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2006 Rice Production Guidelines

Texas Cooperative Extension
The Texas A&M University System

Texas Agricultural Experiment Station
THE TEXAS A&M UNIVERSITY SYSTEM

USDA ARS

2006 Texas Rice Production Guidelines

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These guidelines are based on rice research conducted by research personnel of the Texas Agricultural Experiment Station, Texas Cooperative Extension and United States Department of Agriculture–Agricultural Research Service at the Texas A&M University Agricultural Research and Extension Center at Beaumont and Eagle Lake. This cooperative publication, with distribution by county Extension agents–agriculture, was undertaken to provide Texas rice farmers and landowners with the latest production and economic information for the 2006 rice crop.

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TRRF Proposals Funded for 2005

Project title: Communications, Press and Outreach for the Texas Rice Industry
Project investigator: Jaynen Cockrell
Amount: $9,108
Objective: To 1) continue to publish and upgrade Texas Rice, the newsletter for the Texas rice industry, 2) refine and expand educational materials for presentations and projects dealing with rice production, targeting school children and the general public, 3) work with media contacts (newspaper, television and radio) to get better coverage about events at the Agricultural Research and Extension Center at Beaumont and to highlight the valuable role of agriculture in Texas.

Project title: Cost-Effective Application of Biotechnology to the Texas Rice Industry
Project investigator: William Park, Lloyd Wilson, Rodante Tabien
Amount: $46,927
Objective: To ask how, on a very limited budget, we can take advantage of the flood of information and technology in genomics to bring direct, practical value to the Texas rice industry. This year's efforts have focused on three objectives: 1) further characterization of Cocodrie and Cypress plants into which we inserted the glutamine synthetase gene from alfalfa in collaboration with Ted Wilson, 2) directly testing a candidate gene for herbicide tolerance that we isolated from TX4, and 3) characterization of red rice samples from across the Texas rice belt and from Asia to deal with a potential regulatory threat to our export markets.

Project title: Development of High-Yielding Rice Varieties for Texas
Project investigator: Rodante Tabien
Amount: $109,577
Objective: To develop elite lines/varieties that are high yielding, with superior grain quality, herbicide and seedling cold tolerance. Specifically, it aims to generate crosses and advanced populations for selection, select desirable phenotypes and establish nurseries composed of lines from segregating rows and populations, identify donors for resistance to glyphosate and glufosinate herbicides and generate mutants that are tolerant to either glyphosate or glufosinate herbicides.

Project title: Development of Southern U.S. Rice Varieties Through Conventional and Marker Assisted Selection
Project investigator: Anna McClung
Amount: $31,600
Objective: To develop improved, conventional and specialty varieties that meet current and future needs of the Texas rice industry. The program will use traditional breeding approaches, molecular marker techniques and facilities located in Beaumont, Puerto Rico and in the Western Area.

Project title: 2005 Entomology Research and Extension Program
Project investigator: M. O. Way
Amount: $59,287
Objective: To provide research and extension expertise to develop and implement integrated pest management (IPM) programs for the array of insects attacking rice. Specifically, the project will 1) evaluate novel insecticides, including seed treatments, for control of rice water weevil and rice stink bug; 2) determine planting date influences (including economic analyses) on rice water weevil and stem borer populations and damage; 3) evaluate insecticides for best timing for stem borer control; 4) begin revising economic injury levels for rice stink bug; 6) evaluate residual activity of selected insecticides tank-mixed with selected oils for rice stink bug control; 7) monitor the movement of the Mexican rice borer; and 8) cooperate with the rice industry and regulatory agencies to register insecticides beneficial to Texas rice farmers and the environment.

Project title: Educational Publications for Texas Rice Producers
Project investigator: Dale Fritz
Amount: $3,510
Objective: To 1) provide educational information in support of the Texas rice industry, 2) serve as a delivery method for disseminating new technology and update information to rice producers and 3) provide the latest rice production, management and environmental information to producers and related agribusiness personnel.

Project title: Establishment of Puerto Rico Winter Nursery for Generation Advance and Seed Increase
Project investigator: Anna McClung, Rodante Tabien
Amount: $37,580
Objective: To use the winter breeding nursery facilities to their fullest extent to enhance cultivar development projects. Although most of the research effort is directed toward the development of improved conventional long grain cultivars, niche markets will also be addressed.

Project title: Evaluation of New Rice Varieties, Herbicide Resistant Varieties and Hybrids for Main and Ratoon Crop Production in Texas
Project investigator: Lee Tarpley
Amount: $40,000
Objective: To research a set of potential and current conventional varieties and hybrids for use in Texas rice production. Determine each entry's main and ratoon crop yield potential and milling response when (1) conventional varieties were treated with or without fungicide when nitrogen was not limiting and (2) hybrids receiving a total of 150 or 180 pounds of nitrogen per acre without fungicide. Measure the contribution of specific management practices to ratoon crop yield using Cocodrie as the

test variety. Identify varieties with best yield and milling when planted beyond the optimum date on clay soil at Beaumont. Provide an economic ranking from each entry's average main, ratoon and total crop net income. Provide some variety characteristics and growth stage data for use by researchers and producers.

Project title: Management of Bacterial Panicle Blight Caused by Burkholderia glumae
Project investigator: Joseph P. Krausz
Amount: $11,630
Objective: To 1) evaluate the rice cultivars and lines for reaction to panicle blight in the Uniform Rice Regional Nursery (URRN) trials at the Texas A&M University Agricultural Research and Extension Center at Beaumont, 2) inoculate rice seedlings with the panicle blight bacterium and correlate the reactions with panicle blight reactions observed in the fields, 3) test several products for suppression of panicle blight, especially through the process of systemic acquired resistance, and 4) begin developing a weather-based predictive model for forecasting panicle blight and validate a model already developed in Korea.

Project title: Personnel Support at Eagle Lake Station
Project investigator: Eagle Lake Station
Amount: $60,000
Objective: To support two positions that would oversee farm services activities at the Eagle Lake Center.

Project title: Plant Physiology Research. Texas Rice Ratoon Crop Management and Prevention of Losses in Yield and Quality due to Environmental Stresses
Project investigator: Lee Tarpley
Amount: $47,481
Objective: To 1) focus on unraveling the physiological bases for ratoon crop management, with a 6,000-pound-per-acre ratoon crop goal, 2) conduct further research to determine optimal plant growth regulator (PGR) rates and 3) research rice response to various stresses to determine how to maximize grain set and fill.

Project title: Texas Rice Crop Survey—2005
Project investigator: James Stansel
Amount: $16,000
Objective: To 1) develop statistics for rice production to include county acres by variety, Texas yields, Texas production, estimates of carryover stocks and variety performance data for use by the rice industry; 2) conduct crop development surveys throughout the growing season for use in alerts and crop management; 3) conduct farmers' fields DD50 crop development predictions for farmer management inputs; 4) expand and simplify the crop survey and reporting system; and 5) continue developing rice belt water planning for rice production.

Project title: Water Management and Weed Science Research in Rice
Project investigator: Garry McCauley, J. M. Chandler
Amount: $65,000
Objective: To 1) evaluate the impact of ratoon crop water and nitrogen management on main and ratoon crop yield and milling, 2) evaluate the efficacy and economics of weed management systems using current commercial herbicides in early- and late-season treatments alone and in all combinations, 3) evaluate the influence of growth stage and soil moisture on alligatorweed control with DE638 and Regiment applied alone and in combination with several commercial herbicides, 4) assess control of perennial grasses (perennial banyardgrass and Paspalum species) with commercial and experimental herbicides, 5) evaluate fall and spring vegetation management before planting in a reduced tillage system, 6) determine the impact of tillage intensity in rice production systems on the level of weed management inputs required to optimize control and 7) evaluate and correct the weed science information presented in the Texas Rice Production Guidelines. Establish cooperative research with commercial industry to accomplish this task.

Contents

Land and Seedbed Preparation

G. N. McCauley

Leveling and drainage considerations

Fields for growing rice should be relatively level but gently sloping toward drainage ditches. Ideally, land leveling for a uniform grade of 0.2 percent slope or less provides:

- Necessary early drainage in the spring for early soil preparation, which permits early seeding;
- Uniform flood depth, which reduces the amount of water needed for irrigation; and
- The need for fewer levees.

Importance of early land preparation

Successful rice production requires timely land preparation. Therefore, fields should be plowed in the summer or early fall. Early land preparation is particularly critical when high-residue crops such as grain sorghum or corn are planted the year before rice. If the land has been out of production and is grown up in weeds and brush, prepare it as early as possible.

Early land preparation allows several stands of grass and red rice to be killed by surface cultivation before planting. It also incorporates the crop residue to assure good decomposition of plant material to prevent early-season nitrogen deficiency.

If it is not possible to prepare the land early, plant material decomposition will not be at advanced stages at the time of planting. The soil's microorganisms (bacteria, fungi, etc.) that decompose crop residue will compete with rice plants for nutrients, particularly nitrogen, causing the rice plant to be nitrogen deficient. If this situation arises, you may need to add 10 to 20 more units of nitrogen when the base fertilizer is applied at or near planting.

Land preparation for rice after soybean production

Less land preparation is needed when rice is planted after soybeans because the soil is normally left in fairly good condition. In water-seeded areas where the land is weed-free and firm, it may even be feasible to plant rice after reduced tillage (one or two cultivations) of the crop land.

Seedbed preparation

Seedbed preparation is particularly critical in coarse-textured soils. The seedbed should be firm and well pulverized to maintain proper moisture conditions for drilling. This will ensure rapid germination and emergence of the rice plant.

Although seedbed preparation is less critical in areas where rice is not drilled, it is still important to ensure that the desired soil condition is achieved and to allow rapid emergence of the rice plant. In all situations it is important to have a weed-free seedbed.

To reduce costs, minimize the number of times a field is cultivated before planting. Avoid "recreational" passes over the field. Research has shown that fields cultivated five times have about the same average yields as those more intensely cultivated.

The cost of operating large tractors for rice production means that one cultivation can cost up to $5 per acre. Therefore, some farmers are adding as much as $30 per acre to the cost of land preparation and may not be realizing a corresponding yield increase.

Reduced tillage

Reduced tillage refers to any effort to reduce the number of land-preparation trips across a field. The discussion here will be restricted to spring and fall stale seedbed techniques.

Spring stale seedbed provides less reduction in cultivation than does the fall stale seedbed technique. The spring system involves normal fall land preparation with early spring seedbed preparation. The seedbed is allowed to set and weeds germinate. The weeds are controlled chemically right up to planting. With the spring system, the rice can be drill- or water-seeded. **For satisfactory stand establishment, you must use a minimum- or no-till drill.**

The major benefit of the spring system is the management of red rice. For more details on the spring stale seedbed technique, see the section on Red Rice Control.

The fall stale seedbed technique entails cultivation and seedbed preparation in late summer or early fall. Vegetation is chemically controlled through the fall, winter and spring up to planting. The last burn-down application can be applied with a preplant herbicide application just before planting.

The major advantage of fall stale seedbed is that it ensures optimum early planting, particularly in a wet year when conventional spring field preparation is delayed because of wet field conditions. Equipment and labor costs can be reduced because fields are not cultivated as often with reduced tillage; however, using burn-down herbicides can increase the total herbicide cost.

In a conventional cultivation system, the condition of the seedbed is often unknown until planting. This may make it difficult to select seed rate and to plant. With the fall stale seedbed technique when vegetation is managed properly, the seedbed condition is known for weeks or months before planting. Seeding rate selection and seed booking can be completed well before planting.

In a fall stale seedbed system, the seeding rate can generally be reduced 10 to 20 percent when drilling to moisture. Use a higher seeding rate if a germination flush will be required. This is critical if a preplant herbicide is used.

Planting methods are limited to drill- or water-seeding because broadcast seeding requires tillage equipment for seed incorporation. Because the use of a minimum- or no-till drill is essential, it may be necessary to invest in additional equipment. There is also the potential for extra herbicide use.

Although water seeding can be used, weed residue can cause oxygen deficiency, increase seedling diseases and expose seed to birds.

Reduced tillage can affect fertilizer management before establishing the flood, particularly if the soil surface has significant vegetative residue that restricts contact between the soil and fertilizer. To reduce potential nitrogen loss, apply the nitrogen to a dry soil and flush it into the soil as soon as possible.

Nitrogen applied to a wet soil cannot be effectively washed into the soil and is subject to more loss. Preplant nitrogen can be placed into the soil with the no-till drill or knifed in below the soil surface.

Several herbicides are labeled as preplant burn-down herbicides in a reduced tillage situation. The rates of application depend on the weed species and their sizes. Follow the label directions for rate, method of application, control of specific weeds and other restrictions.

Fall stale seedbed management generally increases yields. With this system there is greater likelihood of planting to moisture even in heavy soils, which results in less stress from germination or early seedling flush. Early flushes can delay emergence and stress young seedlings. The optimum planting date is also more likely, which further raises the yield potential.

After the flood is established, cultural practices for reduced tillage are the same as for conventional tillage rice production.

Stand Establishment

J. W. Stansel and L. Tarpley

Uniform seedling emergence and optimum seedlings per unit area, evenly distributed, are very important to achieving good yields and quality on both main and ratoon crops.

Other factors that affect stand uniformity and density include quality of seedbed, level of seed germination, vigor of germinating seedlings, degree of uniform distribution of seed (both in depth and across the field), soil moisture, soil texture characteristics, drainage and temperature conditions.

Variability in these characteristics is responsible for the wide diversity in planting methods used across the rice belt.

Rice seed germination characteristics also dictate planting methods on some soil types. For example, if rice seed are covered by soil (resulting in low light) and water (low oxygen condition) for extended periods, germination will not occur or will be slow and uneven. These germination restrictions are why seedbed preparation and soil drainage affect stand levels and uniformity.

Rice can be drilled to moisture in coarse-textured soils but must be planted shallow (or uncovered) on heavier textured soils, requiring rain or irrigation to supply moisture for germination. Most coarse-textured soils will crust when drying after being water saturated.

Farmers' experience on each field is important in getting economical results. For example, farmers who have successfully achieved good uniform stands consistently have had some success in reducing their seeding rates. However, farmers should know the hazards of low seeding rates under their conditions before taking such measures.

Varieties

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Long-grain varieties

Banks

Banks was developed by the University of Arkansas from a cross involving LaGrue, Lemont and RA 73 and was released in 2003. It is a conventional-height cultivar (52 inches) that is five days later than Cocodrie. In Texas, its yield potential has been similar to or better than that of both Cocodrie and Wells, while its milling yield is lower than these two cultivars. Like Drew, it has excellent resistance to blast disease and is moderately resistant to sheath blight disease.

Cheniere

Cheniere is a long-grain cultivar released in 2003 by the Louisiana Agricultural Experiment Station. It was developed from a complex cross using Newbonnet, Katy, L201, Lemont and L202. Cheniere is similar to Cocodrie in yield, ratoon and milling quality. Its height is similar to Jefferson, but its maturity is similar to Cypress. It is susceptible to most races of blast and is moderately susceptible to sheath blight disease.

CL131

CL131 is a very early-maturing, semidwarf, long-grain rice variety that provides good yield potential and high tolerance to Newpath herbicide. CL131 is somewhat shorter in height than CL161, similar in maturity to Cocodrie, and 4 to 5 days earlier than Cypress, CL161, and Cheniere. CL131 appears to have good straw strength and resistance to lodging. Evaluations indicate high susceptibility to sheath blight and straighthead as well as susceptibility to blast. CL131 has good adaptability across the entire southern rice growing area with good second-crop potential.

CL161

CL161 is an early, semidwarf, long-grain variety that looks much like Cypress. CL161 provides good yield potential and high tolerance to Newpath herbicide. Its performance and maturity are similar to that of Cypress. It has excellent seedling vigor and good standability. However, this variety can be susceptible to lodging if fertilized excessively. Preliminary research data suggest that milling yields and the potential for a second crop are very good. Preliminary evaluations of CL161 indicate that it is susceptible to sheath blight and blast diseases and is moderately susceptible to straighthead.

CLXL8

CLXL8 combines hybrid yield potential, Newpath herbicide tolerance, disease resistance and straw strength to provide rice producers with high yield and outstanding red rice/weed control. CLXL8 is a long-grain with superior ratoon crop potential. CLXL8 meets industry milling standards.

CLXL730

Released on a limited basis as an experimental (XP730) hybrid in 2005, CLXL730 is equivalent to CLXL8 in grain yield, Newpath tolerance and disease resistance, with better milling yield. CLXL730 is a long-grain with average straw strength and excellent ratoon crop potential. CLXL730 is very easy to thresh and should be harvested as soon as grain moisture reaches acceptable levels.

Cocodrie

Cocodrie was developed by Louisiana Agricultural Experiment Station from a cross of Cypress/L202/Tebonnet. It is a semidwarf, long-grain variety that flowers about a week later than Jefferson. Main crop yields have been excellent and generally better than other cultivars. Ratoon crop yields are similar to Cypress but lower than Jefferson. Cocodrie milling yields have been similar to Jefferson and lower than Cypress or Saber. Cocodrie has improved resistance to blast disease similar to that of Jefferson. Like Cypress, it is considered susceptible to sheath blight disease and is more susceptible than Jefferson to panicle blight.

Cybonnet

The University of Arkansas released Cybonnet in 2003. It was developed from a cross of Cypress/Newbonnet/Katy. It is similar to Cypress in height and maturity; however, like Cocodrie, it has higher yield potential. Like Cypress, it has excellent milling quality and excellent resistance to blast disease (similar to Katy). It is moderately susceptible to sheath blight disease.

Cypress

Cypress is an early-maturing semidwarf variety that was developed from the cross L202/Lemont by the Louisiana Agricultural Experiment Station. Compared with Lemont, it has similar maturity but is slightly taller. Cypress has excellent seedling vigor for a semidwarf variety. Although Cypress has superior milling quality, its main and ratoon crop yields are lower than that of other current cultivars. It is moderately resistant to blast but very susceptible to sheath blight. It is more susceptible than Jefferson to panicle blight.

Francis

Francis is a long-grain cultivar released in 2002 by the University of Arkansas. It was developed from a cross using Lebonnet, Dawn, Starbonnet and LaGrue as parents. Francis' main crop yields are similar to those of Cocodrie, but it has lower milling yields. It is about 4 to 5 inches taller than Cocodrie and its maturity is similar to Cocodrie. It is susceptible to all races of blast and like LaGrue is moderately susceptible to sheath blight disease.

Jefferson

Jefferson is a very early-maturing, semidwarf, long-grain variety developed at Beaumont from the cross Vista/Lebonnet/Rosemont. Main crop yields of Jefferson are better than Cypress but not as high as Cocodrie. The ratoon crop yield of Jefferson is superior to most other cultivars and because of its earlier maturity, the likelihood of harvesting a full second crop is very good. Milling yields of Jefferson tend to be better than Cocodrie but lower than Cypress and Saber. Seedling vigor of Jefferson is not as strong as Cocodrie. Because of the larger grain size of Jefferson and lower tillering abilities, higher seeding rates may be needed to achieve adequate panicles per unit area. An important advantage of Jefferson is its disease resistance. It has one of the best combinations of blast and sheath blight resistance of any semidwarf rice variety.

Pace

Pace is a semidwarf, long-grain variety from the Mississippi Agricultural and Forestry Experiment Station. It has field resistance to sheath blight and good straw strength. It is like Cocodrie in heading maturity and yield potential. Main crop and milling yield is lower than Cocodrie but has better ratoon potential.

Presidio

Presidio was developed from a cross of Jefferson/Maybelle. It is a long grain variety that is very early in maturity like Jefferson and heads, on average, two days earlier than Cocodrie. Presidio is a semidwarf cultivar that averages 37 inches in height, which is similar to Cocodrie. Its main crop yield has been similar to Jefferson, however it has proven to have ratoon crop potential superior to most other varieties. In addition, Presidio also has superior milling quality like that observed in Cypress. Presidio inherited broad spectrum blast resistance and moderate tolerance to sheath blight disease from Jefferson, which is likely enough to preclude the use of fungicides in most circumstances.

Saber

Saber is a semidwarf, conventional long-grain cultivar that was developed at Beaumont from the cross Gulfmont/RU8703196 /Teqing. Its height and maturity are similar to Cocodrie. Main crop yields of Saber are similar to Jefferson but lower than Cocodrie. Its ratoon crop potential is similar to Cocodrie. Saber has very high and stable milling quality like that of Cypress. Saber possesses improved resistance to blast disease that is comparable to Jefferson and improved resistance to sheath blight disease that is better than other commercial cultivars.

Spring

Spring is a very early-maturing, semidwarf, long-grain variety from the University of Arkansas. It has cold tolerance, resistant to blast, good seedling vigor, milling quality but lower yield potential than Cocodrie. It matures in about 114 days, 10 to 12 days earlier than most released varieties. It is taller than Cocodrie with nearly comparable whole and total grain yield.

