaf spot caused by *Cercospora janseana* was severe on Jazzman, Presidio, Sierra, Cocodrie, RU0703144, and RU0703190 in both cropping systems. In the no-tilled production system with a significant amount of previous cover crop residue, straighthead (Fig. 1) caused by unknown physiological disorders occurred in all varieties, with Cocodrie, RU0703144, and RU0703190 having the most severe symptoms (Fig. 2). Brown spot caused by *Cochliobolus miyabeanus* was also commonly present in both production systems, whereas sheath blight caused by *Rhizoctonia solani*, bacterial panicle blight caused by *Burkholderia glumae*, and leaf smut caused by *Entyloma oryzae* were minor in severity for the majority of the varieties. The varieties

Tesanai 2, GP2, Rondo, PI312777, and PI338046 had the lowest levels of all of these diseases and produced grain yields that ranked among the highest in both cropping systems. Tesanai 2, a variety from China, outyielded all other varieties and lines. These results can help to identify rice varieties suitable for organic production relative to disease susceptibility and yield potential.

This research was funded in part by the Texas Rice Research Foundation.

Research conducted by Drs. Xin-Gen Zhou and Anna McClung. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu. USDA is an equal opportunity provider and employer.

Efficacy of Fungicides for Control of Sheath Blight and Narrow Brown Leaf Spot in Rice

Fungicides are essential for effective management of rice diseases such as sheath blight (ShB) and narrow brown leaf spot (NBLS). Sheath blight caused by *Rhizoctonia solani* and NBLS caused by *Cercospora janseana* are among the most common diseases in rice in Texas and other southern states (Groth and Lee, 2003). Selection and application of an effective fungicide at a proper time and rate are key to reducing control costs and maximizing production return. Azoxystrobin-containing fungicides (e.g., Quadris) are most effective in controlling ShB, while propiconazole-containing fungicides (e.g., PropiMax) are most effective in controlling NBLS. In 2009, QuiltXcel, a newly formulated fungicide produced by Syngenta, received Section 3 registration from the EPA. QuiltXcel is a new formulation of azoxystrobin + propiconazole, containing 2x the amount of azoxystrobin than Quilt. QuiltXcel may provide a better fit for rice producers who plant varieties that are highly susceptible to ShB and NBLS.

Two field trials were conducted in 2010. The 1st trial was established at Eagle Lake to evaluate the efficacy of QuiltXcel, Quilt, and Quadris for control of ShB. The 2nd trial was established at Beaumont to identify the best timing and rate of PropiMax (propiconazole) for control of NBLS in the main and ratoon crops. The rice variety for both trials was Cocodrie. Severity of ShB and NBLS was assessed near maturity using a scale of 0 to 9, where 0 represents no symptoms and 9 represents most severe. Grain yield and milling quality were also determined. For the 1st trial, plots were inocluated with the ShB pathogen at the time of panicle differentiation (PD). Two weeks after inoculation, plots were sprayed with fungicides individually. Applications of QuiltXcel (17 fl oz/A), Quilt (28 fl oz/A), and Quadris (9 fl oz/A) equally reduced the ShB disease, and increased grain yield and head rice percentage compared to the unsprayed control (Fig. 1).

For the 2nd trial, the experimental design was a three-factorial (fungicide rate, and main and ratoon crop growth stages). PropiMax (propiconazole) was applied at 0, 5 and 10 fl oz/A at the boot or heading stages of the main crop and at the boot stage of the ratoon crop. NBLS developed from natural inoculum. All fungicide treatments were effective at reducing NBLS severity. At the full labeled rate (10 fl oz/A), PropiMax applied at boot on the main crop tended to have higher yields for the main crop (532 lb/A increase) as well as for the ratoon crop (437 lb/A increase). Either rate of PropiMax equally reduced NBLS severity regardless of the application stage. Ratoon crop plots that received fungicide applications had less NBLS severity compared to untreated plots. All fungicide timing and rate treatments improved the ratoon crop head rice milling quality. These results indicate that fungicide application at boot stage is more effective than the application at heading. Boot stage is the best stage to apply a fungicide for control of NBLS on both main and ratoon crops.

