very important for normal seed germination and seedling growth.

Do not plant varieties with low seedling vigor before the recommended planting dates and soil temperatures. They are more susceptible to environmental hazards, such as disease, cool temperature and salt damage associated with planting too early in the growing season.

Planting earlier than March 15 can result in good

The chapter on Planting Dates (Tarpley et al., 2008) in the Texas Rice Production Guidelines states that:

**Optimum planting dates vary with location. They range from March 15 to April 21 in the western area and from March 21 to April 21 in the eastern area.**

However, planting after April 15 reduces ratoon crop potential. Also, planting is not recommended when the 4-inch daily minimum soil temperature falls below 65 degrees F. The 4-inch minimum soil temperature is an indicator of residual heat in the soil, which is

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Fig. 1. Impact of harvest date on rice yield for 2005 to 2009 on 2,626 fields and 252,149 acres.
Welcome to the April issue of *Texas Rice*. The cover story is by Dr. Garry McCauley. Garry’s research program during his 35 years with the Texas A&M University System AgriLife Research and Extension Center has focused on a number of areas. Collectively, this has helped to shape him as the Center’s expert on water, agronomic, and weed management. Some of Garry’s earlier research helped to lead to the development of water saving rice management strategies which greatly reduced the amount of water used to irrigate rice, cutting height research which shows that the highest ratoon crop yields is consistently achieved with the lowest cutting height, and his herbicide research that led to the release and wide-scale adoption of the Command herbicide across much of the U.S. ricebelt.

Garry’s current article focuses on the effects of planting date on rice yield, and whole grain and total milling yields for a 4 county rice producing area that is to the west of Houston. The take home messages that I gathered from his research is that while it is generally known that yield and grain quality decreases later the planting date, the exact relationship is a bit difficult to pin down and be able to always choose the best planting date. As Dr. McCauley states,

*A production plan should be created during the winter months. Planting date is one of the most critical management components of the rice crop, but probably the most difficult to execute on time. Weather and soil conditions greatly influence planting date so that achieving the planned planting date is very difficult.*

The second article in this issue is by Dr. Guanjie Liu and co-workers. Guanjie recently joined our Center, as a Research Scientist as part of our newly re-initiated plant pathology program. His supervisor, Dr. Shane Zhou, is also new to the Center having joined us last June. It is extremely exciting to see the Center return to having a full-blown plant pathology program. In the early 1990s, Glen Whitney, who was the Center’s Texas A&M University Plant Pathologist retired and his position was not refilled. About 10 years later, Dr. Tony Marchetti retired from USDA-ARS. When USDA decided not to fill this position, this resulted in the Center no longer having any plant pathology research, and not having a scientist who could adequately address plant pathology problems. As a result, our scientist and rice producers were forced to turn to our neighbors in Louisiana to address this need. Dr. Don Groth, who is a high competent rice plant pathologist at LSU’s Crowley Rice Research Center, stepped to the plate and provided badly needed advise.

As Dr. Zhou’s rice plant pathology program gears up, both the rice industry and our Center look forward to his development of improved solutions to rice plant pathogen problems. Shane has already hit a home run as the lead author on a nationally competitive multi-state southern region integrated pest management grant that focuses on rice disease management. This grant will allow Shane to more quickly develop solutions to rice disease problems that will benefit our Texas rice producers. With Guanjie working as his Research Scientist, all indications are that our new plant pathology team will be very productive.

Please keep on sending us your suggestions.

Sincerely,

L.T. Wilson
Professor & Center Director
Jack B. Wendt Endowed Chair in Rice Research
Rice is the staple food for approximately half of the world’s population. Sheath blight (SB) (Fig. 1), caused by the soil-borne fungal pathogen *Rhizoctonia solani*, is one of the major constraints for rice production worldwide. In the United States, sheath blight can cause rice yield losses up to 50% under environmental conditions that are favorable to the disease pathogen (Marchetti and Bollich, 1991). The *R. solani* fungus has a broad host range and attacks many plants including rice rotation crops such as soybeans. So far, complete resistance to this fungus has not been identified in cultivated rice worldwide. Hence, sheath blight is primarily managed by the use of fungicides and cultural practices. Despite the lack of complete resistance, substantial quantitative resistance to the sheath blight pathogen has been observed in the rice germplasm (Fig. 2). This resistance is controlled by multiple genes at different genetic loci known as quantitative trait loci (QTLs) (Table 1). In order to use this for crop protection, significant progress in phenotyping methods and in identifying resistant QTLs have been made, some of which are highlighted in this article.