Trenasse

Trenasse, named from a French word for a pathway through the marsh, is a semidwarf, long-grain variety from the Louisiana Agricultural Experiment Station. It flowers earlier than Cocodrie but has nearly the same maturity. It is taller than Cocodrie with higher yield potential and nearly comparable milling traits.

Wells

Wells is a long-grain variety that was developed by the University of Arkansas from a cross of Newbonnet/3/Lebonnet/CI9902/Labelle. It matures slightly later than Cocodrie and grows to at least 5 inches taller than Cocodrie. Wells has a high main crop yield similar to Cocodrie but lower ratoon crop yield and milling quality. Wells' blast resistance is similar to Cypress, which is less than Cocodrie, but its sheath blight resistance is better than that of Cocodrie.

XL8

XL8 is a rice hybrid developed by RiceTec in Alvin, Texas. Its plant height is about 40 inches. It is widely adapted across soil types. Under most conditions, the main crop of XL8 yields average about 1,000 pounds per acre more than Cocodrie. Although it is similar in maturity to Cocodrie, its ratoon crop yields are much higher. Milling quality is lower than Cocodrie. XL8 has very good disease resistance.

XL723

The conventional (that is, non-herbicide tolerant) long-grain hybrid line XL723 offers superior yield, disease resistance and above average straw strength. XL723 has a short season, making it an excellent choice after wheat or in ratoon situations. The product also has good milling, is easy to thresh and should be harvested as soon as grain moisture reaches acceptable levels.

Medium-grain varieties

Bengal

Bengal is an early-maturing, reduced height, medium-grain variety. It is about 10 inches shorter than Mars. Yields of Bengal are higher than those of other current medium-grain varieties. Milling yields are very good and comparable to those of Mars. Its grain size is larger than that of other medium grains. Bengal is moderately resistant to blast and to sheath blight diseases but is susceptible to straighthead.

Jupiter

Jupiter is a medium-grain variety from the Louisiana Agricultural Experiment Station. It has better grain yield potential than Bengal but milling yield is comparable. It is shorter and has better straw strength than Bengal, thus has better lodging resistance. It has a better disease resistance package than Bengal since Jupiter has tolerance to panicle blight, neck blast and straighthead. It has the same susceptibility to leaf blast as Bengal.

Medark

Medark is a medium grain cultivar released in 2003 by University of Arkansas. It was developed from a cross of Bengal/Rico-1. It is very similar to Bengal in maturity and, like Bengal, has good tolerance to blast and sheath blight diseases. It is slightly shorter than Bengal but has no yield advantage over Bengal.

Specialty rices

Bolivar

Bolivar is a very early-maturing, semidwarf, long-grain cultivar developed at Beaumont from Gulfmont/Teqing. It is earlier maturing and taller than Dixiebelle. Bolivar has a superior canning and processing quality, like Dixiebelle. It has a larger grain size, lower main crop yields and lower whole-grain milling yields than Dixiebelle. Bolivar has better resistance to blast and has lower yield losses because of sheath blight than Dixiebelle.

Della

Della is an aromatic long-grain rice which, like Dellmont, is dry and flaky when cooked. Aromatic varieties cannot be co-mingled with other nonscented varieties and so should be grown only if the producer has an assured market outlet. Della's yield and milling quality are lower than that of than Dellmont and Gulfmont. It is very tall and very susceptible to lodging. Della is susceptible to blast and moderately resistant to sheath blight.

Dellrose

This cultivar was developed from a cross between Lemont and Della that was made by the Louisiana Agricultural Experiment Station. Dellrose has the same aroma and cooking quality as Della and Dellmont. It has an intermediate height and is about 5 inches taller than Dellmont. Dellrose is very early maturing, similar to Della, and has greatly improved yield and milling quality as compared to Della. It is moderately resistant to blast and very susceptible to sheath blight (as is Lemont).

Dixiebelle

Dixiebelle is an early-maturing, semidwarf, long-grain variety developed at Beaumont from Newrex/Bellmont/CB801. Although Dixiebelle can be used like a conventional long grain, it also possesses special qualities, like Rexmont, that make it preferable for the canning and parboiling industry. The main crop yield, ratoon yield and milling quality of Dixiebelle are superior to that of Rexmont and intermediate to that of Gulfmont and Cypress. Dixiebelle is similar to Lemont in its reaction to blast and sheath blight diseases.

Jasmine 85

Jasmine 85 is an aromatic rice possessing the flavor and aroma of the fragrant rices of Thailand. Although it is a long-grain variety, the cooked grains are soft and sticky like a medium grain cultivar. Jasmine 85 matures about 10 days later than Cypress and is taller than Cypress. The seed of Jasmine 85 has some level of dormancy and may volunteer in following years. Under good management, Jasmine 85 has excellent yield potential. However, it is susceptible to lodging under high fertilizer inputs. The milling yield of Jasmine 85 is lower than other southern U.S. long-grain varieties. Jasmine 85 is very resistant to blast disease and shows good tolerance to sheath blight disease.

Neches

Neches is long-grain, waxy rice developed at Beaumont from a cross of waxy Lebonnet and Bellemont. Neches is very similar to Lemont in height and maturity. Waxy rice is desired in Asian markets as a specialty rice and is used by the ingredients industry as a flour and starch. Its grain is completely opaque and when cooked it is very sticky because of its waxy (glutinous) property. Neches' yield and disease resistance are very similar to those of Lemont.

Pirogue

Pirogue is a short-grain variety developed by the Louisiana Agricultural Experiment Station from a cross of Rico 1/S101. Short-grain rice cultivars such as Pirogue have a cooking quality similar to that of medium-grain rice cultivars. Pirogue is very similar to Bengal in yield, height and maturity but is more susceptible to disease and has lower milling yield.

Sabine

Sabine is a new release by the Beaumont station in 2004. It was developed from an experimental line from LSU crossed with Dixiebelle. It has the same superior parboiling and canning quality that is found in Dixiebelle and was developed primarily for use by the processing industry. Sabine is about two inches taller and has higher yield potential than Dixieblle. The two are very similar in maturity, milling quality, and susceptibility to blast and sheath blight diseases.

Sierra

Sierra was developed at Beaumont from a cross involving Dellmont, Basmati 370 and Newrex. It was released in 2003. It is a long-grain rice that possesses the fragrance and cooked kernel elongation characteristics found in basmati-style rice. It has excellent aroma and cooks dry and flaky. Sierra is very similar to Lemont in height, maturity, yield, disease resistance and milling quality.

Table 1. 2005 Texas field yields by variety (main crop).

	2005						
Variety	**Number of fields reported**	**Reported acreage**	**Yield lb/A**	**Yield bbl/A**	**Milling yield %H**	**Milling yield %T**	**Grade**
Cocodrie	266	29,589	6,623	41	59.7	70.1	2.0
Cypress	10	1,278	5,803	36	59.5	70.0	2.0
CL161	75	8,441	5,754	36	58.4	67.7	2.1
Dixiebelle	4	313	7,267	45	59.3	69.3	2.0
Jefferson	11	960	6,303	39	53.9	68.6	2.0
Wells	7	541	6,909	43	54.5	70.8	2.0
Cheniere	86	8,140	6,670	41	59.6	70.5	1.6
CL XL8	75	3,040	7,001	43	55.3	69.1	2.1
XP723	21	1,341	8,580	53	58.3	70.7	2.0
Total	**555**	**53,643**					
Weighted average			**6,795**	**42**	**58.8**	**69.7**	**2.0**

Table 2. 2004 Texas field yields by variety (main crop).

	2004						
Variety	**Number of fields reported**	**Reported acreage**	**Yield lb/A**	**Yield bbl/A**	**Milling yield %H**	**Milling yield %T**	**Grade**
Cocodrie	245	27,398	6,395	39	60.9	70.8	2.1
Cypress	33	3,155	5,845	36	61.8	70.6	1.8
CL161	62	7,470	5,573	34	60.8	68.9	1.8
Dixiebelle	25	2,499	6,609	41	60.4	70.3	2.0
Jefferson	13	1,289	5,824	36	60.7	70.0	2.0
Wells	5	465	6,174	38	59.5	72.0	2.0
Cheniere	76	6,035	6,558	40	62.1	71.6	1.4
CL XL8	N/A	N/A	N/A	0	N/A	N/A	N/A
XP723	N/A	N/A	N/A	0	N/A	N/A	N/A
Total	459	48,311					
Weighted average			**6,231**	**38**	**60.9**	**70.6**	**1.9**

Data compiled by Texas Agricultural Experiment Station, Agricultural Research and Extension Center at Beaumont, Jim Stansel and Brandy Morace. Data compiled from Texas rice belt grower reports, rice dryers and marketing offices.
All yields are adjusted to 12% moisture and weighted for field size and reported acres.

Table 3. 2005 Texas rice acreage by variety and county.

Updated 3-Jan-06			Variety acres by county									
			Long-grain									
County	2004 acreage	2005 acreage	Cocodrie	Cheniere	CL 161	Cypress	Jefferson	CL XL8	Milagro	Dixiebelle	XP723	XP710	Other*
East zone												
Brazoria	15,748	15,975	10,303	2,626	376	0	1,182	0	132	0	0	0	1,356
Chambers	16,024	12,792	0	1,279	7,546	0	0	1,408	2,558	0	0	0	0
Galveston	847	833	833	0	0	0	0	0	0	0	0	0	0
Hardin	762	298	298	0	0	0	0	0	0	0	0	0	0
Jefferson	19,954	19,355	4,405	5,361	6,127	0	0	2,000	0	0	84	0	1,378
Liberty	10,475	9,381	289	2,814	4,690	0	0	1,303	250	0	35	0	0
Orange	90	0	0	0	0	0	0	0	0	0	0	0	0
East total	**63,900**	**58,633**	**16,127**	**12,080**	**18,739**	**0**	**1,182**	**4,711**	**2,940**	**0**	**119**	**0**	**2,734**
Northwest zone												
Austin	2,313	2,359	1,563	667	18	0	111	0	0	0	0	0	0
Colorado	33,273	30,903	19,394	4,870	2,922	681	1,578	641	712	0	105	0	0
Harris	1,522	1,067	97	263	0	0	0	248	0	0	208	0	251
Lavaca	2,189	1,804	1,543	151	0	110	0	0	0	0	0	0	0
Waller	7,868	7,672	3,885	1,866	0	0	0	515	0	0	851	0	554
Wharton	53,413	50,678	28,788	3,565	5,003	5,157	3,120	88	818	1,201	211	1,053	1,674
Northwest total	**100,578**	**94,482**	**55,270**	**11,382**	**7,943**	**5,948**	**4,809**	**1,492**	**1,530**	**1,201**	**1,375**	**1,053**	**2,479**
Southwest zone												
Calhoun	2,488	2,439	2,158	0	0	0	0	0	150	0	0	0	131
Fort Bend	7,933	6,409	5,389	839	0	0	22	0	0	0	110	0	49
Jackson	14,734	12,713	6,144	2,319	1,174	1,246	511	277	528	176	125	0	213
Matagorda	23,672	21,863	7,730	2,186	0	4,671	4,182	0	1,319	1,408	224	0	144
Victoria	1,356	1,705	1,705	0	0	0	0	0	0	0	0	0	0
Southwest total	**50,183**	**45,129**	**23,126**	**5,343**	**1,174**	**5,917**	**4,715**	**277**	**1,997**	**1,584**	**459**	**0**	**537**
Northeast zone												
Bowie	1,510	2,054	1,259	350	45	0	0	40	0	0	0	0	360
Hopkins	0	0	0	0	0	0	0	0	0	0	0	0	0
Red River	639	639	639	0	0	0	0	0	0	0	0	0	0
Northeast total	**2,149**	**2,693**	**1,898**	**350**	**45**	**0**	**0**	**40**	**0**	**0**	**0**	**0**	**360**
2004 total acreage	**216,810**		**136,594**	**20,216**	**22,698**	**16,170**	**8,117**	**2,478**	**0**	**61**	**0.0%**	**891**	**5,107**
2004 percentage	**97.9%**		**63.0%**	**9.3%**	**10.5%**	**7.5%**	**3.7%**	**1.1%**	**0.0%**	**0.0%**		**0.4%**	**2.4%**
2005 total acreage		**200,937**	**96,421**	**29,155**	**27,901**	**11,865**	**10,706**	**6,520**	**6,467**	**2,785**	**1,953**	**1,053**	**6,110**
2005 percentage		**100.0%**	**48.0%**	**14.5%**	**13.9%**	**5.9%**	**5.3%**	**3.2%**	**3.2%**	**1.4%**	**1.0%**	**0.5%**	**3.0%**

Other varieties: Cybonnet, Jasmine 85, Presidio, Sabine, Trenasse, XP733, XP712, XP716, XP721, XP732, Wells, CL131, Sierra, Francis, CLXL730, Risotto

Data compiled by Texas Agricultural Experiment Station, Agricultural Research and Extension Center at Beaumont, Jim Stansel and Brandy Morace. Data collected from dryers, sales offices, agribusiness, USDA/CFSA and county Extension agents as appropriate.

Research funded by TAES–Beaumont and TRRF.

Table 4. Variety information update for 2006 production guidelines. The table below provides a comparison of various characteristics of several rice varieties based upon experimental plot data. All varieties are compared with Cocodrie for main crop yield, ratoon crop yield and milling yield.

Variety	Maturity	Height (inches)	Main crop yield	Ratoon crop yield	Milling yield
Bolivar	Very early	37	Lower	Higher	Lower
Cocodrie	Very early	38	—	—	—
Della (A)	Very early	52	Lower	Lower	Lower
Dellrose (A)	Very early	41	Lower	Lower	Similar
Jefferson	Very early	37	Lower	Higher	Similar
Presidio	Very early	37	Lower	Higher	Higher
Spring	Very early	39	Lower	Higher	Lower
XL8	Very early	45	Similar	Higher	Lower
CL161	Early	38	Higher	Similar	Lower
Banks	Early	44	Similar	Lower	Lower
Cheniere	Early	38	Similar	Similar	Lower
Cybonnet	Early	40	Similar	Similar	Higher
Cypress	Early	41	Lower	Lower	Higher
Dixiebelle	Early	35	Lower	Lower	Similar
Francis	Early	41	Similar	Lower	Lower
Neches (WX)	Early	36	Lower	Lower	Higher
Saber	Early	40	Lower	Similar	Higher
Sabine	Early	38	Lower	Similar	Higher
Wells	Early	43	Higher	Lower	Lower
Bengal (M)	Mid-season	37	Higher	Similar	Higher
Medark (M)	Mid-season	36	Similar	Lower	Higher
Pirogue (S)	Mid-season	40	Similar	Lower	Higher
Jupiter (M)	Mid-season	36	Higher	Lower	Higher
Jasmine 85 (A)	Late	40	Higher	Lower	Lower
Pace	Similar	37	Lower	Higher	Lower
Trenasse	Similar	39	Higher	Similar	Similar

A–aromatic
WX–waxy
M–medium grain
S–short grain

Planting Dates

L. Tarpley, J. W. Stansel and M. F. Jund

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 very important for normal seed germination and seedling growth.

The 4-inch soil temperatures are available daily on week days at the Research and Extension Center at Beaumont, (409) 752-2741, and Western Area Operations headquarters at Eagle Lake, (979) 234-3578. Your county Extension office will also have access to these soil temperatures.

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 stress growing season.

Planting earlier than March 15 can result in good yields but higher production costs. These costs are associated with greater nitrogen requirements because of poor or reduced nitrogen utilization, under cool conditions greater water needs because of additional flushings, and greater herbicide cost because of the difficulty of controlling weeds, and the longer time until permanent flood.

In addition to higher production costs, plantings made before March 15 can lead to reduced stands from 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 first crop yield can be expected for each week's delay in planting after April 21.

Seeding Rates

G. N. McCauley, L. Tarpley and M. F. Jund

Uniform stands of healthy rice seedlings pave the way to a productive rice crop. In general, growers can achieve the desired plant population of 15 to 20 seedlings per square foot (9 to 12 seedlings per 7-inch drill row foot) by drill-seeding 70 to 90 pounds of rice seed per acre the first week of April.

Lower seeding rate and plant populations (15 seedlings per square foot) are preferred when planting high-tillering varieties such as Cypress and Jasmine 85 and when disease pressure is expected to be high after canopy closure.

These recommendations assume average seed size (Cocodrie, Cypress and Cheniere at 18,000 to 19,000 seed per pound), well-prepared seedbeds, planting at recommended depths, good-quality seed and near optimum conditions for April 1 planting.

Adjusting seeding rate for variety

When planting a variety with seed that is larger than average (Jefferson with 16,000 seed per pound) or smaller than average (Dixiebelle or hybrid seed with 20,000 to 21,000 seed per pound), adjust the seeding rate to ensure that the desired number of seed per square foot is achieved.

For example, it is recommended that Jefferson be planted at a 10 percent higher rate than that used for Lemont and Gulfmont, 15 percent over that used for Cypress and Cocodrie and 25 percent over that used for Dixiebelle, assuming similar germination and survival of each variety.

This higher seeding rate will help ensure that varieties with lower-than-average numbers of seed per pound (such as Jefferson) will have a plant population similar to other varieties. See the table at the end of this section that shows the effect of seed size on seed per square foot.

Further increasing the seeding rate of Jefferson can be justified because of its lower tillering and vigor. Compared to Cocodrie, Jefferson has lower tillering capacity, which makes it difficult for Jefferson to yield as well when stands are less than the recommended 20 to 25 seedlings per square foot. Low plant populations of Jefferson (such as 12 live seedlings per square foot or about 40 pounds of seed per acre, assuming 80 percent seedling emergence) will yield well if the seedlings are uniformly distributed and enough nitrogen is applied early.

Table 5. Recommended seeding rates adjusted for seed size and tillering for March 20 to April 1 planting on good seed beds.

	Seeding rate (lb/A)		
Variety	**Drill seeded**	**Broadcast (dry)**	**Water planted**
Jefferson	90-100	110-120	120-130
Lemont, Gulfmont	80	100	120
Priscilla, Wells	70-80	100	120
Cypress, Saber, Bolivar and Cocodrie	60-70	80-90	110

Adjusting seeding rate for conditions

Below are recommendations and considerations when adjusting seeding rate according to planting conditions:

- For broadcast seeding, an additional 20 pounds of seed per acre above the 70 to 90 pounds per acre of drilled seed is recommended.
- If the seedbeds are rough or poorly prepared, increase the seeding rate by 10 pounds or more.
- For each week the crop is seeded before March 15, an additional 10 pounds of seed may also be required because earlier planting usually means cooler weather.
- Increases in seeding rate may not be warranted if soil and air temperatures are 70 degrees or above.

However, growers who have had problems achieving recommended stands should use higher seeding rates.

- When drilling to moisture in stale seedbed conditions, the seeding rate can generally be reduced by 10 to 15 percent from conventional seedbed conditions.
- If soil conditions require a germination flush and Command will be applied preplant, increase the seeding rate to 10 percent above conventional recommendations.
- The need for higher seeding rates can be reduced by using gibberellic acid as a seed treatment, which can increase seedling vigor.

Replanting is not recommended unless stands have fewer than 10 seedlings per square foot over most of the field for conventional varieties and fewer than eight seedlings per square foot for semidwarf varieties. If there are fewer than 15 seedlings per square foot, plot yields can be improved by increasing early nitrogen applications by 30 to 50 pounds per acre.

Rice producers who commonly achieve optimum planting density recognize that actual seedlings per square foot (plant population) is a better measure for comparing field performance than seeding rate because plant population is the final product of:

- Seeding rate
- Live seed per pound of seed (determined by percent germination and seed size)
- Percent emergence (determined by planting conditions, such as seed depth and vigor, soil moisture, temperature, seedling disease and bird feeding).

Growers are encouraged to count seedlings per square foot for a given seeding rate. This information becomes very important in subsequent years when the seeding rate is adjusted for variety and planting conditions. The best measurements of stand density can be made at the three- to four-leaf rice stage. After the fourth leaf, tillering makes stand counts very difficult.

In broadcast rice, stand density is determined by using a square or circular frame of known area. Place the frame on the soil in a representative area and count the seedlings inside the frame. Divide the count by the area of the frame.

In drill-seeded rice, stand density can be determined by counting the seedlings in a known length of row. Divide the count by the length of the row and the row spacing in feet. The best results are obtained when the row is at least 10 feet long. Always make counts in several representative areas of the field.