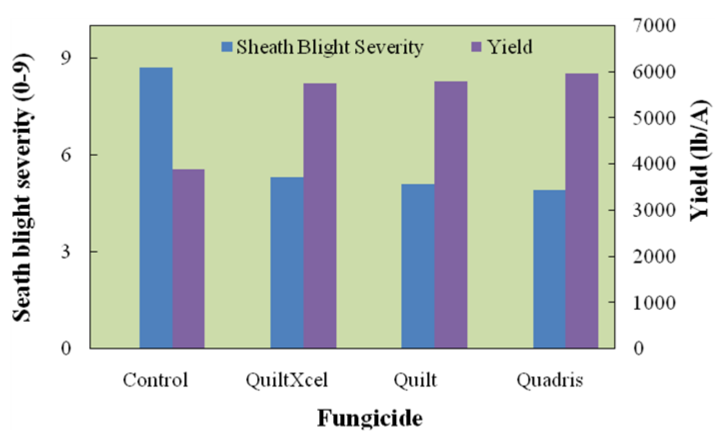

Fig. 1. Effects of fungicides on sheath blight severity and yield in 2010.

This research was funded in part by the Texas Rice Research Foundation. We thank Dow AgroSciences and Syngenta for providing the

agrochemical materials.

Literature Cited:
Groth, D., and Lee, F. 2003. Rice diseases. p. 413-436. *In* C. W. Smith and R. H. Dilday (ed.). Rice Origin, History, Technology, and Production.. John Wiley & Sons, Hoboken, NJ.

Research conducted by Drs. Xin-Gen Zhou, Guangjie Liu and Jack Vawter. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu.

Fertility-Based Herbicide Recovery from Clomazone Herbicide in Hybrid Rice

Field and laboratory studies were conducted to evaluate the effect of fertility on Command injury in hybrid rice. Hybrid rice was drill-seeded in two field locations near Eagle Lake and Ganado, TX, at 0.35 lb/A. In the first objective, Command was applied pre-emergence at 6 rates (0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 lb a.i./A) to produce a standard curve of Command herbicide injury. Visual injury ratings and plant heights were recorded at four sampling dates between Command application and physiological maturity. Tissue samples were collected at each sampling date for chlorophyll content analysis in the laboratory. In the second objective, Command was applied uniformly to field plots to induce injury symptoms. After initial visual injury ratings were recorded at the 4- to 6-leaf growth stage, tissue samples were collected and remediation treatments were applied. Treatments consisted of two common forms of nitrogen fertilizer (ammonium sulfate and urea) and two foliar-applied micronutrient fertilizers (iron sulfate and magnesium sulfate) at different combinations of rates and application timings. Visual injury ratings and plant heights were recorded at four sampling dates between herbicide application and physiological maturity. Tissue samples were collected at each sampling date for chlorophyll content analysis. Grain yield data was taken from all plots. Initial visual injury ratings for the standard curve plots near Eagle Lake were statistically higher in plots that received higher rates of Command. Later visual injury ratings and plant height measurements showed no differences between treatments. However, grain yield of control plots (no Command applied) were statistically different. There was no difference in visual injury ratings and grain yield among the herbicide injury remediation plots. Plant height was different in plots receiving only foliar-applied micronutrient fertilizers when compared to plots receiving nitrogen fertilizers. Visual injury ratings for the standard curve plots near Ganado showed that the highest injury ratings were in plots that received higher rates of Command. There were no differences in plant height or grain yield throughout the study. Visual injury ratings were not different among herbicide injury remediation plots at Ganado. Plant height and grain yield were highest in plots that received the highest rates of nitrogen. Initial laboratory results from chlorophyll extraction showed chlorophyll content decreases as the rate of Command increases in the standard curve study.

Research conducted by B.M. McKnight, S.A. Senseman (Texas AgriLife Research & Texas A&M University, College Station, TX), and G.N. McCauley (Texas AgriLife Research, Eagle Lake, TX.)

Field Evaluation of Rice Varieties for Resistance to Major Diseases

The development and use of improved disease resistance rice varieties remains of foremost importance to rice producers, with field evaluation under local environments essential. In this study, we evaluated new and existing varieties, potential releases, and Texas elite breeding lines for resistance to sheath blight caused by *Rhizoctonia solani*, bacterial panicle blight caused by *Burkholderia glumae* or *B. gladioli*, and narrow brown leaf spot caused by *Cercospora janseana*.

Fig. 1. Field plots to evaluate disease resistance in rice (photo by Dr. X. G. Zhou).