**Disease Resistance Evaluation Methods**

A simple and accurate evaluation method is critical in making the correct assessment of disease reactions and screening for disease resistance. Several evaluation methods for disease reactions and disease resistance have been developed over the past decade. Historically, disease reaction to pathogens in rice plants is evaluated in replicated field experiments. A number of methods have been developed to inoculate field plots for inducing the development of sheath blight. These methods include the use of colonized toothpicks (Zou et al., 2000), liquid inoculum injection (Sato et al., 2004), and solid inoculum broadcasting onto rice plants (Marchetti et al., 1991). In the toothpick inoculation method, autoclaved toothpicks incubated with sheath blight on potato dextrose broth medium for 3 to 5 days are placed behind the leaf collar of the third leaf sheath, counting from the top, at the first stem elongation stage. In
the liquid inoculum injection method, the third leaf sheath from the flag leaf is injected, using a plastic syringe, with liquid mycelium inoculum prepared in potato sucrose agar at heading date. In the solid inoculum broadcasting method, rice plots in the field are inoculated by evenly spreading (broadcasting) the pathogen-infected mixture of rice hulls and rough rice (2:1, v/v) at 58 to 62 days after seedling emergence. However, the evaluation of disease reaction in field plots is often laborious and time-consuming, and is the fundamental bottleneck of genetic studies and germplasm screening.

Inoculation techniques under controlled conditions have also been developed. They include the detached leaf (Jia et al., 2002), mist chamber, and micro-chamber assays (Jia et al., 2007). In the detached leaf assay, pieces of rice leaves 4 inches in length are lined on water-saturated paper tissue in a plastic box and placed at the middle of the leaves with sheath blight mycelium discs excised from potato dextrose agar medium. In the mist chamber assay, rice plants are inoculated and evaluated in a 4 x 3 x 2 meter mist chamber at 50 days after sowing. In the micro-chamber assay, the susceptibility to sheath blight of rice seedlings at the 3rd to 4th leaf stage can be evaluated. A mycelium disc is placed at the base of a rice seedling in a pot covered with a 2- or 3-L soft drink bottle with the bottom removed. Among these three methods, the micro-chamber method (Fig. 3), originally developed by rice breeders in Bangladesh, is one of the most widely used. This method has been used for sheath blight resistance research in a number of labs in the U.S. and South America (Jia et al., 2007). The micro-chamber method creates a favorable environment to encourage the infection and growth of the sheath blight fungus in rice seedlings. Compared to field plot evaluation, the micro-chamber assay has the following advantages: 1) it minimizes morphologically confounding factors on sheath blight resistance by using younger rice seedlings; 2) a shorter period of time (3 to 5 weeks) is needed to complete an evaluation; 3) less experimental space is required; 4) there is the potential for year-around evaluations through the use of a greenhouse; and 5) making disease ratings is relatively easy.

Mapping Quantitative Trait Loci for Sheath Blight Resistance

Plant geneticists and breeders have been searching for the genetic resistance factors to sheath blight in rice varieties for many decades. Sheath blight resistance genes, each contributing a different level of resistance, have been mapped onto different regions of the rice genome using molecular markers such as restricted fragment length polymorphism (RFLP) markers and simple repeat sequence (SSR) markers. A number of QTLs associated with different levels of sheath blight resistance (SB-QTLs) were identified on rice chromosomes using segregating $F_2$ populations.

Fig. 2. Variation in sheath blight resistance in the field, with susceptible Lemont (left) and resistant Jasmine 85 (right). (Photos by G. Liu.)
as well as double haploid (DH) and recombinant inbred line (RIL) populations under field conditions (Table 1). The populations used were mainly derived from crosses of the sheath blight-susceptible variety Lemont with the resistant indica varieties Teqing (from China) or Jasmine 85 (from the Philippines). However these populations are variable for plant height and heading date, which confound reaction to

Table 1. The identified quantitative trait loci (QTL) responsible for sheath blight resistance in rice (Jia et al., 2009).