Table 6. The effect of seed per pound (that is, seed size) on the number of seed per square foot at various seeding rates. The number of live seedlings per square foot depends on the germination rate and planting conditions.[1]

		Seeding rate (lb/A)											
		30	40	50	60	70	80	90	100	110	120	130	140
Variety	**Seed/lb[2]**	**Seed/ft²**											
Bolivar	18,500	13	17	21	25	30	34	38	42	47	51	55	59
CLXL8	21,800	15	20	25	30	35	40	45	50	55	60	65	70
CLXL730	20,100	14	18	23	28	32	37	42	46	51	55	60	65
CL161	19,800	14	18	23	27	32	36	41	45	50	55	59	64
CL131	20,700	14	19	24	29	33	38	43	48	52	57	62	67
Cheniere	20,200	14	19	23	28	32	37	42	46	51	56	60	65
Cocodrie	18,800	13	18	22	26	31	35	40	44	48	53	57	62
Cypress	18,400	13	17	21	25	30	34	38	42	46	51	55	59
Dixiebelle	20,500	14	19	24	28	33	38	42	47	52	56	61	66
Francis	21,100	15	19	24	29	34	39	44	48	53	58	63	68
Gulfmont	16,800	12	15	19	23	27	31	35	39	42	46	50	54
Jacinto	21,300	15	20	24	29	34	39	44	49	54	59	64	68
Jefferson	16,500	11	15	19	23	27	30	34	38	42	45	49	53
Priscilla	16,900	12	16	19	23	27	31	35	39	43	47	50	54
Saber	20,800	14	19	24	29	33	38	43	48	53	57	62	67
Sabine	17,600	12	16	20	24	28	32	36	40	44	48	53	57
Spring	20,700	14	19	24	29	33	38	43	48	52	57	62	67
Trenasse	17,700	12	16	20	24	28	33	37	41	45	49	53	57
Wells	18,200	13	17	21	25	29	33	38	42	46	50	54	58
XP316M	21,800	15	20	25	30	35	40	45	50	55	60	65	70
XL8	20,400	14	19	23	28	33	37	42	47	52	56	61	66
XP710	18,700	13	17	21	26	30	34	39	43	47	52	56	60
XP721	18,000	12	17	21	25	29	33	37	41	45	50	54	58
XL723	20,200	14	19	23	28	32	37	42	46	51	56	60	65

[1]100% to 60% of the seed would be expected to emerge depending on % germination and planting condition.
[2]Seed/lb values are averages and can vary as much as 10% depending on year and degree of seed processing.

Seeding Methods

G. N. McCauley

Seeding methods depend on soil type, weather conditions and producer preference. The main factors to consider in selecting seeding methods are uniformity of seed distribution and seedling emergence. These factors promote good yields as well as grain quality. There is no evidence of yield advantages for drilled versus broadcast seeding or dry versus water seeding if stands are adequate.

On fine clay soils, several seeding methods can be used, including dry and water seeding. A well-prepared, weed-free seedbed is important when rice is dry seeded. When dry seeding with a drill on fine clay soils, flush the field immediately after planting to ensure uniform emergence. Seed can be broadcast on a rough, cloddy seedbed if followed immediately with a flushing so soil clods disintegrate and cover the seed. This allows good germination and uniform emergence.

In some areas, it is possible to broadcast seed on a well-prepared seedbed, followed by dragging to cover the seed. This also requires immediate flushing of the field so that emergence is uniform.

If rice is water seeded, the seedbed may be left in a rough, cloddy condition because flushing breaks up clods and provides some seed coverage.

On sandy soils, plant seed in moist soil 1-2 inches deep. Seeding depth varies with moisture conditions and variety.

Although all of these planting methods can be used for the semidwarf varieties, experience shows that for these varieties, shallow planting is much better for good stand establishment. For example, on coarse soils, do not drill any deeper than necessary. Although soil crusting conditions cannot always be avoided, use proper management to prevent this condition.

Early Flood Rice Culture

G. N. McCauley

Definitions

Two different systems are used to produce rice with early flood culture: **continuous flood** and **pinpoint flood.**

In the continuous flood system, seed coated with calcium peroxide or sprouted seed are dropped into a flooded field that is maintained until near harvest.

In the pinpoint system, dry or preferably sprouted seed are dropped into floodwater. The field is drained after 24 hours and left dry for 3 to 5 days to provide oxygen and allow the roots to anchor or "peg" to the soil.

Then the flood is reestablished and maintained until near harvest. For the rice plant to continue growth, a portion of the plant must be above water by at least the fourth leaf stage.

There are six advantages of applying water to a field and retaining it throughout the growing season:

- Easier water management and less water use;
- Red rice and grass suppression;
- Less seedling stress from cool weather;
- Elimination of early-season blackbird problems;
- Reduction in seedling loss due to salt; and
- Increased nitrogen efficiency, when nitrogen is applied to dry soil before flooding.

Land preparation and stand establishment

Problems that may be encountered with both systems include the presence of aquatic weeds late in the season and stand establishment in unlevel cuts where water may be too deep or seed is covered with too much soil.

The continuous flood technique has three additional disadvantages:

- Possibility of seedling damage from rice seed midge;
- Seedling drift, especially in large, open cuts; and
- The cost of calcium peroxide coating.

Prepare land in fall or as early as possible in the spring so that vegetation can be turned under and decomposed before planting to prevent oxygen depletion during germination when soil is flooded. Because cool water contains more oxygen than does warm water, it is desirable to plant early in the season before floodwater gets warm. Suggested planting dates are from April 1 to April 20.

To minimize seedling drift in the continuous flood technique, it is suggested that the soil surface be "grooved" before flooding by pulling a spike-tooth harrow to create ridges in soil. A compacting groover also can be used to create ridges.

The groover compacts the soil surface to stabilize the ridges for more uniform stand establishment and efficient field drainage. Seeds usually settle between ridges, where they are less likely to drift.

Another way to minimize seedling drift is to muddy floodwater just before applying seed. The suspended soil will slightly cover and help anchor the seed. A relatively cloddy soil surface minimizes seedling drift better than a "mirror smooth" soil surface.

Water management

It is important to flood the soil immediately after seedbed preparation. If flooding is delayed, red rice and other weeds will establish.

Keep the area between the levees as uniformly level as possible. If the water depth in a cut is less than 2 inches in the shallow area and more than 6 inches in the deep area, the crop will not emerge and mature uniformly. Try to maintain a uniform flood depth of less than 4 inches (1 or 2 inches is preferable) before rice emergence. Then increase to 4 inches as rice gets taller.

Fertilization

When soil is dry before planting, apply all of the phosphorus and potassium, if needed, and about 70 percent of the nitrogen. If possible, incorporate the fertilizer into the soil; if not, apply the fertilizer and flood the field immediately.

Apply the remaining nitrogen in the floodwater at panicle differentiation or earlier if plants become nitrogen deficient.

Weed control

Although continuous flood and pinpoint flood culture should suppress red rice and other weeds, they do not provide adequate control. To help control weeds:

- Apply Bolero® 8EC preplant at 4 pints per acre to suppress red rice and control certain other weeds. Apply immediately after soil preparation and flood the field within 3 days. Do not seed the field any sooner than 24 hours after the field has been brought to flood level.
- Apply Ordram® 8E preplant at 3 to 4 pints per acre depending on soil texture. Use ground application equipment only, incorporate immediately and flood as soon as possible. Ordram® 15G preplant incorporated at 20 pounds per acre also can be used. Mechanically incorporate within 6 hours of application and flood as soon as possible.
- Grandstand® at 0.67 to 1 pint per acre can also be used to control certain broadleaf weeds. Permit®, Basagran® or Londax® alone or in combination with propanil also can be used to control certain aquatic weeds. Rates depend on growth stage.

Blackbirds

M. O. Way

Blackbirds, primarily red-winged blackbirds, are pests of rice during the planting season, the seedling stage and the ripening period. The birds consume seed and seedlings on and under the soil, which can result in inadequate plant stands.

In some cases, the fields must be replanted. Reseeding is expensive and delays planting, which may reduce yields and quality and hinder harvesting operations. Also, harvesting the main crop late can make ratoon cropping impractical and increase the chances of blackbird damage on the ripening main and ratoon crops.

Blackbirds also damage the ripening crop by “pinching” grains (squeezing a grain with the beak to force the milky contents into the mouth) in the milk stage, hulling grains in the dough stage, and consuming the contents and breaking panicles by perching and feeding.

This type of damage is insignificant in the ripening main crop, according to results of a study in Matagorda County by personnel of the Texas Agricultural Experiment Station and Texas Cooperative Extension. However, damage to the ripening ratoon crop was found to be severe, particularly along field margins. Yield losses ranged from about 4 to 15 percent, even in fields that were patrolled using firearms. The cost of control was as high as $46 per acre.

Many producers do not ratoon crop, simply because of potential bird problems. Producers have had to abandon parts of fields hit hard by birds and/or have had to harvest too early in order to save the ratoon crop from bird attacks. For both damage periods (planting and heading to harvest), fields close to wetlands or roosts usually suffered more damage.

Unfortunately, no easy solution is available, although a combination of control tactics can reduce the problem.

Bird control on emerging rice

To control blackbirds on emerging rice:

- Delay planting until large flocks of birds move north, and try not to plant when your field is the only one in the area with seeds and seedlings available for the birds.
- Increase the seeding rate if you usually experience bird problems at planting, and cover the seed to make it more difficult for the birds to find.
- Patrol the fields early and consistently using firearms and scare devices.* This is probably the most effective tactic. Laborers can be hired to perform this tedious but important job. If possible, make sure all margins of the field are accessible for patrol. Start patrolling immediately after planting to scare away “scout” birds. Birds are more difficult to move once they establish in a field. Most feeding occurs during the early morning and late afternoon. However, patrol the fields as long as birds are present.
- Use continuous flooding, which can deter blackbirds from feeding on seeds and seedlings. However, other birds, such as ducks, geese, ibises and dowitchers, feed on and/or trample submerged sprouts.
- If possible, destroy roosts and loafing sites on the margins of fields.

DRC 1339, a blackbird toxicant formulated as a bait, can be used to kill blackbirds threatening rice. It can be applied only by authorized governmental personnel. For more information, contact the Texas Wildlife Damage Management Service at 979.845.6201 or 979.234.6599.

Control on ripening rice

To control blackbirds on ripening rice:

- For the ripening ratoon crop, plant an early-maturing variety so that the harvest occurs before the flocks increase to damaging numbers. Late plantings increase the chance of bird damage to the ratoon crop.
- Again, manage the habitat, and patrol early and consistently. These are the most important control measures.
- Harvest as soon as grain moisture is appropriate. The longer rice remains in the field, the greater the chance for bird damage.

Because production inputs have already been invested in the crop, it is imperative that you protect the ripening rice.

In the fall of 2002, the U.S. Environmental Protection Agency approved the use of Bird Shield™ in rice to limit feeding by blackbirds. The active ingredient in Bird Shield™ is methyl anthranilate, a bird repellent.

Bird Shield™ can be applied to rice seed at planting or to heading rice.

Residue data were collected in Texas to help register the product, but field efficacy data are unavailable. For more details, call 409.752.2741.

*Contact the Texas A&M University Agricultural Research and Extension Center at Beaumont for ordering information on scare devices.

Seedling Disease Control

J. P. Krausz

Seed rot and seedling blight are caused by various soil-borne and seed-borne fungi. This disease complex can cause irregular, thin stands and weakened plants. Cool, wet soils and any condition that delays seedling emergence favors the development of seed rots and seedling diseases. In early-planted rice (late February to mid-March), seedling diseases are often more severe and not adequately controlled and may result in the need to replant.

The organism that causes brown leaf spot, *Bipolaris oryzae*, is a common pathogen that infects the glumes as the rice grain matures. When the infected rice is planted the next spring, diseased seedlings often occur. It is best that rice crops with a high incidence of brown leaf spot not be used for seed production.

Fungicide seed treatments have been shown to significantly increase stands in both drilled and water-seeded rice, especially in early plantings. In addition to fungicide seed treatments, other practices that aid in obtaining a healthy, uniform stand include:

- Planting in a well-prepared, uniform seedbed;
- Not planting too deeply;
- Not planting excessively early; and
- Using healthy seed with a high germination level.

The following fungicides are registered for use on rice seed. The trade names are listed for information only and do not constitute an endorsement of the product over other products containing the same active ingredient. Follow the label instructions carefully to avoid problems and obtain maximum efficacy.

Table 7. Fungicides registered for use on rice seed.

Common name	Trade name	Rate/100 lb seed
azoxystrobin	Dynasty®	0.15-1.5 fl oz
carboxin + thiram	Vitavax® 200 RTU Vitavax®-Thiram®	5-6.8 fl oz
fludioxonil	Maxim® 4FS	0.04-0.08 fl oz
mancozeb	Dithane® DF Dithane® F 45 Manzate® 200	2.1-4.3 oz 3.2-6.4 fl oz 2-4 oz
mefenoxam	Apron® XL LS	0.16-0.64 fl oz
metalaxyl*	Allegiance FL	0.375-0.75 oz
thiram	Thiram® 42S	3.3 fl oz

*Use in combination with another material to broaden spectrum of control.

Irrigation and Water Management

G. N. McCauley

Reducing irrigation costs

There are two general ways to reduce irrigation costs:

- Reduce the amount of water used to produce the rice crop; and
- Pump each unit of water at the lowest possible cost.

The major factors affecting pumping cost are fuel price, pumping head or lift and pumping plant (power unit and pump) efficiency.

Individual producers can do little to control the price of fuel or pumping lift. However, pumping efficiency can be controlled through careful selection of pumping equipment and timely maintenance of the pump and power unit.

Irrigation costs also can be reduced by maintaining canals and laterals free of leaks and unwanted vegetation.

Evaluating pump unit performance

Procedures for evaluating pumping unit performance are described in the publications L-1718, *Evaluating Irrigation Pumping Plant Performance* (Texas Cooperative Extension); BCTR-86-10-12, *Evaluating Pump Plant Efficiencies* and BCTR-86-10-13, *Using Airlines,* which are available from your county Extension office.

To evaluate pumping performance, you must measure three values: pumping rate, total pumping head (pumping lift plus head or pressure at the pump discharge) and fuel use per hour. To compare the performance of two or more pumping plants with similar pumping lift or head, you can measure only pumping rate and fuel use.

Measuring the amount of water pumped is essential to any evaluation of the pumping plant or of water management practices. Use a propeller-type irrigation water meter, or some other appropriate method, combined with an accurate record of fuel used to calculate fuel cost per unit of water. This is the minimum valid figure for making management decisions on pumping plant operation, repair or replacement.

Precision land forming

Precision land forming, with laser-controlled or manually controlled equipment, makes it easier to manage water. This does not mean that the land surface is absolutely level or flat. “Land grading” is a better, more descriptive term because some grade, or slope, is desirable for surface drainage.

Shallow flood depth decreases the amount of water required and increases yield if grass and weeds are controlled. Land leveling or grading makes it possible to maintain uniform, shallow flood depth, improve uniformity of water distribution when the field is flushed and improve surface drainage.

Temporary shallow flooding

An adequate water supply and timely flushing (temporary shallow flooding) are essential for maximum yields. Early-season water management is important but often overlooked. Appropriate early-season water management practices are determined largely by the planting method.

Flushing encourages uniform, rapid emergence with the broadcast, dry-seeded method of planting. Flushing is normally not used to obtain emergence when rice is drilled into coarse-textured soils because these soils are prone to crusting, thus impeding seedling emergence.

Flushing may be necessary if there is not enough moisture available for germination and/or emergence is hindered by soil crusting following a rain. Do not allow the soil to dry or a soil crust to form on shallow-planted, semidwarf varieties.

Research indicates that much of the irrigation water applied in flushing leaves the field as runoff. Improved management in the flushing operation could reduce the amount of water required and reduce irrigation pumping costs. Introducing exactly the right amount of water to accomplish the desired flushing with little or no runoff from the bottom of the field is difficult with single inlet irrigation systems.

A **multiple inlet system**, which introduces irrigation water to each individual cut, makes efficient flushing much easier to accomplish and also makes it possible to maintain freeboard on each levee for storage of rainfall. Use of an inflow meter also allows you to precisely control the amount of inflow.

Water-seeded rice on heavy soils

When rice is water seeded on heavy soils, establish a 2- to 4-inch flood as soon as possible after land preparation. Plant rice immediately to minimize seed midge damage and ensure a good stand. When seed has sprouted, drain the water to a low level or drain it completely to enable rice seedlings to become well anchored.

If cuts (the areas between levees) are completely drained, flushing will eventually be necessary to prevent soils from drying out and reducing seedling stand. Floods that last longer than 7 to 10 days may lead to seed midge damage.

Early-season water management

Early-season water management should provide soil moisture for growth of the rice seedlings, discourage germination of weed seeds and maintain high nitrogen fertilizer efficiency. Young rice plants grow well under alternating moist and dry soil conditions, but denitrification can seriously reduce the soil's nitrogen level under these conditions.

If possible, keep the soil moist to increase nitrogen efficiency, decrease germination of weed seed and reduce salt damage in areas subject to such damage. Keeping the soil moist appears to be especially important for semidwarf varieties.

Delay flushing until 24 hours after propanil is applied (alone or in combination with a preemergence herbicide). Flushing immediately after propanil application washes off the propanil.

Permanent flood

Do not put on permanent flood until plants are actively tillering (assuming continuous flood culture is not being used). To maintain the permanent flood, apply additional water to replace that lost by evaporation, transpiration, seepage and runoff.

The permanent flood is drained during mid-season only when the rice is subject to straighthead. If application of a mid-season herbicide is necessary, lower the flood level to obtain better exposure of broadleaved weeds.

Maintaining a permanent flood is critical during panicle development. The rice plant uses water at a high rate during this period, and moisture stress reduces yield. Maintain a constant flood to provide adequate water for normal plant growth and development.

To ensure availability of water during the reproductive stage, apply the permanent flood 7 to 10 days before anticipated panicle differentiation or sooner.

Maintain the permanent flood at the minimum depth necessary to control weeds. Shallow flood depth minimizes the quantity of water required and increases yield if weeds are controlled.

Field storage of rainfall can also reduce the amount of irrigation water required. However, rainfall can be stored in the field only if some freeboard is available on each levee gate.

Fertilization

L. Tarpley and M. F. Jund

Research and experience have shown that there is a great deal of flexibility in how farmers can manage their fertilizer programs, provided that the basic nutrient requirements are met. These suggestions provide basic information on which a farmer can build an economic rice fertilizer program and make adjustments to fit particular situations.

Fertilizer can profoundly influence rice yield, and it is a major cost for rice production. Therefore, a critical review of fertilizer practices can mean increased income without sacrificing yields.

For maximum net profit, apply only those fertilizer materials needed for maximum economic yields. If your soil has been tested accurately to predict fertilizer needs, you can have confidence in the fertilizer recommendations and it will help you develop an economical fertilizer management program.

Of the three primary nutrients (nitrogen, phosphorus and potassium, or N, P and K), nitrogen affects rice yield in Texas most. Because soil nitrogen availability changes rapidly and constantly, soil testing is useless for determining nitrogen rates for rice. The recommended nitrogen rates (Table 8) for each rice variety are determined by nitrogen fertilizer response in research tests.

Table 8. Main crop nitrogen requirements (lb N/A) for specific varieties on various soil types.

Variety	Western rice belt[a]		Eastern rice belt	
	fine (clayey)	coarse (sandy)	fine (clayey)	coarse (sandy)
Long grain				
Banks	170	150	170	150
Cypress[b]	170	150	170	150
Cheniere	170	150	170	150
CL131	170	150	170	150
CL161	170	150	170	150
Cybonnet	170	150	170	150
Cocodrie	170	150	170	150
Della	100	80	110	100
Dellmont	170	150	170	150
Dixiebelle	170	150	170	150
Francis	170	150	170	150
Jefferson	170	150	170	150
Madison	170	150	170	150
Presidio	170	150	170	150
Sabine	170	150	170	150
Spring	170	150	170	150
Trenasse	170	150	170	150
Wells	150	130	150	150
Hybrid rice[c]				
CLXL8	180	150	180	150
CLXL730	180	150	180	150
XL723	180	150	180	150
XL8	180	150	180	150
XP721	180	150	180	150
XP316M	180	150	180	150
Medium grain				
Bengal	150	120	150	130

[a] Research results from Matagorda County indicate that the semidwarf varieties growing on clayey, high pH (6.7+) soils such as Lake Charles clay may require significantly more units of nitrogen for maximum yields, especially when nitrogen fertilizer is lost in runoff or top dressing cannot be applied to dry soil just before flooding. Sandy (light-colored) soils in this area do not require extra nitrogen.
[b] Cypress leaves tend to be a lighter green than other semidwarfs and it is more likely to lodge when excess nitrogen rates are applied.
[c] Splitting N in two applications with 90 or 120 lb N/A applied just before flooding and 60 lb N/A applied between boot stage and 5% heading has reduced lodging, increased main crop yield and milling plus improved ratoon yields, especially on clay soils that supply little N.