More than 48 varieties and elite lines were evaluated in five trials at Beaumont and Eagle Lake in Texas during 2009 and 2010 (Fig. 1). The Beaumont test site has a clay soil and high humidity, while Eagle Lake has sandy soil and a less humid environment. Sheath blight was introduced into field plots by inoculation. Narrow brown leaf spot developed from natural infection. Bacterial panicle blight developed from either natural infection or bacterial inoculum sprayed on panicles at heading stage. All but a few varieties and lines were susceptible or very susceptible to sheath blight with disease severity ratings of 5 or above on a 0 to 9 scale. CL142-AR, Jasmine 85, Milagro Filipino, Templeton, Rondo, and the hybrid XL723 showed partial resistance to sheath blight. All varieties and lines were susceptible to bacterial panicle blight, except for Catahoula, Jupiter, Spring, XL723, and the two TX elite lines, RU0703190 and RU0703144, which showed partial resistance. All of the varieties, except for CL181-AR, Jazzman, Sabine, and Sierra, were resistant or moderately resistant to narrow brown leaf spot.

This research was funded, in part, by the Texas Rice Research Foundation.

Research conducted by Drs. Xin-Gen Zhou, Rodante E. Tabien and Anna A. McClung. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu. USDA is an equal opportunity provider and employer.

Fungicide Seed Treatment to Control Rice Seedling Diseases

Seedling diseases are caused by various soil-borne and seed-borne fungi including *Rhizoctonia solani*, *Sclerotium rolfsii*, *Fusarium* spp., and *Pythium* spp. Infections by these pathogens can cause irregular, thin stands, and weakened plants. Seedling diseases are typically more severe in early plantings when the soil is cold. Severe seedling diseases may result in the need to replant. Seed treatment with fungicides can be an effective tool to manage seedling diseases. The objective of this study was to evaluate the efficacy of different fungicide seed treatments for seedling disease control and yield impact under different environments.

Fig. 1. Plant stands in plots with CruiserMaxx-treated seeds (front left) and untreated seeds (front right) (photo by Dr. X. G. Zhou).

Two field trials at Beaumont and one at Eagle Lake were conducted in 2010. The soil is clay at the Beaumont test site, and sandy at the Eagle Lake test site. Both fields had been cropped with rice for many years and had a history of seedling diseases. Eight fungicides were evaluated. CruiserMaxx manufactured by Syngenta contains Maxim 4FS (fludioxonil), Dynasty (azoxystrobin), Apron XL (mefenoxam) and Cruiser 5FS (thiamethoxam). Trilex 2000 (trifloxystrobin and metalaxyl) and the experimental product L1875-A are manufactured by Bayer CropScience, while the experimental products V-10226, V-10230, V-10260, V-10320 and V-10321, contain Nipsit INSIDE (Clothianidin) and are manufactured by Valent. Prior to planting, seeds of the variety Cocodrie were treated with CruiserMaxx at either the full recommended rate or 1/2 the full rate, or with one of the other seed treatments individually. Untreated seeds served as the control. Stands and seedling vigor were assessed at 3 to 4 weeks after emergence. Grain yield was determined at maturity.

Reduced plant stands were high in the untreated control plots in all trials. CruiserMaxx at the full and half rate increased stands by 23 to 57% depending on the test location (Fig. 1). CruiserMaxx at the full rate increased grain yield by 15 to 22%. Both seed treatments improved seedling vigor and percent head rice milling yield. However, CruiserMaxx at half rate was not effective in increasing yield. Each of the other seed treatments had a similar effect on increasing stands, improving seedling vigor, and increasing yield. The results of these trials indicate that fungicide seed treatment can effectively reduce seedling diseases and increase yield under Texas environments.

This research was funded in part by the Texas Rice Research Foundation. We appreciate the financial support from Bayer CropScience and Valent and the chemistry material support from Syngenta.

Research conducted by Drs. Xin-Gen Zhou, Guangjie Liu and Jack Vawter. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu.

Highlights of Entomology Project Research in 2010-2011

The Entomology Project (EP) continues to serve stakeholders by developing new rice pest management tools, revising treatment thresholds, and developing comprehensive integrated pest management (IPM) programs for rice water weevil, chinch bug, aphids, thrips, fall armyworm, stalk borers, and rice stink bug.

In 2011, we helped to obtain an Experimental Use Permit (EUP) for NipsIt INSIDE, which is an effective seed treatment for rice water weevil and certain seedling pests of rice. Under this EUP, up to 10,000 acres of rice can be treated in 2011. Other insecticidal seed treatments labeled for rice are Dermacor X-100 and CruiserMaxx Rice.