<table>
<thead>
<tr>
<th>Year</th>
<th>Mapping Population</th>
<th>RSB-QTLs</th>
<th>Related to</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Plant</td>
<td>Heading Date</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Height</td>
<td>Date</td>
</tr>
<tr>
<td>1995</td>
<td>Lemont/Teqing F$_4$ bulk</td>
<td>$QSbr2a$, $QSbr3a$, $QSbr4a$, $QSbr8a$, $QSbr9a$, $QSbr12a$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1999</td>
<td>Lemont/Jasmine 85 DH lines</td>
<td>$qSB-2$, $qSB-3$, $qSB-7$</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2002</td>
<td>Zhaiyeqing 8/Jingxi 17 DH lines</td>
<td>$qSB-2$, $qSB-3$, $qSB-7$, $qSB-11$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2002</td>
<td>Zhenshan 97/ Minghui 63 F$_{11-12}$ RILs</td>
<td>$qSB-5$, $qSB-9$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2004</td>
<td>WSS2/ Hinohikari (SB resistance from Tetep) BC$_1$F$_1$</td>
<td>$qSB-3$, $qSB-12$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2005</td>
<td>Lemont/Teqing, F$_{10-11}$ RILs</td>
<td>$qSB-1$, $qSB-2$, $qSB-3-1$, $qSB-3-2$, $qSB4-1$, $qSB4-2$, $qSB-5$, $qSB-6-1$, $qSB-6-2$, $qSB-7$, $qSB-8-1$, $qSB-8-2$, $qSB-9$, $qSB-10$, $qSB-12$</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2005</td>
<td>Lemont/Teqing F$_2$</td>
<td>$qSB-9$, $qSB-11$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2007</td>
<td>Lemont/Teqing BC$_1$F$_1$</td>
<td>$qSB11Le$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2009</td>
<td>Rosemont/Pecos F$_{2-3}$</td>
<td>Four $ShB$-QTLs</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>2009</td>
<td>Lemont/Jasmine 85 F$_2$ RILs</td>
<td>$qShB1$, $qShB2-1$, $qShB2-2$, $qShB3-1$, $qShB5$, $qShB6$, $qShB9-1$, $qShB9-2$</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Continued on next page
Sheath Blight...

Sheath blight in the field. Furthermore, the accurate and reliable measurement of sheath blight resistance under field conditions is also affected by a number of environmental factors including light intensity, humidity, temperature, nitrogen rate, and silica level in soil, as well as plant morphology traits such as growth stage and plant architecture. For instance, different SB-QTLs were detected at the seedling stage using micro-chamber assay and at the heading stage in rice fields (Liu et al., 2009).

So far, numerous SB-QTLs have been identified using a field evaluation method (Table 1). Among them are the major SB-QTL qSB9-2 at the bottom of chromosome 9 and other minor SB-QTLs in chromosomes 1, 2, 3, 5, 6, and 9 that were confirmed using a Lemont/Jasmine 85 RIL population under controlled conditions (Liu et al., 2009). The SB-QTL qSB9-2 was found to co-segregate with the SSR marker RM245 on chromosome 9, contributing to 24.3% and 27.2% of total resistance using micro-chamber and mist chamber assays, respectively. Identification of qSB9-2 in Jasmine 85 is a significant accomplishment towards developing genetic resistance to sheath blight disease in rice.

**Future Perspectives**

Fine mapping and cloning genes for sheath blight resistance is the next important step to understand mechanisms of resistance and increase selection precision using marker-assisted selection. The use of the marker RM245 identified in our study (Liu et al., 2009) in combination with the micro-chamber assay can serve as a new and powerful tool for implementing marker-assisted selection to improve sheath blight resistance screening in future rice-breeding programs. Beginning in 2010, the new varieties or elite lines included in the Uniform Rice Regional Nursery (URRN) will be evaluated in field nurseries at Eagle Lake and Beaumont, Texas, to screen resistance to sheath blight and to assist in developing varietal recommendations for Texas rice producers.

For more information, please consult the following references:


**Fig.3** The active mycelia (top left) of sheath blight pathogen were inoculated to evaluate the resistance of rice varieties (resistant Jasmine 85 and susceptible Lemont, right) using micro-chambers assay (bottom left) in greenhouse. (Photos by G. Liu.)
yields but higher production costs because: 1) reduced nitrogen utilization increases the amount of nitrogen required; 2) additional flushings increase the amount of water required; 3) weeds are harder to control, so more herbicide is needed; and 4) there is a longer time until permanent flood.

Plantings made before March 15 may also have reduced stands caused by seedling diseases and salt accumulation at the soil surface following cold, drying winds.