Soil testing is useful for predicting phosphorus, potassium and micronutrient needs for rice and for developing economical fertilizer rates. To manage fertilizer accurately, you need to have a knowledge of the soil nutrient availability (soil test information), crop management practices, climatic conditions and past fertilizer response.

It is vital that soil samples be collected properly—the sample must be representative of the soils in the field. Sample soils in the fall or early winter so that the test results may be obtained in time to plan the coming year's fertilization program.

Take one composite sample from each uniform area in the field. Sample separately any portion of the field that varies because of soil texture, organic matter and/or slope. Take a minimum of 10 or 15 samples randomly selected from each uniform area. Take the cores or slices from the plow layer (5 to 6 inches). Thoroughly mix all the samples from each uniform field or area and remove a pint of it as a composite sample.

Send a "control soil" or "reference" sample with your field samples to use to determine the accuracy of the soil test. Obtain and maintain a control soil sample for your farm by collecting several gallons of soil, drying and crushing it into aggregates and storing it in a dry place for future use.

When the control sample analysis doesn't match previous soil test results, ask the soil test lab to rerun your samples.

Critical soil test levels established in research tests help determine how much phosphorus and potassium to apply.

- Apply phosphorus when the soil test shows 15 ppm or less phosphorus on sandy soils, or 10 ppm or less phosphorus on clay soils.
- Apply potassium when the soil test shows 50 ppm or less potassium.

If you use this approach to develop a rice fertilizer program for each field, it will help you take advantage of the fact that fertilizers applied when needed will increase income, but when applied in excessive rates and not needed will decrease income.

Complete the appropriate form and send it with the composite soil samples and your control soil sample to a soil testing laboratory. The addresses and phone numbers of three soil-testing labs:

Soil Test Laboratory
Texas Cooperative Extension
Soil and Crop Sciences Department,
The Texas A&M University. System
2474 TAMU
College Station, TX 77843-2474 • Phone: 979.845.4816

A & L Plains Agricultural Labs, Inc.
302 34th Street (P. O. Box 1590)
Lubbock, TX 79408 • Phone: 806.763.4278

Wharton County Junior College
Soil and Forage Testing Lab
911 Bolling Highway
Wharton, TX 77488 • Phone: 979.532.6395

Efficient fertilizer management

To establish plant nutrition efficiency and to develop economical fertilizer programs, it is important that you understand the behavior of plant nutrients in flooded soils. Fertilizer efficiency is determined by the interaction of nutrient source, water management, application rate and timing.

Nitrogen

Although rice can use both ammonium and nitrate sources of nitrogen, under flooded conditions the nitrate form is unstable and is lost from the soil by leaching and denitrification (a microbial process that converts nitrate to nitrogen gas).

However, ammonium nitrogen (urea and ammonium sulfate) is stable when below the flooded soil surface away from air and can be used by the rice plant. Ammonium on the soil surface or in floodwater gradually changes to nitrate and is lost by denitrification.

Ammonium sulfate and urea sources of ammonium are about equally efficient for rice and much more efficient than nitrate nitrogen.

If the soils are drained for several days, urea and ammonium sulfate can be converted to the nitrate nitrogen form. Upon flooding the soil, the nitrate nitrogen is lost primarily through denitrification. Therefore, to conserve and maintain nitrogen efficiency, nitrogen fertilizer should be incorporated or flushed into the soil with irrigation water and the soil should remain water saturated or as moist as possible.

Another way to increase nitrogen efficiency is to use banded fluid fertilizer. Recent research has shown that applying fluid fertilizer in a band 2 to 3 inches below the soil surface can improve N uptake in rice compared to dry broadcast fertilizer.

Concerns about banding fluid fertilizer include the skill required to apply the fertilizer uniformly over the field, the initial cost of application equipment and the time required to fill fertilizer tanks. To reduce application costs, attach the fluid applicator knives to the seed drill, which allows 75 to 100 percent of the total N plus P and K to be applied while planting.

In addition, establishing a flood at the four-leaf growth stage rather than at the six-leaf or later stage maximizes the efficiency of banded fluid fertilizer.

Phosphorus

Flooding soils (saturating them with water) increases the availability of phosphorus. Flooding releases native soil phosphorus and increases phosphorus mobility. It also results in a soil pH change toward neutral, which converts unavailable phosphorus to the more available form.

Phosphorus fertilizer usually increases yields on clay soils testing below 10 ppm phosphorus and on sandy soils testing less than 15 ppm phosphorus.

Potassium

Unlike phosphorus, potassium is not greatly activated by flooding but is more available upon flooding. Most Texas rice soils do not require additional potassium.

If potassium fertilizer is needed, it is on the very coarse (sandy) soil types testing less than 50 ppm potassium.

Micronutrients

Soil flooding increases the availability of many micronutrients. Generally, iron, manganese, boron and molybdenum become more available under flooded soil conditions, but zinc usually becomes less available. Although iron and zinc deficiency may occur at any location in the rice belt, the area most likely to be affected, historically, is west of a line from Bay City to Wharton to East Bernard.

Environmental conditions that contribute to deficiencies of iron and/or zinc include:

- Alkaline soils with a pH above 7.2
- History of chlorotic (yellow) seedlings
- Excessively high rates of native phosphorus

Symptoms of iron and zinc deficiencies in rice seedlings include:

- Entire leaves become chlorotic, then start dying after 3 to 7 days (iron).
- Midribs of the younger leaves, especially the base, become chlorotic within 2 to 4 days after flooding (zinc).
- Chlorosis is usually more severe where the flood is deepest and water is coldest (zinc).
- Leaves lose sturdiness and float on the floodwater (zinc).
- Brown, bronze and eventually black blotches and streaks appear in lower leaves followed by stunted growth (zinc).
- Rice plants start to recover soon after the field is drained (zinc).

In these situations, apply 10 pounds of zinc sulfate and/or 100 pounds of iron sulfate per acre at the seedling stage. If other proven sources are used, select rates according to the zinc and iron content and availability. Soil applications are more effective than are foliar sprays.

Soil and plant additives

Soil additives, foliar-applied nutrient growth stimulators and yield enhancers have not increased rice yields in research tests or demonstrations conducted throughout the rice belt.

General fertilizer recommendations

Although soil testing is highly recommended to determine fertilizer needs, the following general recommendations can be used in the absence of a soil test for the first crop, assuming semidwarf varieties planted the first week of April.

- 170-40-0* on fine (heavy) soils
- 150-50-20 on coarse (light) soils

(*Units of nitrogen, phosphorus and potassium, respectively, with ⅓ of nitrogen and all phosphorus and potassium applied preplant, or by the three-leaf growth stage, ⅓ of nitrogen on dry soil just before flood and remaining nitrogen at panicle differentiation [PD]).

Nitrogen rates

Using these generalized recommendations, you may need to adjust nitrogen rates, depending on location, planting date, variety grown, water management and soil conditions. See location and variety adjustment in Table 8.

Do not delay nitrogen topdressing when plants become nitrogen-deficient, as the yield potential of the semidwarf plant types drops each day they exhibit nitrogen deficiency (yellowing).

Make further adjustments in nitrogen recognizing that early-planted rice grows slowly in cool temperatures and may require five to 15 more units of nitrogen than does late-planted rice.

If a field has a history of severe lodging or has not been cropped recently, reduce the suggested nitrogen rates. An additional 10 to 15 pounds of nitrogen may be needed when too much low-nitrogen foliage or plant residue has been plowed under just before planting. The straw can cause temporary unavailability of the initially applied nitrogen.

If rice is to follow grain sorghum or corn in rotation, shred or disk the grain sorghum or corn stubble immediately after harvest to decrease the nitrogen immobilization during the growing season. Depending on the rate of straw decomposition, the immobilized nitrogen will begin to become available to rice plants at a later growth stage.

Symptoms and characteristics of nitrogen deficiency include:

- Rice on levees is darker green than rice between levees.
- Rice between levees has dark green areas as well as light green rice.
- Plants have yellowish lower (older) leaves with possible brown tips, and green upper (younger) leaves with yellow tips.
- The chlorophyll reading is low.

Phosphorus and potash rates

Phosphorus and potash rates above the general recommendations previously mentioned have not proven profitable. Mixing potash with topdress nitrogen has not increased yields.

Applying excessive phosphorus and potash fertilizer needlessly increases production costs. Also, excess phosphorus can lower yields by increasing weed competition and by reducing micronutrient availability.

Fertilizer timing for main crop yield

There are many options as to the number of nitrogen applications required to produce maximum economic yield. Maximum yields have been obtained by applying all fertilizer in one preplant application (late plantings) or in multiple applications when planting at recommended times.

Nitrogen applied at or near heading has not increased main crop yields when sufficient nitrogen is available, but it can maximize ratoon crop potential. (See the ratoon crop section for a discussion of ratoon crop nitrogen rates and timing.)

The following recommended nitrogen timings consistently provide maximum economical yield over a wide range of soil types and planting dates.

March plantings (three applications)

- Apply about 20 to 25 percent of the nitrogen and all of the needed phosphorus and potassium just before planting or by the three-leaf stage of rice growth.
- Apply 35 to 40 percent on dry soil just before flooding.
- Apply 40 percent at panicle differentiation (PD) or before if needed.

April plantings (three applications)

For April planting, increase early-season nitrogen applications over those for March plantings, because April plantings usually grow faster because of the warmer temperature and require more nitrogen early. Apply about one-third of the nitrogen at each of the three application times.

May plantings (two applications)

Apply about two-thirds of the nitrogen and required phosphorus and potassium just before planting. Apply the remaining one-third at PD or earlier if needed to correct nitrogen deficiencies.

Nitrogen timing rates for continuous flood, pinpoint flood or "knifed-in" or "banded" preplant fertilizer application

Use the two applications described under May planting above.

Other factors influencing nitrogen timing

Generally, to reduce the total nitrogen required, apply less than 60 pounds of nitrogen per acre after flood establishment. This limitation may influence the number of nitrogen applications.

Also, to lower costs, consider nitrogen formulations and the application cost per unit of nitrogen applied by comparing applicator rates for various weights of fertilizer and adjusting these.

Maximizing benefits of fertilizer application

Preplant or initial fertilizer application

Apply initial fertilizer (nitrogen, phosphorus, potassium) just before planting, at planting or before the three-leaf stage of rice growth. To increase nitrogen efficiency, incorporate or drill preplant fertilizer applications into the soil.

If the initial fertilizer application is made at seeding time or before the three-leaf stage of rice growth, be sure the application is on dry soil and the field is flushed as soon as possible to move the fertilizer into the root zone.

After seedling emergence and after initial fertilizer application, keep the soil moist until time for the pre-flooding application. If weed populations are high, a postemergence nitrogen application may be more economical than a broadcast preplant application because it does not stimulate early weed growth.

Preflood application

To gain the most from preflood nitrogen application, apply the nitrogen on dry soil just before flooding and allow the floodwater to carry the fertilizer away from air and into the root zone, where it has more protection from loss.

If the soil is so wet just before flooding that the applied floodwater will not carry fertilizer nitrogen into the soil, establish the flood and apply 50 percent of the preflood nitrogen in the floodwater and the remaining preflood nitrogen 10 days later.

Some producers prefer applications in floodwater because fertilizer application streaks are less evident. However, in doing so, up to 20 percent of the applied nitrogen may be lost. (Splitting the preflood nitrogen application converts a three-way nitrogen split into a four-way split, and, if a heading topdressing is justified for the ratoon, the conventional three-way becomes a five-way split of nitrogen.)

PD application

The PD application is made when 30 percent of the main stems have 2 mm or longer panicles. During this growth stage, this application is efficiently used (taken up within 3 days) by plants because the roots cover the flooded soil surface. If the rice plants appear nitrogen-deficient, apply nitrogen before the PD stage.

The chlorophyll meter is very useful for determining the need for PD nitrogen. If fields are very uniform in stand emergence (emergence within 2 days), applications earlier than PD might be warranted.

Chlorophyll meter use

Because the green color of rice plants as detected by the human eye varies with cloudiness and the time of day, it is sometimes difficult to tell if nitrogen topdressing will be economical. Minolta's model 502 chlorophyll meter provides a quick and unbiased estimate of the need for additional nitrogen during PD and 2 weeks before PD.

For example, research data (Fig. 1) show that, for Lemont plants with chlorophyll readings of 40 or more, topdressing will not increase yields enough to justify the cost.

The procedure for using a Minolta model 502 chlorophyll meter to determine the average chlorophyll reading in a rice field is to walk into representative areas of the rice field and insert the edge of a most recently matured leaf, at a point three-fourths of the way up the leaf, into the measuring head of the meter. When the measuring head is clamped on the leaf, the meter will provide an instant three-digit chlorophyll value.

The meter will store and average up to 30 readings. Fields having chlorophyll readings above the critical levels given above are unlikely to benefit from nitrogen topdressings. Fields having lower chlorophyll values will benefit from topdressing nitrogen (Fig. 1).

Although plant density can influence chlorophyll readings in rice fields, plant density usually must be less than 10 to 12 plants per square foot before affecting the chlorophyll value.

Another factor influencing the chlorophyll readings of rice leaves is that the leaf midrib frequently does not divide the leaf down the center. The narrow side of the leaf tends to read one or two chlorophyll values higher than the wide side. Therefore, to reduce variation in chlorophyll readings within a field, take readings only from leaves having centered midribs, or take an equal number of readings on each side of the midrib.

Other factors that influence chlorophyll readings include rice cultivar, the position of the leaf on plant and the location on the leaf where the reading is taken. Keep in mind also that chlorophyll readings may be influenced by cool weather as well as deficiencies of phosphorus, zinc and iron.

Table 9. Critical chlorophyll levels above which commonly provide no yield benefits to additional nitrogen fertilizer.

Variety	Chlorophyll reading
Francis and Jefferson	41–42
Dixiebelle, Presidio, Priscilla and Sabine	39–40
Banks, Cheniere, CL131 and 161, Cocodrie, Cybonnet and Saber	38–39
Cypress, Spring and Trenasse	37–38

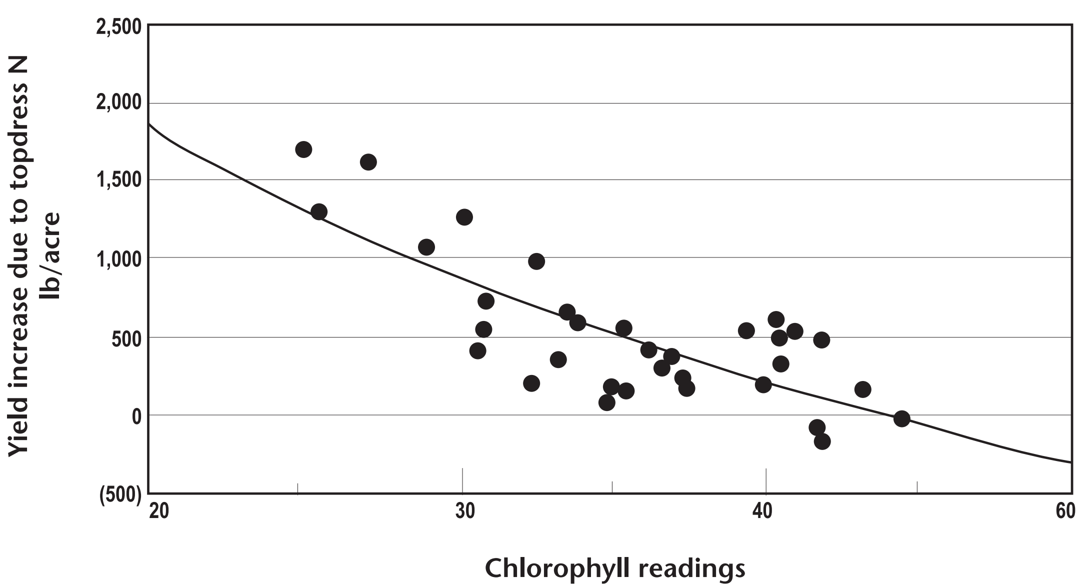

Figure 1. Relationship between yield increase and chlorophyll readings.

2005 Variety Evaluation for Main and Ratoon Crop Yield Potential

L. Tarpley and M. F. Jund

Variety evaluations at Beaumont and Eagle Lake compare main and ratoon crop yield, milling quality and other agronomic traits of recently released varieties and hybrids with established cultivars using management practices that maximize yield potential.

On clay soil at Beaumont (Table 10), main crop fungicide generally increased main crop yield and whole grain milling for most conventional varieties. Fungicide did not significantly improve ratoon yield in 2005 as it had in the previous year.

For hybrids, which received no fungicide, increasing the preflood N from 90 to 120 pounds per acre improved main crop yield but did not consistently improve main crop whole grain milling. Other tests have shown that late season N may influence milling for hybrids rather than preflood N especially on clay soil. In addition, increasing main crop preflood N to 120 pounds per acre did not consistently increase ratoon yield on clay soil.

Table 10. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted March 31 on clay soil at Beaumont, Texas in 2005.

Variety[1] or hybrid[2]	Treatment number	Preplant N (lb/A)	Preflood N (lb/A)	Mid season N (lb/A)	Heading N (lb/A)	MC fungicide	MC yield lb/A @12%	RC yield[3] lb/A @12%	MC milling % whole	MC milling % total
Spring	1	45	90	80	0	No	5,542	1,778	55	68
Spring	2	45	90	80	0	Yes	6,625	1,893	58	69
Trenasse	1	45	90	80	0	No	7,480	2,263	52	68
Trenasse	2	45	90	80	0	Yes	7,995	2,483	55	68
Presidio	1	45	90	80	0	No	7,480	3,021	64	71
Presidio	2	45	90	80	0	Yes	7,995	3,138	65	71
Sabine	1	45	90	80	0	No	7,381	1,972	65	70
Sabine	2	45	90	80	0	Yes	7,565	1,884	66	71
CL131	1	45	90	80	0	No	7,392	2,040	62	69
CL131	2	45	90	80	0	Yes	7,995	2,251	64	70
CL161	1	45	90	80	0	No	6,626	2,248	46	62
CL161	2	45	90	80	0	Yes	6,915	2,526	48	63
Cheniere	1	45	90	80	0	No	7,173	2,192	46	65
Cheniere	2	45	90	80	0	Yes	7,203	2,544	47	66
Cybonnet	1	45	90	80	0	No	7,487	2,553	58	67
Cybonnet	2	45	90	80	0	Yes	7,882	2,278	62	69
Banks	1	45	90	80	0	No	7,122	NA	53	64
Banks	2	45	90	80	0	Yes	7,390	NA	56	66
Cocodrie	1	45	90	80	0	No	8,143	3,022	58	68
Cocodrie	2	45	90	80	0	Yes	8,368	3,130	59	68
XP716	1	0	90	0	60	No	7,795	3,477	44	59
XP716	2	0	120	0	60	No	8,134	2,496	43	57
XP723	1	0	90	0	60	No	9,852	2,515	63	71
XP723	2	0	120	0	60	No	10,576	2,420	52	70
XP728	1	0	90	0	60	No	8,638	3,541	53	70
XP728	2	0	120	0	60	No	9,436	3,532	57	70
XP729	1	0	90	0	60	No	8,378	3,168	60	71
XP729	2	0	120	0	60	No	9,518	3,176	60	71
CLXP730	1	0	90	0	60	No	8,826	2,604	61	72
CLXP730	2	0	120	0	60	No	9,121	2,397	60	71
CLXL8	1	0	90	0	60	No	7,428	2,023	59	71
CLXL8	2	0	120	0	60	No	7,765	2,106	52	70
XP731	1	0	90	0	60	No	8,667	2,620	60	72
XP731	2	0	120	0	60	No	9,560	2,978	61	71
XP732	1	0	90	0	60	No	8,620	3,199	61	72
XP732	2	0	120	0	60	No	9,913	3,316	–	–

[1]Conventional varieties were evaluated using a total of 215 lb N applied in a three-way split with or without fungicide (8 oz Quadris plus 6 oz Tilt) at late boot. Ratoon received 135 lb N in a single preflood application plus 8 oz Quadris and 2 oz Karate at late boot.

[2]Hybrids were evaluated using either 90 or 120 lb N applied all preflood and supplemented with 60 lb N at late boot to early heading. Hybrids received no fungicide. Hybrid ratoon received 135 lb N in a single preflood application.

[3]Ratoon crop was harvested after Hurricane Rita. Yields of early maturing varieties (spring) along with varieties which were flowering (Cheniere) at the time of very high winds likely had ratoon yields significantly reduced.