In 2010, we evaluated Belay 2.13EC (clothianidin = active ingredient) as a postflood (10 days after flood) treatment for rice water weevil control. Currently, seed treatments and application of pyrethroids/diflubenzuron before and soon after flood are effective. A later postflood treatment, such as Belay 2.13EC at 10 days after flood, can serve as a “rescue” application to control the larval stages of this root-feeding pest. Table 1 shows Belay 2.13EC provided significant control of rice water weevil in 2010. In 2011, we are evaluating both Belay 2.13EC and dinotefuran 3G applied 10 days after flood for the control of rice water weevil. Also, we continue to evaluate the above 3 seed treatments for control of major pests, and minor pests of rice, such as chinch bug, thrips, and aphids. Seeding rate studies of 15, 25 and 35 lb/A for a hybrid variety (XP 753) are being conducted to determine if seeding rate affects efficacy when applied at recommended labeled rates.

We will continue to monitor movement of the Mexican rice borer, which has become an important pest of Texas-grown rice. This pest invaded the Texas Rice Belt in 1988 and has gradually moved north and east. Today, the Mexican rice borer is found throughout the Texas Rice Belt, including Orange County where it was first detected in pheromone traps last year (Table 2). We work very closely with Dr. Gene Reagan and his staff at the LSU AgCenter to develop an IPM program for this pest, which has been recently found in Louisiana where it threatens the rice and sugarcane industries.

We will evaluate Endigo ZC for control of rice stink bug in 2011. This foliar-applied insecticide contains 2 active ingredients, lambda-cyhalotrhin and thiamethoxam. Thus, it provides contact and residual control of the rice stink bug. Results in 2010 suggest Endigo ZC provides long-lasting control of rice stink bug equal to Tenchu 20SG.

We continue to try to solve pest problems for our clientele. Do not hesitate to contact me for additional information or suggestions to make the EP more responsive to our rice industry. As always, we thank the Texas Rice Research Foundation for generous support of our research and extension activities.

Research conducted by Mo Way, Mark Nunez, and Becky Pearson. Texas A&M AgriLife Research and Extension Center at Beaumont. For more information, please contact Mo Way at 409-658-2186 or moway@aesrg.tamu.edu.

Update on Rice Disease and Bacterial Panicle Blight Occurrences in Texas

Diseases or disease-like symptoms that are common locally include rice blast (*Magnaporthe oryzae*), brown spot (*Cercospora janseana*), sheath rot (*Sarocladium oryzae*), stem rot (*Magnaporthe salvinii*), false smut (*Ustilaginoidea virens*), kernel smut (*Tilletia barclayana*), pecky rice (various fungi and bacteria and insect injury), and straighthead (a physiological disorder with unknown causes). Sheath rot has increased in severity in recent years especially on the ratoon crop. Straighthead can be problematic in fields with sandy loam soil, arsenic residues, or in fields that have an abundance of non-decomposed organic matter. Minor diseases include black kernel (*Curvularia lunata*), crown sheath rot (*Gaeumannomyces graminis*), leaf smut (*Entyloma oryzae*), leaf scald (*Microdochium oryzae*), stackburn (*Alternaria padwickii*), and sheath spot (*Rhizoctonia oryzae*).

Fig. 1. Symptoms of bacterial panicle blight on rice (photo by Dr. X. G. Zhou).

In 2010, panicle blight was widespread throughout the Texas Rice Belt. Bacterial panicle blight, caused by *Burkholderia glumae*, is thought to have contributed to yield losses last year. However, the effect of this disease on yield is poorly understood and the symptoms and yield losses caused by this disease are easily confused with those causes by elevated temperatures. We know bacterial panicle blight can cause partially filled or aborted grain (Fig. 1). Symptoms began to appear at heading, with infected florets initially showing discoloration ranging from light green to light brown on the basal portion with a reddish-brown margin separating this area from the rest of the floret (Fig. 2). Main crop disease symptoms were most prevalent with CL111, CL261, Cocodrie, and Francis. Symptoms were also present in the ratoon crop but at a lower level. Bacterial panicle blight was first detected in high levels in the U.S. in 1995. In 2010, it occurred in Arkansas, Louisiana, Mississippi, Texas, and Missouri. Ongoing research focuses on unraveling the respective effects of high temperature and bacterial panicle blight on panicle blight.