Planting after the optimum planting dates reduces the opportunity to produce high yields. It has been estimated that a 5 percent reduction in main crop yield can be expected for each week’s delay in planting after April 21.

Low plant populations will yield well if the seedlings are uniformly distributed and enough nitrogen is applied early.

These recommendations are meant to assist in the development of a production plan. However, the recommendations have not been changed in years. Periodic research evaluates the impact of planting early or late but has not attempted to evaluate the full range of planting dates. Target planting dates are difficult to achieve due to variable weather and soil conditions.

In 2005, the advisory committee for Western Area Rice Clinic requested a survey to determine the performance of rice varieties on farm settings as compared to small research plots. The clinic serves the Colorado, Wharton, Matagorda, and Jackson Counties, which provide a desirable region to sample data and evaluate the field performance of commercial rice varieties, since 65% of Texas rice is grown in these counties. A large part of the rice produced in these counties goes to commercial dryers. The sampling region stretches from the coastal regions of Matagorda and Jackson Counties over three counties to the northwest region of Colorado County, and provides a wide variety of soils, pressures from insects, disease and weeds, slopes, technology development,
and management. Estimates of varietal performance obtained from these counties would be representative of the region.

Surveys of the performance of rice varieties have been conducted each year since 2005. Survey response has represented 65 to 80% of the certified acreage each year. Data was collected from dryers, marketing offices, and a few producers, and the database is being maintained so information can be verified if necessary. Each set contains information on source, harvest date, variety, field size, dry yield, and total and whole milled grain. Each data set in the database was evaluated to eliminate questionable or duplicate entries. Questionable data that cannot be resolved was deleted. Data from the male lines of hybrid seed fields was eliminated. Varieties with less than four fields across all sources were eliminated from the varietal performance section. Entries were eliminated only if multiple key inputs are missing. Comparisons evaluate yield by harvest date, whole milled grain by harvest date, maximum-minimum-average yield by variety, maximum-minimum-average whole milled grain by variety, and the impact of planting before, during, and after the recommended planting window.

Harvest dates for rice planted on the beginning and end of the recommended planting window were estimated using a DD50 development model. The annual survey can also be used to validate the planting date recommendations. Figure 1 shows the relation of yield to harvest date for 2,626 fields from 2005 to 2009. The green vertical bar represents the harvest date for rice planted on March 15th, which is the start of the recommended planting window, while the blue vertical bar represents rice planted on April 21st, which is the end of the recommended planting window. Most of the early-planted rice yielded between 6,000 and 8,000 lb/acre. The high and very high yields decline past the blue line. Low yields start to increase about half way through the recommended planting period. The trend continues past the blue line.

Figure 2 presents the relation of whole milled grain to harvest date. Again the green and blue lines represent rice planted at the beginning and ending of the recommended planting window. There appears to be a general decline in whole milled grain from the first harvested fields to the last. The low and very low levels of whole milled grain start near the end of the recommended planting window.

Each year, the harvest dates for rice planted on the beginning and ending of the planting window was estimated by the DD50 development model. These dates were used to determine the percentage of fields that belonged to each of the following six groups based on planting and harvesting dates: 1) early, 2) in window, 3) one week late, 4) two weeks late, 5) three weeks late, and 6) later than three weeks. Table 1 presents the state average yield (USDA National Agricultural Statistics Service, 2010), number of

Fig. 2. Impact of harvest date on rice whole milled grain for 2005 to 2009 on 2,626 fields and 252,149 acres.
Planting Date ...

Table 1. Comparison of planting date and yield in Texas from 2005 to 2009.

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Yield (lb/acre)</th>
<th>Fields (No.)</th>
<th>Percent Fields in Each Planting Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Early</td>
<td>In Planting Window</td>
</tr>
<tr>
<td>2005</td>
<td>6,600</td>
<td>545</td>
<td>0.18</td>
</tr>
<tr>
<td>2006</td>
<td>7,170</td>
<td>571</td>
<td>2.28</td>
</tr>
<tr>
<td>2007</td>
<td>6,550</td>
<td>358</td>
<td>0.56</td>
</tr>
<tr>
<td>2008</td>
<td>6,900</td>
<td>538</td>
<td>0.37</td>
</tr>
<tr>
<td>2009</td>
<td>7,770</td>
<td>619</td>
<td>0.65</td>
</tr>
</tbody>
</table>