Main crop fungicide applied to conventional varieties at Eagle Lake (Table 11) increased main crop yield except for the varieties Trenasse, Presidio and Sabine. Fungicide generally improved main crop whole grain milling but did not significantly increase ratoon yield. Applying 120 pounds of preflood nitrogen per acre to hybrids at Eagle Lake did not improve main or ratoon crop yield over the 90-pound preflood application in 2005.

Table 11. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted March 24 on sandy soil at Eagle Lake, Texas in 2005.

Variety[1] or hybrid[2]	Treatment number	Preplant N (lb/A)	Preflood N (lb/A)	Mid season N (lb/A)	Heading N (lb/A)	MC fungicide	MC Total N rate lb/A	MC yield lb/A @12%	RC yield lb/A @12%	MC milling	
										% whole	% total
Trenasse	1	45	80	60	0	No	185	9,569	2,629	59	70
Trenasse	2	45	80	60	0	Yes	185	9,750	2,578	61	71
Presidio	1	45	80	60	0	No	185	7,951	3,776	55	69
Presidio	2	45	80	60	0	Yes	185	7,709	3,978	58	70
Sabine	1	45	80	60	0	No	185	8,111	2,399	62	70
Sabine	2	45	80	60	0	Yes	185	8,194	2,450	63	71
CL131	1	45	80	60	0	No	185	8,334	1,902	63	71
CL131	2	45	80	60	0	Yes	185	9,212	2,211	65	72
CL161	1	45	80	60	0	No	185	8,355	2,298	65	71
CL161	2	45	80	60	0	Yes	185	8,623	2,392	65	72
Cheniere	1	45	80	60	0	No	185	8,331	2,296	61	71
Cheniere	2	45	80	60	0	Yes	185	8,963	2,188	61	72
Cybonnet	1	45	80	60	0	No	185	8,995	2,521	63	72
Cybonnet	2	45	80	60	0	Yes	185	9,452	2,516	65	72
Banks	1	45	80	60	0	No	185	9,572	NA	53	69
Banks	2	45	80	60	0	Yes	185	10,197	NA	54	70
Cocodrie	1	45	80	60	0	No	185	8,865	2,409	60	71
Cocodrie	2	45	80	60	0	Yes	185	9,527	2,560	62	72
XP716	1	0	90	0	30	No	120	10,787	2,621	60	67
XP716	2	0	120	0	30	No	150	10,352	2,521	59	68
XP721	1	0	90	0	30	No	120	10,189	2,649	48	68
XP721	2	0	120	0	30	No	150	10,049	2,621	54	69
XP723	1	0	90	0	30	No	120	11,392	3,120	54	69
XP723	2	0	120	0	30	No	150	11,453	2,764	55	69
XP728	1	0	90	0	30	No	120	11,228	3,788	50	69
XP728	2	0	120	0	30	No	150	11,237	3,777	53	69
XP729	1	0	90	0	30	No	120	11,583	3,619	52	70
XP729	2	0	120	0	30	No	150	11,704	3,452	55	69
CLXP730	1	0	90	0	30	No	120	10,715	3,439	57	70
CLXP730	2	0	120	0	30	No	150	10,307	3,451	58	70
CLXL8	1	0	90	0	30	No	120	10,326	3,542	52	69
CLXL8	2	0	120	0	30	No	150	10,180	3,888	53	69
XP732	1	0	90	0	30	No	120	11,718	2,947	54	69
XP732	2	0	120	0	30	No	150	11,524	2,926	56	69

[1]Conventional varieties were evaluated using a total of 185 lb N applied in a three-way split with or without fungicide (8 oz Quadris plus 6 oz Tilt) at late boot. Ratoon received 135 lb N in a single preflood application plus 8 oz Quadris and 2 oz Karate at late boot.
[2]Hybrids were evaluated using either 90 or 120 lb N applied all preflood and supplemented with 30 lb N at late boot to early heading. Hybrids received no fungicide. Hybrid ratoon received 135 lb N in a single preflood application.

Weed Control

J. M. Chandler and G. N. McCauley

The best approach to controlling weeds in rice involves a combination of good cultural, mechanical and chemical practices. Cultural and mechanical practices include:

- Using certified seed that is relatively free of weedseed;
- Using crop rotations and preparing a good seedbed to eliminate all weeds before planting rice;
- Leveling land in combination with good water management; and
- Developing weed maps or records for individual fields as an aid in determining which herbicides can be used most effectively.

With the semidwarf varieties, it is particularly critical to maintain good early-season weed control because early competition from weeds can significantly reduce rice yields. Therefore, it may be advisable to use a residual herbicide to obtain good initial weed control.

Residual herbicides applied in combination with specific post emergence herbicides provide good to excellent control of emerged weeds and provide an additional 4 to 6 weeks of residual control of susceptible species. Because they are soil-active herbicides, applying them at improper rates can result in either long-term rice injury and/or poor weed control. Certain herbicides have label restrictions associated with methods of planting and limitations related to soil texture and water management.

Recommendations and strengths/weaknesses

The following is a chronological list of herbicides available for rice with suggested application rates, plus their strengths and weaknesses. READ THE LABEL for specific instructions and precautions.

Preplant incorporated herbicides

Ordram® 3.0-4.0 lb a.i./acre

Strengths:
- Suppresses red rice with proper water management
- Broad spectrum weed control

Weaknesses:
- Requires immediate soil incorporation
- Soil must stay moist to retain herbicide
- Water management critical
- Restricted to water-seeded rice

Preemergence herbicides

Bolero® 2.0-4.0 lb a.i./acre

Strengths:
- Rate not dependent on soil factors (texture, organic matter, etc.)
- Safe on rice as soil-applied herbicide
- Can be used on water-seeded rice
- Residual control

Weakness:
- Poor control of broadleaf signalgrass, Texasweed and hemp sesbania

Command® 0.4-0.6 lb a.i./acre

Strengths:
- Provides excellent control of grassy weeds
- Very economical

Weaknesses:
- Use rate dependent on soil texture
- Application technique critical
- Does not control nutsedge, broadleaf and aquatic-weeds

Facet® 0.25-0.50 lb a.i./acre

Strengths:
- Can be applied preemergence or delayed preemergence
- Season-long control of susceptible weeds
- Water management not critical
- Safe on rice

Weaknesses:
- Narrow spectrum control
- Rate dependent on soil texture
- Do not apply preemergence to water-seeded rice

Facet® + Bolero® 0.25-0.50 + 2.0-4.0 lb a.i./acre

Strengths:
- Good control of grass and aquatic weeds
- Safe on rice
- Residual control

Weakness:
- Does not control broadleaf weeds

Prowl® 0.75 to 1.0 lb a.i./acre

Strengths:
- Good control of grassy weeds
- Residual control

Weaknesses:
- Narrow spectrum control
- Short residual control of grassy weeds
- Water management critical

Postemergence herbicides

Aim® 0.025 lb a.i./acre + surfactant

Strengths:
- Good control of many broadleaf weeds
- Low use rates
- Very economical

Weaknesses:
- Timing of application critical. Must be applied to small weeds for efficacy
- No residual control
- Occasional temporary crop injury

Basagran® 0.75-1.0 lb a.i./acre

Strengths:
- Very safe on rice
- Excellent control of yellow nutsedge and dayflower

Weaknesses:
- No residual control
- Very narrow weed control spectrum when applied alone

Blazer® 0.25 lb a.i./acre + surfactant

Strengths:
- Excellent control of hemp sesbania
- Timing of application not critical

Weakness:
- Very narrow weed spectrum

Clincher® 0.19-0.28 lb a.i./acre + COC

Strengths:
- Safe on rice
- Excellent control of annual grassy weeds and knotgrass

Weaknesses:
- Does not control broadleaf, aquatic weeds or sedges
- Multi-tillered grass control, good to poor

Duet® 2-4 qt/acre + surfactant

Strengths:
- Broad spectrum weed control
- Safe on rice

Weaknesses:
- No residual control of weeds
- Performance dependent on environmental conditions

Facet® 0.25-0.50 lb a.i./acre + COC

Strengths:
- Season-long control of susceptible weeds
- Water management not critical
- Safe on rice

Weakness:
- Narrow spectrum control

Grandstand R® 0.25-0.38 lb a.i./acre + surfactant

Strengths:
- Good control of broadleaf weeds
- Environmental conditions do not have large impact on performance
- Excellent broad spectrum control of weeds when applied in combination with propanil or propanil + Ordram

Weaknesses:
- Water management critical – delay flushing for 72 hours after application
- Does not control grasses
- May injure rice if applied to young rice

Grasp® 0.031-0.036 lb a.i./acre + COC

Strengths:
- Residual control for some weeds and barnyardgrass
- Broad spectrum control of broadleaf weeds, flatsedges and barnyardgrass
- Good control of alligatorweed

Weakness:
- Propanil antagonism on some weeds (alligatorweed)

Londax® 0.6-1.0 oz a.i./acre + surfactant

Strengths:
- Safe on rice
- Timing of application not critical
- Provides some residual control

Weaknesses:
- Narrow spectrum control
- Water management critical
- Water must cover weeds and remain static in field for minimum of 5 days

Permit® 0.031-0.062 lb a.i./acre

Strengths:
- Excellent control of sedges
- Safe on rice

Weaknesses:
- Does not control grassy weeds
- Narrow weed spectrum

Propanil 3.0-4.0 lb a.i./acre

Strengths:
- Safe on rice
- Fairly broad spectrum weed control
- Used in combination with many other herbicides to increase spectrum of weed control

Weaknesses:
- No control of sprangletop or dayflower
- No residual control
- Performance dependent on environmental conditions
- Phytotoxic interaction with certain insecticides

Propanil + Aim® 3.0-4.0 lb + 0.025-0.05 lb a.i./acre

Strength:
- Broad spectrum weed control

Weaknesses:
- No residual control
- Most effective on small weeds

Propanil + Basagran® 2.0-4.0 + 0.75-1.0 lb a.i./acre

Strengths:
- Safe on rice
- Broad spectrum weed control

Weaknesses:
- No residual control
- Does not control sprangletop

Propanil + Bolero® 2.0-4.0 + 2.0-4.0 lb a.i./acre

Strengths:
- Rate not dependent on soil factors (texture, organic matter, etc.)
- Safe on rice as soil-applied herbicide
- Can be used on water-seeded rice
- Residual control

Weakness:
- Poor control of broadleaf signalgrass, Texasweed and hemp sesbania

Propanil + Ordram® 2.0-4.0 + 2.0-3.0 lb a.i./acre

Strengths:
- Broad spectrum weed control
- Stage of rice growth not critical

Weaknesses:
- Stage of weed growth critical
- Performance dependent on environmental conditions

Propanil + Permit® 3.0-4.0 + 0.031-0.062 lb a.i./acre

Strengths:

- Broad spectrum weed control
- Excellent control of sedges
- Safe on rice

Weaknesses:

- No residual control
- Weak on sprangletop

Regiment® 11.25-15.0 gm a.i./acre + an approved surfactant

Strengths:

- Broad spectrum weed control
- Excellent control of large barnyardgrass

Weaknesses:

- No residual control
- Occasional temporary crop injury

Table 12. Herbicide comparisons.

Herbicides	Weeds and control																			
	Barnyardgrass	**Crabgrass**	**Signalgrass**	**Sprangletop**	**Red Rice**	**Nutsedges**	**Flatsedges**	**Spikerush**	**Ammania (redstem)**	**Dayflower**	**Ducksalad**	**Eclipta**	**Gooseweed**	**Jointvechs**	**Morningglories**	**Hemp Sesbania**	**Smartweed**	**Water-hyssop**	**Texasweed**	**Alligatorweed**
Preplant incorporate																				
Ordram (water-seeding rice)	G	G	F	P	G	P	G	P	F	P	P	P	P	P	P	P	P	P	P	F
Preemergence																				
Bolero	G	E	F	G	P	P	G	G	G	G	G	G	F	F	P	P	P	P	P	P
Command	E	E	G	E	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Facet	E	E	E	P	P	P	P	P	P	P	P	G	P	G	G	F	P	F	P	P
Facet + Bolero	E	E	E	G	P	P	G	G	G	G	G	G	F	G	G	F	P	F	P	P
Prowl	G	E	G	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Postemergence																				
Aim[1]	P	P	P	P	P	P	P	P	F	F	F	F	P	E	E	E	G	E	G	F
Basagran[1]	P	P	P	P	P	G	G	G	G	E	E	G	G	P	P	P	F	G	P	P
Blazer	P	P	P	P	P	P	P	P	E	P	P	P	P	P	P	E	P	P	P	P
Clincher	E	F	E	E	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Duet	E	E	E	P	P	G	E	E	E	G	F	E	E	E	E	E	G	G	G	P
Facet	E	E	E	P	P	P	P	P	P	P	P	G	P	G	G	F	P	F	P	P
Grandstand R[2]	P	P	P	P	P	P	P	P	E	F	P	G	G	G	E	G	P	G	G	F
Grasp	G	P	P	P	P	F	G	P	F	G	E	G	P	G	F	G	G	P	G	G
Londax	P	P	P	P	P	F	G	G	G	G	G	G	G	F	P	P	P	G	G	P
Permit	P	P	P	P	P	E	G	P	P	P	P	P	P	P	P	G	P	P	P	P
Propanil[1]	E	E	E	P	P	P	P	G	F	P	F	G	P	G	P	G	P	G	F	P
Propanil + Aim	E	E	E	P	P	P	P	P	F	F	F	G	P	E	E	E	G	E	G	P
Propanil + Basagran	E	E	E	P	P	G	G	G	G	E	E	G	G	G	P	G	G	G	F	P
Propanil + Bolero	E	E	E	G	P	P	G	E	G	G	G	G	F	G	P	G	P	G	G	P
Propanil + Ordram	E	E	E	E	P	F	G	G	F	F	F	E	P	G	P	E	F	G	G	P
Propanil + Permit	E	E	E	P	P	E	G	G	F	P	F	G	P	G	P	G	P	G	F	P
Regiment	E	P	P	P	P	P	P	P	F	G	G	F	P	G	G	G	G	G	F	F
Ricestar HT	E	E	E	G	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Storm	P	P	P	P	P	G	G	G	E	E	E	G	G	P	P	E	F	G	P	P
Postflood																				
2,4-D[2]	P	P	P	P	P	P	G	G	E	E	E	E	F	F	E	E	F	E	E	G
Clincher	G	P	E	E	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Grasp	G	P	P	P	P	F	G	G	F	G	E	E	–	G	P	G	G	G	–	G
Ordram 15G	G	G	P	F	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Clearfield* System																				
Newpath (2 applications)	E	E	E	F	E	G	E	G	G	F	F	P	P	P	G	P	G	P	F	P
Beyond	—	—	—	—	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Control symbols P=poor <49%, F=fair 50-69%, G=good 70-89% and E=excellent 90-100%. Control expected under optimum conditions.

[1]early postemergence

[2]mid season

Ricestar® 0.94-1.23 oz a.i./acre

Strengths:

- Safe on rice
- Excellent control of grassy weeds

Weaknesses:

- Does not control broadleaf, aquatic weeds or sedges
- Multi-tillered grass control, good to poor

Storm® 1.5 pt product/acre + surfactant

Strengths:

- Safe on rice
- Excellent control of yellow nutsedge, dayflower and hemp sesbania

Weaknesses:

- No residual control
- Does not control grassy weeds

Post-flood herbicides

2,4-D 0.75-1.25 lb a.i./acre + surfactant

Strengths:

- Very economical
- Good control of broadleaf weeds

Weaknesses:

- Timing of application critical
- No residual control

Grasp® 0.031-0.036 lb a.i./acre + COC

Strengths:

- Controls large barnyardgrass, many broadleaf weeds and flat sedge
- Excellent control of aquatic weeds

Weakness:

- Does not control broadleaf signalgrass, sprangletop or fall panicum

Clincher® 0.25-0.28 lb a.i./acre + COC

Strengths:

- Safe on rice
- Safe on adjacent broadleaf crops (soybean and cotton)
- Good control of annual grassy weeds and knotgrass

Weakness:

- Does not control broadleaf weeds or sedges

Ordram® 15G 2.0-3.0 lb a.i./acre

Strength:

- Controls barnyardgrass and dayflower with proper water management

Weaknesses:

- No residual control when applied postemergence
- Narrow spectrum weed control
- Deep water depth must be maintained

CLEARFIELD* System

NewPath® 0.0625 fb 0.0625 lb a.i./acre + surfactant for postemergence applications

Strengths:

- Excellent control of red rice, grassy weeds and nutsedge
- Residual control

Weaknesses:

- Application timing and water management critical
- Clearfield varieties must be grown
- Two applications required
- CL121 and CL141 sensitive to postemergence applications

Beyond® 0.04 lb a.i./acre + COC

Strengths:

- Controls red rice escapes in Clearfield
- Limited carryover

Weaknesses:

- Restricted to CL161 and CLXL8
- Cannot be tankmixed with other herbicides
- Can only be used after two 0.0625 lbs a.i./acre application of NewPath
- Timing critical
- ⅔ of red rice must be exposed at application

Metering Ordram® 8EC in the Floodwater

J. M. Chandler and G. N. McCauley

As the permanent flood is being established, Ordram® 8EC can be metered into the irrigation water. A metering device or spigot (See Fig. 2) is used to apply the Ordram® 8EC at the point where the water enters the field.

It is important to get good agitation of the Ordram® 8 EC in the water at the point of entry to ensure uniform distribution of the herbicide in the field.

Proper calibration of the metering device is important. A disc orifice in the metering device is used to regulate

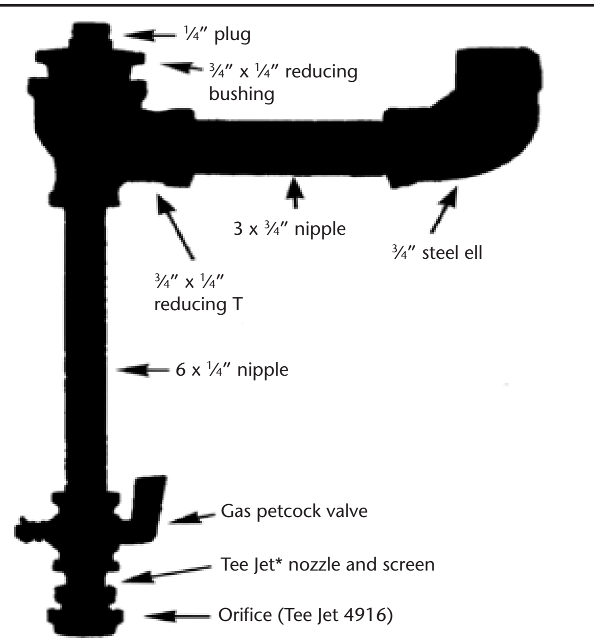

Figure 2. A metering device or spigot used to apply the Ordram® 8EC at the point where the water enters the field. *Not an endorsement for this specific product; other similar products also are suitable.

the flow of Ordram® 8 EC. A chart can be acquired from a local dealer or distributor to determine the correct orifice size to meter the herbicide.

Two factors must be known to determine the proper orifice size: the size of the field, and an estimate of the number of hours needed to flood the entire field. It may be necessary to monitor the metering device and water discharge rate to ensure proper application of the herbicide.

The major advantage of this application technique is the minimal application cost. This method can be used in situations when conventional methods are unsuitable because of poor weather conditions.

Disadvantages include:

- Requires monitoring the application of the herbicide during the period of establishing the flood;
- Requires special calibration of equipment and a knowledge of time required to flood the field; and
- Weed control performance could be erratic and rice injury is possible, particularly if the Ordram® 8 EC is not uniformly applied in the field.

Red Rice Control

J. M. Chandler and G. N. McCauley

Controlling red rice requires a program approach that uses good management – a combination of preventive, cultural and chemical methods in conjunction with crop rotation.

Preventive practices

Preventive measures include planting high-quality rice seed and using clean equipment and machinery in farm operations. Use of high quality rice seed free of red rice is extremely important in preventing the introduction of red rice into a field. After working a field infested with red rice, whether during field preparation or harvesting, clean machinery before moving to the next field to prevent the introduction of red rice seed into other fields. Mud and other debris that clings to tractors and cultivating equipment can contain red rice seed that can be moved into a red-rice-free field.

Cultural methods

In addition to preventive practices, certain cultural methods can be used. During seedbed preparation, it is important to **destroy all red rice plants** in the field before planting.

Because red rice is more vigorous and grows faster than commercial rice, give commercial rice an opportunity to compete effectively with red rice by **planting it at the suggested (or at a slightly higher) seeding rate.** Red rice tillering and seed production are decreased when competition from commercial rice is high.

Use **proper water management** to suppress red rice effectively. Permitting soil to cycle (dry out and rewet) encourages the germination of weed and red rice seed.