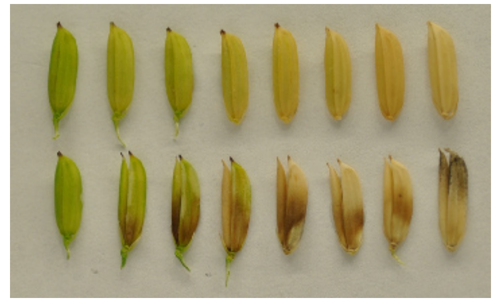

Fig. 2. Developmental symptoms of bacterial panicle blight on infected kernels (lower row) relative to healthy kernels (upper row) (photo by Dr. X. G. Zhou).

We sincerely appreciate the financial support provided by the Texas Rice Research Foundation and the crop consultants Cliff Mock, Glenn Crane and J. J. Schmidt for their assistance in field disease surveys for this study.

Research was conducted by Drs. Xin-Gen Zhou, Mo Way, Lloyd T. Wilson, Garry McCauley, Rodante E. Tabien, and Young-Ki Jo. For more information, please contact Dr. Xin-Gen (Shane) Zhou at (409) 752-2741 or xzhou@aesrg.tamu.edu.

Alternate Crops

Effects of Winter Legume Cover Crop and N Fertilization on Biomass Sorghum Yield

Agricultural biomass production is an alternative source of energy with reduced greenhouse gas emissions relative to petrochemical industry sources. Increased N fertilization requirements by the high-yielding bioenergy crops, however, can result in increased greenhouse gas emissions and reduced groundwater quality. Legume cover crops are known to increase crop yields via N fixation compared to fallowing. Sorghum-sudangrass [*Sorghum bicolor* (L.) Moench], in combination with winter legume cover crops as N sources, is expected to be a promising biofuel feedstock that should readily fit into crop production systems in Texas.

The objective of this study is to evaluate the effects of N sequestration by legume cover crops on subsequent sorghum-sudangrass growth and yield. Bigbee clover (*Trifolium berytheum* Boiss. & Bl.) and Hairy vetch (*Vicia villosa* Roth) were selected as winter cover crops for the study. The study was established at the Beaumont Center in October 2010 as a split plot design, with the cover crop type (Bigbee clover, Hairy vech, and no cover crop control) as a main factor and urea N fertilization at the variable rate (0, 40, 80, and 120 lb N/A) as a sub-factor. The site was fertilized with potash and triple superphosphate on October 5, 2010 at 50 lb K_2O/A and 50 lb P_2O_5/A per soil test recommendations, and the cover crops were planted on October 6, 2010 (Fig. 1). The recommended seeding rates of 20 lb/A for Bigbee clover and 40 lb/A for Hairy vetch were used. Fertilizer N was applied in May 2011 prior to planting sorghum. The biomass sorghum N content and biomass yield will be determined as a function of the N cover crop sequestration and urea N applied.

Fig. 1. Established Bigbee clover cover (left) and Hairy vetch cover (right). Picture taken by Kirill Kostyanovsky on November 16, 2010.

Research conducted by Kirill Kostyanovsky, Lee Tarpley, Fugen Dou and Darrell Hagler. This project was supported by

the Texas AgriLife Bioenergy Research Foundation. For more information, contact Dr. Dou at 409-752-2741 ext 2223 or f-dou@aesrg.tamu.edu.

Growth, Development, and Yield Analyses of Energy Cane Varieties

Due to the U.S. government mandate for major increases in biofuel supplies, the production of cellulosic crops, primarily energy cane and high biomass sorghum, is expected to expand rapidly over the next several years in the Upper Gulf Coast region. To select energy cane varieties with the greatest potential in biomass production, it is important to understand key physiological processes involved with photosynthesis and nodal production. In this study, field experiments were conducted to provide detailed data on management, growth, development, and yield on multiple energy cane varieties.