fields in the survey, and the percentage of fields in the various planting groups. It is interesting to note that when the percent of fields planted in the planting window was over 67%, then the state average yield exceeds 7,000 lb/acre. However, when the percent fields planted in the planting window drops to about 50%, then the state average yield was ca. 6,500 lb/acre. Early-planted rice exceeded 2% in 2006 when the rice planted in the planting window was about 74%. In all other years, the early-planted rice was less the 1%. It is interesting to note that the year 2006 had the most early and on-time planted rice, and also had the most very late-planted rice. Very late-planted rice ranged from 4.46 to 14.01%, with an average of 9.70%. A large part of the rice planted three weeks after the window and later has been the variety Milagro, and this was planted late intentionally. It had been thought by some that Milagro is daylength sensitive (tropical rice) and thus had to be planted late. Efforts were initiated in the fall of 2009 to correct this misconception.

Grain yields were categorized into seven groups: less than 3,999, 4,000 to 4,999, 5,000 to 5,999, 6,000 to 6,999, 7,000 to 7,999, 8,000 to 8,999, and greater than 9,000 lb/acre. Figure 3 was constructed using these yield groups and the planting group data discussed above. The Microsoft Excel frequency distribution function was used to determine the number of field yields in each planting group. The number of fields was converted to a percent of fields in each planting group. The distribution data was plotted. Figure 3 showed that:

- Planting early was not disastrous. The chance

Fig. 3. Distribution of fields in yield groups by planting period for 2,626 fields surveyed in Colorado, Wharton, Matagorda and Jackson Counties from 2005 to 2009.
Planting Date ...

of extremely low yields and yields below 6,999 lb/acre were reduced. However, this planting group had the greatest chance of yielding in the 7,000 to 7,999 lb/acre group.

- Planting very late (> three weeks) resulted in lower chance of producing about 6,000 lb/acre and the greatest chance of yielding less than 5,999 lb/acre.

- Planting in the window provided the second lowest chance of yield less than 5,999 lb/acre and the greatest chance of yielding above 8,000 lb/acre.

- Each week that rice planting was delayed reduced the chance of yields above 7,000 lb/acre and increases the chance of yielding less than 6999 lb/acre.

A frequency yield distribution was also created for whole milled grain at 2% groupings. The whole milled grain percentage groups used were less than 53.9, 54.0 to 55.9, 56.0 to 59.9, 60.0 to 61.9, 62.0 to 63.9, and greater than 64%. The frequency distributions were presented in Figure 4. Although, interpretation of this graph is more difficult, Fig. 4 showed that:

- Planting early resulted in a lower chance of an extremely low percent whole milled grain, but a good chance of producing whole milled grain greater than 62%.

- Planting in the window resulted in the lowest chance of whole milled grain levels below 55.9% and strong chance of producing whole milled grain above 64%.

- Early planting reduced the chance of extremely low whole milled grain and the greatest chance of being above 64%.

- Planting 1, 2, and 3 weeks late resulted in a good chance of extremely low milling and lower chance at whole milled grain above 64%. Results in the midrange of whole milled grain were generally mixed.

A production plan should be created during the winter months. Planting date is one of the most critical management components of the rice crop, but probably the most difficult to execute on time. Weather and soil conditions greatly influence planting date and greatly reduce the chance of achieving the planned planting date. This survey has shown that planting date is very important to maximizing grain yield and whole milled grain percentage.

References cited in this article are as follows:


Fig. 4. Distribution of fields in whole milled grain groups by planting period for 2,626 fields surveyed in Colorado, Wharton, Matagorda and Jackson Counties from 2005 to 2008.
As of April 15, 2010, the main crop rice acreage in Texas had been planted was 61.7%. In comparison, 83.9, 53.1, 83.7, and 86.3% had been planted by April 15 in 2006, 2007, 2008, and 2009, respectively.

With regards to main crop rice acreage in Texas that had germinated by August 15, 2010, about 31.7% had emerged seedlings by that date. In comparison, 73.1, 37.7, 63.0, and 67.4% had emerged seedlings by April 15 in 2006, 2007, 2008, and 2009, respectively.

The figures below show the graphical comparison of rice acreage percentage that had been planted and had emerged seedlings by April 15 in 2006 to 2010.

Weekly updates on the acreage and percentage of rice grown in Texas that are in the various growth stages are available at our website at http://beaumont.tamu.edu/CropSurvey/CropSurveyReport.aspx.