Water seeding in combination with good water management helps suppress red rice. Two suggested techniques are continuous flood culture and the pinpoint flood system (see **Early Flood Rice Culture - Definition**). In these two cultural systems, it is important to flood immediately after seedbed preparation. A delay in flooding allows red rice seed to germinate and get established before flooding, resulting in a loss of red rice suppression.

Post-harvest management is critical in red rice management. High-moisture red rice seed incorporated in the soil may remain dormant for many years. Red rice seed left on the soil surface over winter will lose dormancy. These seed will germinate by March and can be killed by cultivation. Red rice will lose its dormancy through a series of wetting and drying cycles. A winter with alternating dry and wet periods most likely will result in severe red rice pressure in the following season. A wet winter generally results in lower red rice pressure the next season.

Herbicide use

Although both continuous and pinpoint flood culture suppress red rice, they may not provide adequate control. To improve control, use herbicides in combination with specific water management techniques.

Apply Ordram® 8E preplant soil-incorporated at 3 to 4 pints per acre, depending on the soil texture. Use ground application equipment only, incorporate immediately and flood as soon as possible.

Ordram® 15G preplant incorporated at 20 to 27 pounds per acre also can be used. Mechanically incorporate it within 6 hours of application and flood as soon as possible.

Newpath® can be applied only to CLEARFIELD* rice varieties and provides very effective control of red rice. Two applications are critical for control. The first 4-ounce application can be applied preplant and incorporated or at spiking to one leaf rice or red rice. The later application has proven to provide better red rice control. The second application should be applied at four-leaf rice or red rice. Applications made later (five- to six-leaf) may reduce control.

It is important that the herbicide be activated immediately after application with a flush or rainfall. The best control is obtained when the flood is applied no later than 7 days of the last application.

Field selection is critical. Non-CLEARFIELD* rice fields and other crops are extremely sensitive to drift.

Escapes can occur in either of these chemical management systems. In the CLEARFIELD*/Newpath system, Beyond® at 5 oz per acre can be used to control escapes. Beyond® can be applied between late tillering and panicle initiation. Beyond® can be applied only following two applications of Newpath. It is strongly recommended that escapes be rougued from fields before heading.

Stale seedbed technique

Another method of red rice control is to cultivate the rice field in early spring and keep it idle or stale to allow germination and growth of red rice. If possible, fields should be flushed to maximize red rice seed germination.

When red rice is actively growing and 4 inches tall or less, apply 1 quart of Roundup UltraMax®. When applying by air, apply 3 to 5 gallons of water per acre. (Application to red rice growing in saturated soils is not as effective as on dry soils.) For the most effective control of red rice, wait at least 6 days but not more than 9 days after application to flood and plant using the waterseeded method. Normal production practices are then followed.

Crop rotation

The most practical and economical way to control red rice is to rotate grain sorghum and soybeans with rice. Two suggested 3-year crop rotations are soybeans/soybeans/rice or grain sorghum/soybeans/rice. When growing soybeans in these rotations, use a herbicide such as Frontier®, Lasso®, Dual® or Treflan® at recommended label rates. Planting grain sorghum in the rotation and using atrazine is also effective. Although red rice can be controlled with these herbicides, early cultivation and application of a selective postemergent soybean herbicide such as Poast®, Select®, Fusion®, Assure® II or Fusilade® DX are necessary to control any red rice that escapes the soil-applied herbicide. It is important to plant alternate crops for at least 2 years before rice to achieve satisfactory control of red rice.

Disease Control

J. P. Krausz

Rice diseases are a serious limiting factor in the production of rice in Texas. It is estimated that diseases annually reduce rice yields an average of 12 percent across the Texas rice belt. Because disease losses must be subtracted from that relatively small portion of potential yield that would contribute directly to net return, the average percent loss in potential net return because of diseases would be considerably greater than 12 percent.

Unfortunately, over the past decade many changes in rice production practices designed to obtain maximum yields have also created conditions favorable for diseases. Some of the practices include increased nitrogen fertilization, widespread use of varieties very susceptible to sheath blight, shortened rotations and more dense plant canopies. Rice producers must seek to manage disease losses through an integrated use of sound cultural practices, resistant varieties and chemical controls.

Rice blast

Rice blast, caused by the fungus *Pyricularia grisea,* can result in severe losses to susceptible varieties when environmental conditions such as warm, moist weather favor disease development.

The blast fungus causes leaf symptoms on young plants and panicle blast or rotten neck symptoms later in the growing season. Leaf lesions are spindle-shaped and elongated with brown to purple-brown borders and grayish centers.

The rotten neck phase of the disease is commonly observed. With rotten neck, a brownish lesion on the internode at the base of the panicle often prevents the grains from filling or weakens the neck of the panicle so that filled heads break off before harvest.

The rice blast fungus is a highly variable pathogen, and there are many pathogenic races. In recent years, the race IC-17 has been the most prevalent in Texas, followed by IB-49. The adoption of varieties with resistance to the races of blast prevalent in Texas has greatly reduced losses caused by blast.

Chemical control of blast usually is not recommended when moderately resistant varieties of rice are planted. When moderately susceptible or susceptible varieties are grown in areas where blast has historically occurred, preventive applications of Quadris® or Gem® fungicide may be necessary.

The rotten neck phase of blast can occur without leaf blast symptoms because the spores of the pathogen can become air-borne and blow into the field from a distant source. If leaf blast lesions are in the field, the potential for the rotten neck phase of blast is greatly increased.

For optimum blast control, apply Quadris® or Gem® at late boot to reduce sporulation on leaf lesions and to protect the collar of the flag leaf. Apply again about 5 to 7 days later when 50 percent of the main tillers have 70 to 90 percent of the panical length emerged.

The late-boot application is most important if there are leaf lesions caused by blast. The heading application is more important to protect panicles from spore showers. Blast is favored by excessive nitrogen fertility, thick stands, lighter soils and inadequate flooding.

Kernel smut

Kernel smut is a serious disease caused by the fungus *Tilletia barclayanna* (*Neovossia horrid*a). The disease causes the endosperm of the rice grain to be replaced completely or partially by a black mass of smut spores. Usually only one to five grains per panicle are infected.

Although yield losses are insignificant, monetary losses can be very high if the rice can't be sold or the price is reduced at the mill. Infested lots of grain often have a dull, grayish cast caused by the smut spores. Rice lots exceeding 3 percent kernel smut infection presently will not qualify for government loan.

The disease is not systemic. The smut spores fall to the soil surface, where they remain dormant until the following rice crop, or they can be introduced into a field on the surface of infested rice seed. The smut spores float to the surface of the irrigation water where they germinate and produce air-borne spores which infect individual rice florets. Disease development is favored by frequent light showers and high relative humidity.

Kernel smut is difficult to control. Field tests indicate that a late-boot application of Tilt® or Propimax® at 4 to 6 fluid ounces per acre reduces the number of smutted kernels. The semidwarf varieties Lemont and Gulfmont are less susceptible to the disease than Cocodrie or Cypress.

Heavy nitrogen fertilization favors the disease. A 3-year crop rotation should help reduce the number of smut spores present. Do not plant seed contaminated with smut spores.

Sheath blight

Sheath blight, caused by the fungus *Rhizoctonia solani,* has rapidly become the most important rice disease in Texas and probably the second most important rice disease worldwide.

A change in cultural practices during the 1980s is the reason for this. The increased use of sheath-blight-susceptible semidwarf varieties, along with the recommended high nitrogen fertilization required to obtain their maximum yield potential, has resulted in much greater losses from sheath blight. Also, the trend toward shorter crop rotations has made the disease more troublesome by allowing the fungus to increase in quantity within fields. As a result, rice producers have increased their reliance on fungicides to manage sheath blight.

Cultural control

To most effectively and economically reduce losses from sheath blight, use an integrated package of management practices. Some practices may be economical only where sheath blight is a persistent, significant problem. Others are recommended in all situations as sound production practices that will help prevent the buildup of a sheath blight problem or limit its effects where the problem exists. Some recommended cultural practices include:

- Avoiding excessive seeding rates, which result in an excessively dense canopy that creates a microclimate favorable to disease development.
- Avoiding excessive rates of nitrogen fertilization, which increase the severity of the disease.
- Where possible, increasing the interval between rice crops to at least 1 year of rice in every 3 years. Research has shown that rotations of pasture-pasture-rice, soybean-soybean-rice and rice-soybean-rice had average incidence of sheath blight of 0.4, 2.7 and 5.4 percent, respectively, at panicle differentiation. In addition, more sheath blight inoculum for future rice crops tends to be produced in drilled soybeans than in row-planted soybeans.
- Controlling grass weeds that can serve as hosts of the sheath blight fungus. Barnyardgrass, crabgrass and broadleaf signalgrass are known hosts of the pathogen.

Variety selection

Long-grain rice varieties differ in their susceptibility to sheath blight. Among those considered very susceptible are Cocodrie, Gulfmont and Cypress.

Less susceptible (moderately susceptible) are Jefferson, Saber and most of the medium grain varieties. Taller varieties tend to sustain less loss than semidwarf varieties.

Chemical control

In many situations, foliar fungicides may be economically justified for reducing losses from sheath blight if:

- The disease pressure is sufficiently high;
- Susceptible varieties of rice are grown;
- The crop has a high yield potential in the absence of sheath blight; and
- Environmental conditions are favorable for the disease to spread to the upper leaves of the rice plant.

It is difficult to estimate the potential severity of sheath blight in a field in order to determine the economic feasibility of applying a fungicide. However, with the high costs of fungicide spray programs and the need to reduce production costs, estimates should be made.

To estimate the severity of sheath blight infestation, monitor the field at or shortly after panicle differentiation (PD) growth stage (See Fig. 3). It may not be necessary to precisely monitor a field with a recent history of severe sheath blight that is on a short crop rotation (more than one rice crop in a 3-year interval).

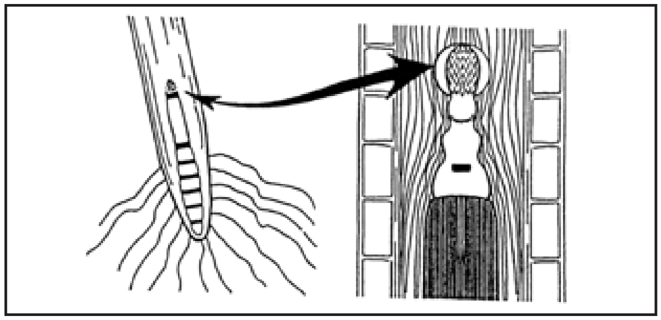

Figure 3. Panicle differentiation (PD).

Monitoring for sheath blight

Sheath blight develops at an amazingly rapid pace during favorable environmental conditions. Begin scouting for evidence of sheath blight during PD by walking across the field in a zigzag pattern (See Fig. 4), periodically observing rice at and several inches above the water line for any evidence of early sheath blight lesions.

If no sheath blight is found, wait a week and monitor again. If some sheath blight is found, a more precise monitoring is necessary to accurately estimate the amount of sheath blight present.

A very helpful checking tool can be made from a ¾-inch PVC pipe fashioned into the shape of a “T,” with a 4-foot handle connected by a “T” joint to two 14-inch lateral tubes. The device is used to push open the rice canopy and is a back-saver.

To monitor more precisely, divide large fields into 45- to 50-acre sections and monitor each section separately (See Fig. 4). Walk the field sections in a “U” pattern, randomly stopping to check for the presence of sheath blight.

Record the stop as positive for sheath blight even if only one small sheath blight lesion is found on a single plant. The stop is considered negative if absolutely no sheath blight is found. The total number of stops should be at least equal to the number of acres in the area scouted (i.e., 45 acres = 45 or more stops).

Finally, divide the number of positive stops where sheath blight was found by the total number of stops and multiply by 100. This will give the percentage of positive sheath blight stops.

The thresholds for economical fungicide application are based on the amount of sheath blight present at PD and the variety planted.

Several other factors to consider in deciding whether or not to use a fungicide include plant density, prevailing weather and ratoon cropping. The denser the canopy, the more favorable the conditions for sheath blight to develop. The thresholds suggested do not take into account the possibility of second cropping (ratoon cropping) the field being evaluated. They are based on only one harvest.

It is well documented that when sheath blight is controlled by fungicides in the first crop, a significant increase in yield also can occur in the second crop. Therefore, if a ratoon crop is planned, the suggested thresholds might be reduced to 25 percent positive stops for very susceptible varieties or 30 percent positive stops for moderately susceptible varieties.

The thresholds are estimates based on information and conditions occurring at the time of evaluation, preferably at PD. If very favorable weather conditions develop later and persist, sheath blight could develop rapidly and make the original threshold determination obsolete. Sheath blight should be monitored periodically during the development of the rice crop. Evaluate alternatives at each step.

Table 13. Threshold guidelines suggested for economical fungicide application.

Sheath blight susceptibility	Positive stops	Infected tillers
Very susceptible varieties: Gulfmont, Lemont, Cypress, Cocodrie	35%	5%
Moderately susceptible to moderately resistant varities: Cheniere, Jefferson, Saber, XL8	45%	10%

Stem rot

Stem rot is caused by a soil-borne fungus (*Sclerotium oryzae*) and is a significant problem in all southern rice-producing states and California. The pathogen survives the winter as tiny resistant structures called sclerotia which can remain alive in the soil for up to 6 years.

Stem rot is initiated when the sclerotia float to the water surface and infect the rice plant at the waterline.

At first, small, rectangular, black lesions develop on the sheath. Later these lesions enlarge as the fungus penetrates inward toward the culm.

In the later stages of crop maturity, large areas within infested fields may begin to lodge soon after drainage has begun. Within infected culms and sheaths, numerous tiny, black sclerotia can be seen.

Although commercial long grain rice varieties lack significant levels of resistance to stem rot, the newer semidwarf varieties tend to be more tolerant to stem rot because of their resistance to lodging.

Currently registered fungicides do not adequately control stem rot and are not recommended for this purpose. Quadris® and Tilt®, when applied for sheath blight, can suppress stem rot moderately.

Crop rotation and reduced rates of nitrogen fertilizer in fields with a history of stem rot are recommended control practices.

Narrow brown leaf spot

Narrow brown leaf spot, caused by the fungus *Cercospora janseana,* causes more yield and grain loss than is often suspected. The fungus attacks the leaf, sheath, uppermost internodes and glumes.

On leaf blades, it causes short, linear, narrow, brown lesions parallel to the leaf veins. As plants approach maturity, leaf spotting can become severe on the more susceptible varieties and result in severe leaf blighting and premature death. Infection of the leaf sheaths result in a large brown blotch or "net blotch."

The fungus also can cause a "neck blight," where the internodal area above and below the node at the base of the panicle becomes light brown to tan. The affected area dies and the kernels in the lower portion of the panicle fail to fill. Low nitrogen levels seem to enhance the disease.

Tilt®, Quadris®, Stratego® and Quilt® fungicides applied in the mid- to late-boot stage have been effective in suppressing the diseases caused by *C. janseana.*

Panicle blanking complex

Florets that do not pollinate or fill properly can result from of a number of biological and environmental factors. Often "blanked" florets can be numerous and result in significant yield losses. Completely empty florets indicate that they never successfully pollinated.

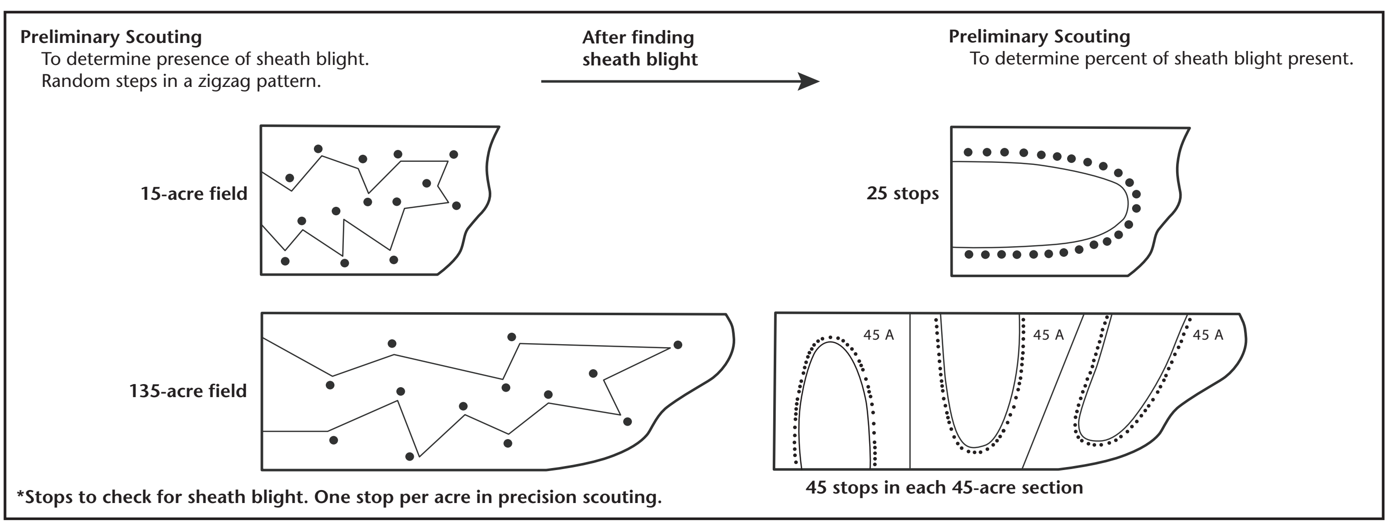

Figure 4. Suggested scouting procedure for sheath blight.

Table 14. Fungicides for rice foliar disease control.

Material	Rate/A and timing	Sheath blight control[2]
Gem 25WG	8.0–9.8 oz @ PD-5 days to late boot	7.5–8.0
Moncut 70WG	8–16 oz @ PD AND PD+ 10–14 days	7–7.5
Moncut 70WP	11–16 oz @ PD-5–10 days	6
Propimax	10 f. oz @ PD to PD+10 days	5
Quadris	9.2–12.3 fl oz @ PD+5 days to late boot	8–8.5
Quilt	14–34.5 fl oz @ PD+5 days to late boot	7.5–8.0
Stratego	14–19 fl oz @ PD+5 days to late boot	7–7.5
Tilt	10 fl oz @ PD TO PD+10 days	5

[1]See product label for details on application rate and timing.
[2]Sheath blight control ratings 0–9.: 0 = no control; 9 = very good control
Some other rice diseases for which fungicides have shown some efficacy include:
Stem rot: Quadris 9.2–12.8 fl oz/A at PD to mid-boot.
Kernel Smut: Tilt or Propimax 4.0–6.0 fl oz/A at late boot.
Blast: Quadris 12.2 fl oz/A or Gem 6.4 to 9.8 oz/A at late boot and again at early heading when 50 percent of the main tillers have panicles 70 to 80 percent of their length emerged but with the panicle bases yet unexposed. If only one fungicide application is used, the early heading application is often onsidered the preferable one.

Research at Texas A&M and the International Rice Research Institute (IRRI) has shown that temperatures above 95 degrees F during the pollination process (anthesis) cause floret sterility. Another high-temperature sensitive period that can cause pollen sterility occurs about 10 days before pollen shed.

Early planting may be one way to reduce heat-induced sterility. Heat sterility should not be confused with the disease called panicle blight.

With panicle blight, florets often are pollinated but developing embryos abort, leaving a small embryo or undeveloped seed between the glumes. Upon close observation a few days after panicle exertion, a lack of luster in the green glumes of the affected panicle can be noticed. Within 1 to 2 weeks, the glumes turn various shades of tan to light brown and lack the turgidity and brightness of healthy glumes.

Two important characteristics of panicle blight separate it from other panicle disorders:

- Panicle blight often does not appear to prevent successful pollination; and
- The rachis or branches of the panicle remain green for a while right to the base of each floret, even after the glumes dessicate and turn tan.

Pollination takes place and a small grain begins to form, but it aborts and remains small and underdeveloped. Research shows that panicle blight is caused by a bacterium, *Burkholderia glumae.* Varieties with California

Table 15. Disease reaction of varieties in Texas.