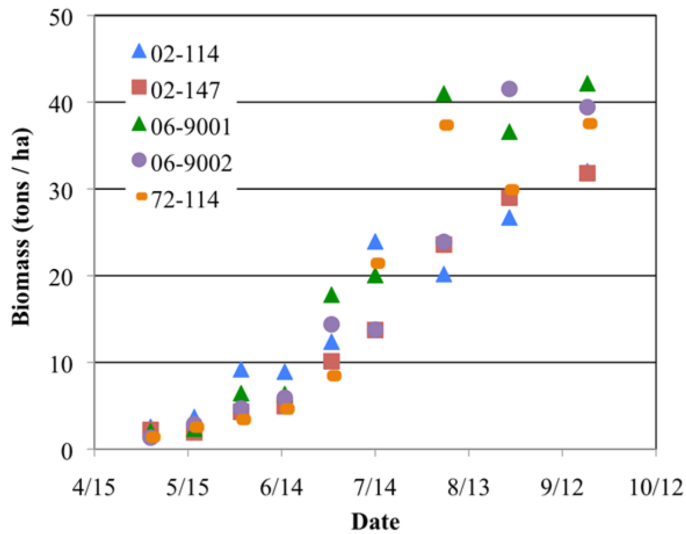

Fig. 1. Biomass for five energy cane varieties throughout the growing season at Beaumont, TX, in 2010.

In 2009 and 2010, detailed yield sampling was conducted on 9 varieties (00-961, 01-07, 02-144, 02-147, 06-9001, 06-9002, 72-114, 95-988, and 99-233) to estimate number of stalks per unit area, plant height, culm diameter, green and dry weight, sugar content, post sugar extraction dry weight, and water content. In 2010, destructive sampling was conducted 9 time ca. once every two weeks from May 4 until maturity during the course of crop development on each of 5 varieties (02-144, 02-147, 06-9001, 06-9002 and 72-114), with the following data estimated: 1) cane height and number of nodes, 2) stem length, diameter, and dry mass for each node, 3) leaf blade length, width, area, and dry mass, and 4) leaf sheath length and dry mass.

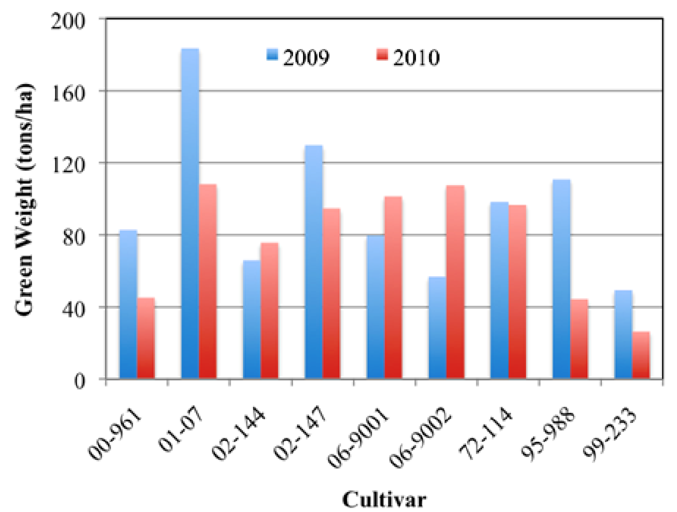

Fig. 2. Green weight for the nine energy cane varieties sampled at Beaumont, TX, in 2009 and 2010.

Yield sampling showed that cane densities range from 0.4 x 10^5 to 2.6 x 10^5 ha^{-1} across the two years, with 06-9001 and 99-233 having the highest and lowest culm densities, respectively. Green weight, juice weight, and sugar weight ranged from 26 to 184, 12 to 91, and 2 to 12 tons ha^{-1}. In both years, 01-07 produced the greatest yield. The average yield in 2010 was lower than that in 2009, which was partially due to the unusually cool weather that reduced overwintering tiller bud survival, and extended periods of lower than normal rainfall (Fig. 2).

Throughout the season, 06-9001, 06-9002, and 72-114 produced a greater amount of biomass than 02-144 and 02-147 (Fig. 1). Biomass continued to increase until mid August for 06-9001, 06-9002, and 72-114, and until October for 02-144 and 02-147, with the highest biomass reaching ca. 40 tons (dry weight) per ha. The seasonal pattern of increasing cane height is consistent with biomass increasing. By the end of the season, 06-9001, 06-9002, and 72-114 were the tallest, followed by 02-147, and 02-114. Energy canes produced a maximum of 17 to 23 above ground nodes, with leaf area index reaching a maximum in early August.

Research conducted by Jiale Lv, Lloyd "Ted" Wilson, and Yubin Yang. For additional information, please contact Dr. Lv at (409) 752-2741 or lvjiale@aesrg.tamu.edu.