Rice variety	Blast	Kernel smut	Sheath blight	Stem rot	Brown leaf spot	Narrow brown leaf spot	Straighthead
Banks	R	—	MR	S	—	—	—
Bengal	MR	MS	MS	S	MR	MS	VS
Bolivar	R	—	MS	S	S	R	R
CL 161	S	S	S	S	MS	MS	MR
Cheniere	S	—	MS	S	—	MS	R
Cocodrie	R	S	VS	S	MR	MS	S
Cybonnet	R	—	MS	S	—	—	—
Cypress	MR	S	VS	S	MR	S	MS
Della	S	—	MR	S	—	MR	MS
Dellrose	MR	—	S	S	MS	MR	MS
Dixiebelle	MS	—	MS	S	R	MS	MR
Francis	S	—	MS	S	MS	MR	MR
Jasmine 85	R	MS	R	—	S	R	VS
Jefferson	R	S	MR	S	MR	MS	MR
Medark	MR	—	MR	S	—	MS	—
Neches	MR	—	VS	S	—	—	—
Pirogue	S	—	MR	S	—	MR	R
Presidio	R	S	MR	S	MR	MS	MR
Saber	R	S	MR	S	R	MS	R
Sabine	MS	—	R	S	—	—	—
Sierra	MR	—	VS	S	—	—	—
Wells	MR	MR	MS	S	R	R	MS
XL-8	R	—	MR	S	S	R	MR

VR=very resistant; R=resistant; MR=moderately resistant; MS=moderately susceptible; S=susceptible; VS=very susceptible.
These ratings are relative. Varieties rated S or VS for a disease may show extensive disease development under favorable conditions. Varieties rated R or MR show significantly less damage under similar conditions.

germplasm, such as Cypress, Maybelle and Cocodrie, seem to be more prone to serious damage by panicle blight.

Currently, the best way to manage panicle blight involves the use of timely planting, proper varietal choice and avoiding excessive seeding and nitrogen rates. The copper-based product Top-Cop® applied at 2 quarts per acre at late boot has suppressed panicle blight in field tests, but foliar phytotoxicity has been reported. If used, it is best to apply Top-Cop® when the foliage is dry and without use of a surfactant.

Ear blight is a disease complex caused by several fungi, including those that cause narrow brown leaf spot (*Cercospora janseana*) and brown leaf spot (*Cochliobolus miyabeanus*). These fungi can cause discoloration and blight of the uppermost internodes, the neck below the panicle, the branches of the rachis, and spikelets of the panicles. This often results in poorly developed grains.

Tilt®, Quadris®, Stratego® and Quilt® applied in the mid- to late-boot stage help suppress this disease complex.

Black sheath rot

Black sheath rot or crown sheath rot is caused by the soil-borne fungus *Gaeumannomyces graminis* var. *graminis* and has been in Texas rice fields for at least several decades.

Previously considered a minor disease of rice, it is becoming more of a problem with the increasingly intensive production systems and shorter rotations. The disease is widespread in the Texas rice belt and can cause reduced tillering, poor grain fill and lodging. The disease usually is observed late in the main crop, but also has been found to infect the ratoon crop to some extent.

Affected plants show a brown to black discoloration of the leaf sheaths from the crown to considerably above the water line. In the early stages of the infection a dark, reddish-brown web of fungal mycelia (filaments) may be seen on the inward-facing surface of diseased leaf sheaths.

As the discolored, infected sheath tissue ages, fungal reproductive structures (perithecia) form within the tissue. The perithecia are tiny, black, globose structures imbedded in the sheath tissue, often with short beaks protruding through the surface. These perithecia are barely visible and about the size of a grain of black pepper.

Crop rotation, especially with nongrass crops, will help reduce the carryover of fungal inoculum. Thorough disking and maintenance of a clean fallow field from the summer before to planting rice will decompose plant residue and eliminate weed hosts upon which the pathogen survives.

False smut

False smut is a disease caused by the fungus *Ustilaginoidea virens,* which infects the rice flowers during booting to early heading.

The infected florets are transformed into a globose, velvety "smut ball" measuring up to ½-inch in diameter. Immature smut balls appear orange and are covered with a thin membrane. At maturity, the membrane ruptures and exposes a mass of greenish-black powdery spores.

False smut has historically been a minor disease in Texas, but the recent disease spread in Arkansas, from a few counties in 1997 to 26 counties by 2000, has raised concern in Texas. Rice significantly contaminated with false smut spores could be docked in price.

False smut management suggestions include:

- Plant rice as early as practical, because late maturing fields seem to have more false smut;
- Use recommended rates of nitrogen. The disease is more severe under high nitrogen fertility; and
- Limited data suggest that Tilt® and Quadris® applied at late boot have given some control of the disease. The applications would probably not be economical unless mills start to dock growers for contaminated rice.

Other diseases

The rice plant is attacked by many fungi that cause diseases of relatively minor economic importance. A disease may be considered minor if it rarely occurs or if it causes little or no loss in net profit even when it is commonly observed.

Leaf smut and brown spot are often considered minor diseases. When brown spot is prevalent, it usually indicates that a rice crop is nutritionally deficient or stressed by unfavorable soil conditions.

Crop rotation, use of high-quality planting seed and balanced fertility are recommended controls. Foliar fungicides are not economical for control of either leaf smut or brown spot.

Narrow brown leaf spot is one of the most common rice diseases in the Upper Gulf Coast and varies in severity from year to year. The brown blotch phase of the disease occurs when the causal fungus attacks the uppermost sheath an inch or so below the panicle. Narrow brown leaf spot can cause significant yield loss, and fungicide applications have resulted in increased yields.

However, in the absence of other yield-limiting diseases that respond to fungicide treatments, it often is not economical to treat rice crops for narrow brown leaf spot alone. Its erratic nature also makes it difficult to predict severe infections.

The fungicides Tilt®, Quadris®, Stratego® and Quilt®, when used to control sheath blight, aid in controlling narrow brown leaf spot. Crop rotation, residue management and varietal resistance should aid in managing narrow brown leaf spot.

Straighthead

Straighthead is a physiological disorder that causes the entire head to be blank and remain upright at maturity. Straighthead generally occurs in spots scattered throughout a field.

It is most easily recognized near harvest when normal plants have downturned heads from the weight of the grain in the panicle, while affected plants remain upright. Hulls of affected grain are distorted into a crescent shape or "parrot beak." Affected plants are darker green through the growing season and often produce shoots from lower nodes on the plant.

The disorder is more frequently found on sandy loam than on clay soils and has been associated with arsenic residues remaining in fields that were at one time planted to cotton. Other, as yet unknown, soil factors also are involved in causing straighthead. Often it is found in fields where excessive nondecaying vegetation has been plowed under soon before planting.

Control of straighthead is mainly achieved by planting resistant varieties. When planting a susceptible variety on fields with a history of straighthead, draining the field just before internode elongation has also provided control. Use caution when draining fields planted to a variety susceptible to blast disease, as leaf blast can intensify in fields that are temporarily drained mid-season.

Insect Management Alternatives

M. O. Way, J. K. Olson and B. M. Drees

Insecticides should be applied only when a pest infestation reaches or exceeds levels high enough to economically justify or pay for the treatment in terms of increased yield and/or quality. Besides chemical applications, many other rice production practices influence insect populations and their associated damage. Cultural practices can greatly reduce the number of insecticide applications required.

Water management is critical for rice production and influences insect populations. The rice water weevil is an aquatic pest that requires saturated soil for the larvae to survive.

One way to suppress an infestation is to drain the field and allow the soil to dry during larval development. However, the soil must be so dry that it cracks before the larvae will die. In general, applying the permanent flood early relative to rice emergence can make the rice water weevil damage more severe.

Fall armyworm and chinch bug populations can be much more damaging if there is no standing water. Timely flushing or flooding can help alleviate fall armyworm, chinch bug, aphid and mite problems.

Planting dates influence the abundance of insect pests. Late-planted rice is more vulnerable to attack by armyworms and stalk borers. Rice is likely to escape heavy infestation if it is planted early or late in relation to the emergence of adult rice water weevils. Early-maturing rice also may escape high populations of adult rice stink bugs that move into late-planted rice from declining alternate hosts such as sorghum.

Fertilization practices can affect the damage caused by rice water weevil larvae. Producers should be careful not to overfertilize, which increases the potential for lodging and disease problems.

A recent 3-year study in Texas showed that increasing nitrogen fertilizer at panicle differentiation did not compensate for rice water weevil damage. In other words, when rice water weevil damage is observed after the permanent flood, do not apply “extra” nitrogen at panicle differentiation to make up for the damage.

Another recent 3-year study in Texas showed that increasing nitrogen fertilizer immediately before the flood did not protect rice from rice water weevil damage. Thus, do not apply “extra” nitrogen immediately before the flood in anticipation of later rice water weevil damage.

Variety selection is important not only because varietal response to nitrogen also affects the plants’ response to root damage from rice water weevils, but also because certain varieties show some resistance to feeding by rice water weevils, rice stink bugs and stem borers. Resistance may result from plant characteristics that make certain varieties less attractive to pests than others.

Weed control practices can reduce the number of alternate hosts in a rice field. Rice stink bug populations build up on other grasses in rice fields, in grassy areas around field margins and in adjoining pastures and sorghum fields. They begin breeding in rice as the rice heads develop. Thus, sound weed control can delay or reduce rice stink bug infestations in rice fields.

Rice stand has a major impact on rice water weevil populations. In general, thinner stands are associated with more rice water weevils and more damage. Thin rice stands also result in more weeds, including grasses, which can harbor high populations of rice stink bug. And, thin stands are susceptible to damage by chinch bugs, fall armyworms and rice whorl maggots.

Thus, to discourage insect problems, growers should employ production practices that ensure strong, uniform stands, including:

- Preparing a good seedbed
- Planting high-quality seed at the proper depth, time and rate
- Eliminating early weed competition
- Employing proper irrigation procedures

Insecticide-herbicide interactions

Phytotoxicity, or plant damage from the use of certain insecticides and herbicides in close sequence, is well documented in rice. Foliar burn can be caused by applying propanil within 15 days of a carbaryl (Sevin®) application or within 14 days of a methyl parathion application, as is often contemplated for fall armyworm, chinch bug or aphid control.

Recent insecticide regulatory actions

Be aware that granular carbofuron (Furadan® 3G) cannot be applied on rice. The U.S. Environmental Protection Agency (EPA) withdrew the use of granular carbofuran after the 1999 growing season.

Karate®Z

For the 1998 growing season, lambda-cyhalothrin (Karate®) was registered by the U.S. EPA to control rice water weevils, fall armyworms, chinch bugs, rice stink bugs, grasshoppers, leafhoppers, selected aphid species and stalk borers. For the 2004 growing season, Karate® was replaced by Karate® Z, which is more concentrated

(2.08 versus 1.0 pound of active ingredient per gallon), less susceptible to breakdown by sunlight, safer for handlers and more rainfast than is Karate®.

Texas data show Karate® Z to be as effective as, if not more effective than, Karate®. For more information, see the "Insecticides for Rice Water Weevil Control," "Insecticides for Chinch Bug Control," "Insecticides for Fall Armyworm Control," "Insecticides for Grasshopper Control" and "Insecticides for Rice Stink Bug Control" tables.

Icon™ 6.2FS

Fipronil (Icon™ 6.2FS) was registered for the 1998 growing season by the U.S. EPA to control rice water weevils, chinch bugs and stem borers.

Texas data show that Icon™ 6.2FS, when applied as a seed treatment, provides excellent control of rice water weevils and chinch bugs. Texas studies indicate that Icon™ 6.2FS also provides some control of stalk borers. Icon™ 6.2FS can be applied to dry or pregerminated seed.

Texas research shows that if rice fields are to be pinpoint flooded and planted with Icon™ 6.2FS-treated, pregerminated seed, they should be drained as soon as possible after seeding. Delaying field drainage may decrease the effectiveness of the insecticide.

Also, Texas data show that pregerminated seed should not be treated with Icon™ 6.2FS while the seed is dripping wet. Wait until the seed is drier to maximize the insecticide's effectiveness.

In addition, Texas studies indicate that water-seeding Icon™ 6.2FS-treated seed immediately after insecticide application may reduce the efficacy of the seed treatment. Give the treatment time to adsorb to seed before water seeding. For more information, see the "Insecticides for Rice Water Weevil Control" and "Insecticides for Chinch Bug Control" tables.

Mustang MAX™

In the winter of 2003, the U.S. Environmental Protection Agency approved the use of Mustang MAX™ against the rice water weevils, fall armyworms, chinch bugs, rice stink bugs, grasshoppers, leafhoppers and selected aphid species. Both Mustang MAX™ and Fury® possess the same active ingredient—zeta-cypermethrin—but Mustang MAX™ contains a resolved isomer of zeta-cypermethrin.

This means that the resolved isomer of zeta-cypermethrin in Mustang MAX™ is about twice as "active" as that in Fury®. Therefore, for equivalent control, apply less zeta-cypermethrin when using Mustang MAX™ compared to Fury®. Clearly, this technology is better for the environment.

For more information, see the "Insecticides for Rice Water Weevil Control," "Insecticides for Chinch Bug Control," "Insecticides for Fall Armyworm Control," "Insecticides for Grasshopper Control" and "Insecticides for Rice Stink Bug Control" tables.

Dimilin® 2L

In the spring of 1999, the U.S. EPA approved the use of Dimilin® 2L to control rice water weevils. Texas data from several years show that Dimilin® 2L is as effective as other rice water weevil insecticides when applied at the proper rates and times.

The active ingredient in Dimilin® 2L is diflubenzuron, which sterilizes the eggs developing in female adult rice water weevils and prevents larval emergence from eggs. Thus, Dimilin® 2L must be applied shortly after application of the permanent flood, when adult rice water weevils invade rice fields. For more information, see "Insecticides for Rice Water Weevil Control."

Prolex®

In the spring of 2004, the U.S. EPA approved the use of Prolex™ against the rice water weevil, fall armyworm, chinch bug, rice stink bug, grasshoppers, leafhoppers and selected aphid species. The active ingredient in Prolex™ is gamma-cyhalothrin. For more information, see the "Insecticides for Rice Water Weevil Control," "Insecticides for Chinch Bug Control," "Insecticides for Fall Armyworm Control," "Insecticides for Grasshopper Control" and "Insecticides for Rice Stink Bug Control" tables.

Rice water weevil (*Lissorhoptrus oryzophilus*)

Identification and damage recognition

Rice water weevils are ⅛-inch-long, brown beetles that move into rice fields from overwintering habitats while fields are being flushed and flooded. They appear to be attracted to areas with deep water and thin plant stands.

Adult feeding activity produces characteristic slit-like scars on the leaves. If many egg-laying adult females are in the field soon after flooding, they can subsequently produce high larval (root maggot) populations.

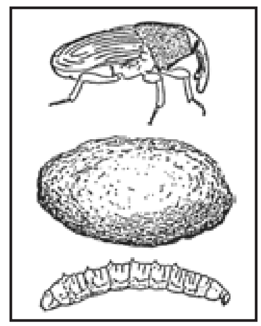

Figure 5. Rice water weevil life stages: adult, ⅛ inch long (top); pupal cell, ⅓ inch long; and larva, ⅓ inch long (bottom).

Root maggots are aquatic, requiring saturated soils to survive. They feed on the roots of young plants. They are white and grow to nearly ⅓ inch long just before pupating inside mud cells attached to roots.

The life cycle is from 35 to 65 days. Adult weevils emerge from pupal cells throughout the reproductive stage of rice plant development. They are most active during the evening and at night. They cause some additional leaf damage before leaving the field to find alternate host plants and either begin another generation or overwinter.

The root damage caused by many root maggots reduces yield. Damage caused during the main crop can lower the ratoon crop's yield.

In general, if rice in a field harbors an average of one larva per plant, you can expect yield losses of about 80 and 20 pounds per acre for the main and ratoon crops, respectively. This relationship is linear, meaning that an average of five larvae per plant will reduce yield about 400 and 100 pounds per acre for the main and ratoon crops, respectively.

Research indicates that rice water weevil feeding does not affect milling quality.

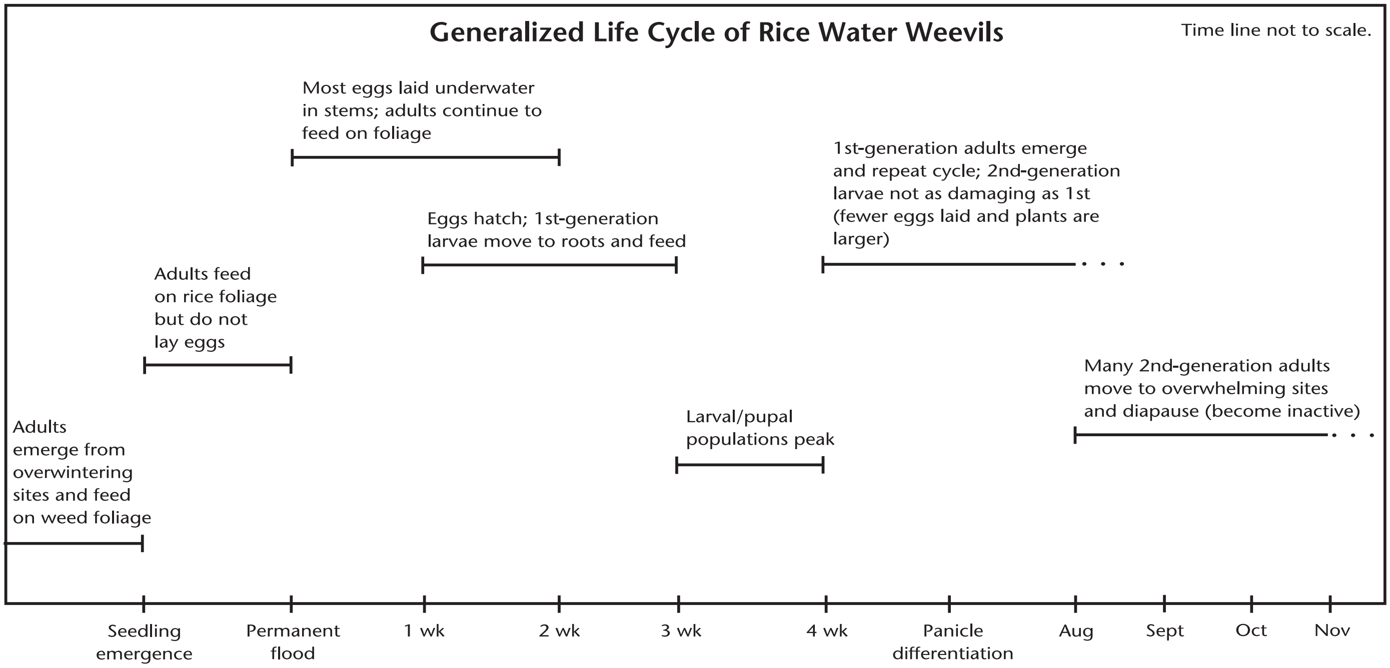

Figure 6. Rice water weevil occurrence during rice production in Texas.

Sampling for larvae

The rice water weevil **core sampler and screen bucket** (Fig. 7) can be used to sample for root maggots directly.

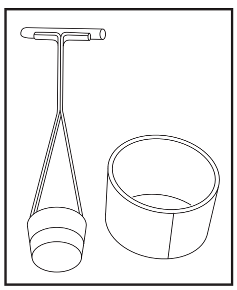

Figure 7. Core sampler and screen bucket.

The core sampler is made from a 4-inch-diameter PVC pipe. The business end of the pipe can be beveled or sharpened to make coring easier. The handle can be long or short, bolted to the sides of the pipe and made of durable metal.

The screen bucket can be made from a 6-quart galvanized metal bucket with the bottom removed and replaced with a fine (40-mesh) screen.

After taking a core sample containing plants and soil, place it in the bucket, and submerge the bucket so that it is partially filled with water. Wash the sample vigorously in the bucket by separating the plant material and rinsing the debris by lifting and lowering the bucket. Dislodged weevil larvae float and are caught in the surface tension, where you can count them.

Take samples 3 to 4 weeks after the permanent flood in a delayed flood system and 2 to 3 weeks after rice emergence through the permanent flood in a pinpoint or continuous flood system.

This procedure can be used over time to monitor the development of weevils and evaluate the effect of a treatment. This direct larval-sampling method is accurate and often used in rice water weevil research. However, it is messy and labor intensive. Furthermore, close inspection is necessary to identify the small larvae.

Sampling for adult feeding activity

Sampling for adult feeding activity was recommended when Furadan® 3G was available. **Now that Furadan® 3G cannot be applied on rice, adult sampling is not recommended.** Insecticides currently registered for rice water weevil are applied as seed treatments or close to the time of the permanent flood.

Table 16. Relative susceptibility of selected rice varieties to rice water weevil.

Variety	Very susceptible	Susceptible	Moderately resistant
Bengal	✓		
Cheniere	✓		
CL 121	✓		
Cocodrie	✓		
Cypress	✓		
Francis	✓		
Saber	✓		
XP712	✓		
Bolivar		✓	
CL 161		✓	
CLXP730		✓	
Dixiebelle		✓	
Gulfmont		✓	
Pirogue		✓	
Presidio		✓	
Wells		✓	
XP 721		✓	
XP 723		✓	
XP 729		✓	
CL XL8			✓
Jefferson			✓
Lemont			✓
Priscilla			✓
XL8			✓
XP 728			✓
XP 731			✓

Texas data have not shown a good correlation between adult feeding activity or adult densities early post-flood and subsequent larval densities. **Thus, sampling for adult activity to predict larval populations and damage is not recommended.**

Rice water weevil control alternatives

Occasionally, populations of root maggots can be reduced by draining the rice fields and allowing the soil to dry. This practice can be effective if there is no rain.

However, the cost of this method may be prohibitive. Furthermore, drying rice fields during this phase of plant development can affect fertilization, encourage blast development and delay plant maturity, which reduces the probability of producing a ratoon crop.

In general, you can reduce rice water weevil populations and damage by delaying application of the permanent flood. Recent research shows that applying the flood 4 weeks or longer after emergence can dramatically reduce rice water weevil populations and damage compared to applying the flood 2 weeks after emergence.

Data from 2000-2005 show that rice water weevils develop varying population densities on different rice varieties. Table 17 lists selected varieties in order of their relative susceptibility to rice water weevil.

Table 17. Insecticides for rice water weevil control.

Active ingredient/product	Rate per acre: Active ingredient	Rate per acre: Product	Timing of applications
diflubenzuron Dimilin® 2L	0.19–0.25 lb 0.13 lb per application	12.0–16.0 fl oz 8.0 fl oz per application	**Delayed flood:** 2 to 5 days after permanent flood. **Pinpoint/continuous flood:** At time of emergence through water to 5 days later, when adults are active in field, and a second application 5 to 7 days after the first application.
fipronil Icon® 6.2FS	Adjust rate of seed treatment to ensure each acre is treated with: 0.025–0.05 lb	0.5–1.0 fl oz	**Dry-seeded:** Seed treatment applied to dry seed. **Water-seeded:** Seed treatment applied after soaking to pregerminated seed.
gamma-cyhalothrin Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	**Delayed flood:** At time of permanent flood to 5 days later. **Pinpoint/continuous flood:** At time of emergence through water to 1 week later, when adults are active in field, and a second application 7 to 10 days after the first application.
lambda-cyhalothrin Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	**Delayed flood:** At time of permanent flood to 5 days later. Texas data show application immediately before permanent flood also provides good control. **Pinpoint/continuous flood:** At time of emergence through water to 1 week later, when adults are active in field, and a second application 7 to 10 days after the first application.
zeta-cypermethrin Mustang MAX™	0.020–0.025 lb	3.2–4.0 fl oz	**Delayed flood:** At time of permanent flood to 5 days later. **Pinpoint/continuous flood:** At time of emergence through water to 1 week later, when adults are active in field, and a second application 7 to 10 days after the first application.

Remarks and restrictions

diflubenzuron

- Use at least 5 gallons total volume per acre.
- Do not apply Dimilin® 2L if flooding is in progress.
- Do not disturb flood for at least 7 days after application.
- Do not release treated flood water for at least 2 weeks after application.
- Do not apply within 80 days of harvest.
- Do not drain treated water into crayfish ponds or fields intended for crayfish farming.
- Do not enter treated fields for 12 hours after application.

fipronil

- Icon™ 6.2FS can only be applied by selected commercial seed treatment facilities that have seed treatment machines to accurately apply chemicals.
- Drain pregerminated rice seed for at least 4 hours after removal from soak tank so seed no longer drips. Pregerminated seed treated with Icon™ 6.2FS can be stored for up to 48 hours before planting.
- Exposed treated seeds may be hazardous to birds and other wildlife. Cover, incorporate or clean up treated rice seeds that are spilled during loading or are visible on soil surfaces in turn areas. Do not store excess treated seed beyond planting time. Dispose of excess treated seed by burial away from streams and bodies of water. Treated seed should not be planted in rice cultivation areas where local drainage is released to estuarine water bodies. Do not contaminate water when disposing of equipment wash waters or rinsate.

(continued on page 34)

fipronil (continued)

- Hydrogen sulfide production, which is related to high organic material, can interfere with the efficacy of Icon™ 6.2FS insecticide and has been linked to poor plant vigor and significant yield reductions. Rice seed treated with Icon™ 6.2FS should not be planted under the following conditions:
  - Fields cropped the previous year with rice, pasture or maintained as weedy fallow that have produced a buildup of organic material
  - Newly land formed fields, leveled fields, or planed fields that produce a buildup of organic material in the drop area
  - Fields with a history of hydrogen sulfide production
  - Fields maintained under a continuous flood following rice pegging where a buildup of organic material exists
- To prevent treated rice seed from drifting into crayfish ponds in production during aerial seeding, maintain a 100-foot buffer zone between crayfish ponds and the treated portion of the rice fields.
- After seeding, hold water in treated rice fields for 24 hours before release into drainage ditches.
- Do not release water from treated rice fields directly into crayfish ponds.
- Do not fish or commercially grow fish, shellfish or crayfish in treated rice fields before harvest.
- Do not plant leafy vegetables within 1 month after planting treated rice seed.
- Do not plant root crops within 5 months after planting treated rice seed.
- Do not plant small grains, other than rice, within 12 months after planting of treated rice seed.

gamma-cyhalothrin

- Prolex™ kills adults, which prevents egg laying. Thus, timing of Prolex™ is critical for control.
- Gamma-cyhalothrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.06 lb A.I. per acre per season.
- Do not use treated rice field for aquaculture of edible fish and crustaceans.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

lambda-cyhalothrin

- Karate®Z kills adults, which prevents egg laying. Thus, timing of Karate®Z is critical for control. Texas data show applications later than 10 days after the permanent flood are ineffective.
- Lambda-cyhalothrin does not interact with propanil.
- Do not release treated flood water within 1 week of application.
- Do not apply more than 0.12 lb. A.I. per acre per season.
- Do not apply within 21 days of harvest.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not enter treated fields for 24 hours after application.

zeta-cypermethrin

- Mustang MAX™ kills adults, which prevents egg laying. Thus, timing of Mustang MAX™ is critical for control. Texas data show applications later than 10 days after permanent flood are ineffective.
- Zeta-cypermethrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.1 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 14 days of harvest.
- Do not enter treated field for 12 hours after application.

For additional information on the above products, read the labels or contact the Texas Agricultural Experiment Station at 409.752.2741.

Chinch bug (*Blissus leucopterus leucopterus*)

Identification, biology and damage

Chinch bugs overwinter as adults. They are black, about 1⁄8 to 1⁄6 inch long (females are larger than males) and elongate, about three times longer than wide. When viewed from above, the adult appears to have a white “x” on its back.

These insects have piercing-sucking mouthparts, which they insert into the food-conducting tissues of plants and withdraw fluids. If you turn the insect on its back, you can see the long, strawlike mouthparts usually held between its legs.

Adults overwinter and can move into fields after the rice emerges. Females lay elongate orange eggs about 1⁄16 inch long on rice stems, between leaf sheaths and stems, and in the soil. In the spring, eggs typically hatch in about 12 days.

First-instar nymphs are orange and about 1⁄16 inch long. Five instars (stages) are completed in about 40 days with each successive instar being larger and darker. The last instar is black, has conspicuous wing pads and is almost as large as the adult.

Newly emerging rice is most susceptible to damage and death. Symptoms of chinch bug damage include striping, stippling and yellowing of leaves. Severely affected seedlings turn brown and die.

Inspect the rice often for chinch bugs from emergence to about 3 weeks later. Look for adults on foliage and behind leaf sheaths; then inspect the stem; and finally probe the soil around the plant. Also, bend the seedling from side to side and closely inspect the gap between soil and stem for chinch bugs.

Recent Texas data show that as few as an average of one chinch bug per two seedlings can cause significant mortality in rice, as well as reduction in height and delay in maturity of the surviving plants. If populations on seedling rice approach an average of one adult per two plants, quick control is suggested.

Table 18. **Insecticides for chinch bug control.**

Active ingredient/product	Rate per acre		Timing of applications
	Active ingredient	Product	
carbaryl			
Sevin® 50W	1.0–1.5 lb	2–3 lb	Apply when adult populations approach an average of one per two seedlings.
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
Fipronil			
Icon® 6.2FS	Adjust rate of seed treatment to ensure each acre is treated with: 0.025–0.05 lb	0.5–1.0 fl oz	**Dry-seeded:** Seed treatment applied to dry seed. **Water-seeded:** Seed treatment applied after soaking to pre germinated seed. Apply when adult populations approach an average of one per two seedlings.
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	Apply when adult populations approach an average of one per two seedlings.
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	Apply when adult populations approach an average of one per two seedlings.
zeta-cypermethrin			
Mustang MAX™	0.0165–0.025 lb	2.64–4.0 fl oz	Apply when adult populations apporach an average of one per two seedlings.

Remarks and restrictions

carbaryl

- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply propanil within 15 days of a carbaryl application.
- Do not enter treated fields for 12 hours after application.
- Do not apply more than 4 lb A.I. per acre per crop.
- Up to two applications per crop may be made but not more often than once every 7 days.
- Do not apply within 14 days of harvest.

fipronil

- Icon™6.2FS can be applied only by selected commercial seed treatment facilities that have seed treatment machines to accurately apply chemicals.
- Drain pregerminated rice seed for at least 4 hours after removal from the soak tank so the seed no longer drips. Pregerminated seed treated with Icon™6.2FS can be stored for up to 48 hours before planting.
- Do not plant small grains, other than rice, within 12 months following planting of treated rice seed.
- Do not fish or commercially grow fish, shellfish or crustaceans in treated rice fields prior to harvest.
- Protect treated seed from sunlight and extreme temperatures that degrade the insecticide. (See other remarks and restrictions for fipronil use under "Insecticides for Rice Water Weevil Control.")

gamma-cyhalothrin

- Prolex™ does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.06 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

lambda-cyhalothrin

- Lambda-cyhalothrin does not interact with propanil.
- Do not release treated flood water within 1 week of application.
- Do not apply more than 0.12 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not enter treated fields for 24 hours after application.
- Do not apply within 21 days of harvest.

zeta-cypermethrin

- Zeta-cypermethrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.1 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 14 days of harvest.
- Do not enter treated field for 12 hours after application.

For additional information on the above products, read the labels or contact the Texas Agricultural Experiment Station at 409.752.2741.

Timely flushing or flooding of fields can minimize chinch bug damage in paddy rice but not on levee rice. If timely flushing or flooding is impossible, apply an appropriate insecticide. Chinch bugs on levee rice can be controlled with direct application of insecticides.

Recent Texas data show that chinch bug damage to and mortality of young rice can be dramatically increased before or after applications of propanil. The combination of chinch bugs and propanil can cause much greater damage and death to young rice than either factor alone. So, if rice is infested with chinch bugs or suffers from chinch bug damage, use caution in selecting a postemergence herbicide.

Although chinch bugs occur on older rice (tillering to maturation), no data are available on the relationship between chinch bug densities and damage to older rice.

Fall armyworm (*Spodoptera frugiperda*)

Identification, biology and damage

All life stages of the fall armyworm can survive along the Gulf Coast during the winter when the larvae feed on grain crops, grasses and other weeds. Rice is most often attacked during the seedling and tillering stages, before flooding.

Caterpillars hatch from egg masses deposited by female moths in the field, or they move into rice from adjoining areas. Caterpillars or larvae are light tan to greenish or brownish and are about 1½ inches long when fully grown. They have three yellowish-white, hairlike stripes on the back, a conspicuous inverted "Y" on the head and prominent black tubercles on the body from which hairs arise.

Small larvae are difficult to detect. They feed in groups near the ground, especially in the hearts of plants. Older larvae feed on leaf blades and can severely reduce plant stands.

Research indicates that a 25 percent leaf loss in the seedling stage decreases rice yields an average of 130 pounds per acre. Many producers detect infestations of partially grown larvae by observing cattle egrets in the field or by noticing larvae adhering to rubber boots when walking through fields in the morning.

When an infestation is detected, the field can be flooded to force the larvae up onto the foliage and restrict feeding and movement from plant to plant, thereby reducing plant damage. Infestations are generally more severe in late-planted rice fields and in fields adjacent to pasture or grassy areas.

Sampling methods and economic threshold levels

Stands can be reduced by caterpillars attacking rice seedlings before flooding. When defoliation is more than 25 percent 2 or 3 weeks before heading, yields can be reduced.

In Arkansas, control is recommended when there are three or more worms per square foot. In Texas, the suggested time for using an insecticide for fall armyworm control is before flooding when larvae are present and stands are threatened, or after flooding when larvae are present and average defoliation approaches 25 percent.

Table 19. Insecticides for fall armyworm control.

Active ingredient/product	Rate per acre		Timing of applications
	Active ingredient	Product	
carbaryl			
Sevin® 50W	1.0–1.5 lb	2–3 lb	Apply when larvae are present and rice stands are threatened or when excessive defoliation occurs; use highest rates when larvae are large.
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
zeta-cypermethrin			
Mustang MAX™	0.0165–0.025 lb	2.64–4.0 fl oz	

Remarks and restrictions

carbaryl

- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply propanil within 15 days of a carbaryl application.
- Do not enter treated fields for 12 hours after application.
- Do not apply more than 4 lb A.I. per acre per crop.
- Up to two applications per crop may be made but not more often than once every 7 days.
- Do not apply within 14 days of harvest.

gamma-cyhalothrin

- Prolex™ does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.06 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

(continued on page 37)

Table 19. Insecticides for fall armyworm control (continued).

lambda-cyhalothrin

- Lambda-cyhalothrin does not interact with propanil.
- Do not apply more than 0.12 lb. A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not release treated flood water within 1 week of application.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

methyl parathion

- Do not apply within 14 days of a propanil application.
- Do not enter treated fields for 48 hours after application.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 15 days of harvest.

zeta-cypermethrin

- Zeta-cypermethrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.1 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 14 days of harvest.
- Do not enter treated field for 12 hours after application.

For additional information on the above products, read the labels or contact Texas Agricultural Experiment Station at 409.752.2741.

Grasshoppers

Identification, biology and damage

Several grasshopper species attack rice. The most common and abundant is the meadow grasshopper, *Conocephalus fasciatus*. This green insect, 7/8 to 1 1/8 inches long, feeds on rice leaves and flowers.

A more serious pest can be the differential grasshopper, *Melanopsis differentialis*. It is larger (1 1/4 to 1 1/2 inches long), light brown to yellowish with two black bands on the inside of each jumping leg.

The differential grasshopper enters rice fields from surrounding pasturelands as food becomes scarce. Winged adults chew on the stems of rice plants. When plants are attacked just before or at panicle emergence, the injured plants produce white or "blasted" heads.

Sampling methods and economic threshold levels

In Arkansas, control is recommended when seven to 10 grasshoppers are observed per square yard, accompanied by excessive leaf loss. In Mississippi, control measures are suggested only after grasshoppers occur on 10 or more heads per 100 heads inspected.

Table 20. Insecticides for grasshopper control.

Active ingredient/product	Rate per acre		Timing of applications
	Active ingredient	Product	
carbaryl			
Sevin® 50W	1.0–1.5 lb	2–3 lb	Generally, grasshoppers do not cause economic damage. Apply when defoliation or stem and panicle damage is excessive.
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
methyl parathion	0.5 lb	1 pt (for 4 lb/gal product)	
Penncap-M®	0.5–0.75 lb	2–3 pt	
zeta-cypermethrin			
Mustang MAX™	0.020–0.025 lb	3.2–4.0 fl oz	

Remarks and restrictions

carbaryl

- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply propanil within 15 days of a carbaryl application.
- Do not enter treated fields for 12 hours after application.
- Do not apply more than 4 lb A.I. per acre per crop.
- Up to two applications per crop may be made but not more often than once every 7 days.
- Do not apply within 14 days of harvest.

(continued on page 38)

Table 20. Insecticides for grasshopper control (continued).

gamma-cyhalothrin
- Prolex™ does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.06 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

lambda-cyhalothrin
- Lambda-cyhalothrin does not interact with propanil.
- Do not apply more than 0.12 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not release treated flood water within 1 week of application.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

methyl parathion and Penncap-M®
- Do not apply within 14 days of a propanil application.
- Do not enter treated fields for 48 hours after application.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 15 days of harvest.

zeta-cypermethrin
- Zeta-cypermethrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.1 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 14 days of harvest.
- Do not enter treated field for 12 hours after application.

For additional information on the above products, read the labels or contact the Texas Agricultural Experiment Station at 409.752.2741.

Rice stink bug (*Oebalus pugnax*)

Identification, biology and damage recognition

Adult rice stink bugs overwinter near the ground in grasses. In the spring, the straw-colored, ⅜- to ½-inch-long adults become active and deposit light green egg clusters containing 10 to 50 cylindrical eggs on foliage and panicles of grasses that are producing seed.

Nymphs hatching from these eggs are at first bright red with black markings, but as they grow they become tan-colored with intricate red and black patterns on their abdomens. Unlike adults, nymphs have neither wings nor the forward-pointing spines behind their heads.

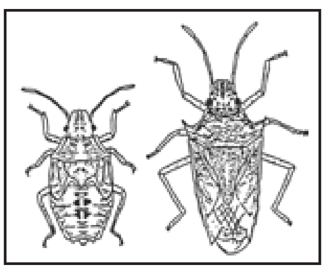

Figure 8. Rice stink bug, nymph and adult.

As the rice panicles emerge, mobile adults migrate from their alternate host plants into rice fields and are generally much more abundant along field margins.

Rice stink bug feeding reduces the quality and quantity of yield. With their sucking mouthparts, they can completely remove a grain's contents in the milk stage of development. Grains attacked later become shriveled kernels or develop spots (associated with microorganisms), light yellow to black, commonly called "peck."

The presence of discolored grains lowers the grade and market value of the rice. The damage is much more pronounced on milled, parboiled kernels. High percentage of peck has also been correlated with reduced head yield and increased percentage of broken kernels in milled rice.

The percentage of peck in a graded lot of rice represents a broad range of grain imperfections that may not be caused solely by the rice stink bug. Research has shown that even when preventive rice stink bug control programs are conducted, graders often find some level of peck. Other causes could include plant pathogens, genetic imperfections, environmental conditions during grain development, untimely harvest or a combination of factors.

Data from Arkansas show that long-, medium- and short-grain varieties exhibit the least to the most amount of peck caused by rice stink bug.

Sampling techniques and economic thresholds

Single applications of labeled pesticides (carbaryl, lambda-cyhalothrin, gamma-cyhalothrin, zeta-cypermethrin, malathion or methyl parathion) have too little residual activity to protect the kernels during their entire development. Therefore, preventive treatments are usually unjustified and their cost can be prohibitive, except for seed crop production.

Scout rice fields from heading to dough, and apply insecticides only when rice stink bug populations exceed economic thresholds.

Direct observation method

In Arkansas, an economic threshold has been established based on randomly checking 100 heads of rice with binoculars. Treatment is recommended when 10 or more stink bugs per 100 heads are observed. The structure of semidwarf rice varieties may make this method unreliable.

Sweep net sampling and economic thresholds

The only recommended technique for sampling stink bug populations is to use a 15-inch-diameter insect sweep net. When 50 percent of the panicles have emerged (headed), sample the fields once or twice a week until harvest.

The best times for sampling are early morning or late evening, when rice stink bugs are most active and abundant on rice heads. Sample when the foliage is not wet from dew.

While walking through the field, make 10 consecutive (180-degree) sweeps. Swing the net from side to side with each step. Be sure to sweep so that the top of the net is even with the top of the panicles.

After 10 successive sweeps, count the **adult** rice stink bugs as they are removed from the net. Normally, 10 samples of 10 consecutive sweeps are made in a field to determine the population. Then calculate the average number of stink bugs caught per 10 sweeps. Avoid sampling field margins and during midday.

Formerly, an insecticide application was justified when infestation levels reached or exceeded five or more stink bugs (nymphs and adults) per 10 sweeps during the first 2 weeks after 75 percent panicle emergence. Thereafter, insecticides were applied when 10 or more bugs per 10 sweeps were present.

In 1988, variable economic threshold levels were developed using a method called dynamic programming analysis. Validation of these levels in commercial fields is a continual process. New threshold levels respond to changing marketing and production conditions.

Directions for using variable economic thresholds

1. Monitor the fields with a standard 15-inch-diameter, heavy-duty sweep net. Take 10-sweep samples in at least 10 randomly selected sites within the field, and calculate the average number of adult rice stink bugs per 10-sweep sample. Sample at least once each week beginning at heading.
2. Determine the stage of average plant development within the field (heading, milk or soft dough) and find the appropriate section of Table 21 (A, B or C). The milk stage occurs about 15 days after heading.
3. Estimate the expected yield (4,500, 6,000 or 7,500 pounds per acre) and find the appropriate columns in Table 21.
4. Find the column within the appropriate yield level that represents marketing conditions:
   - Rice moving into the government loan program (low price situation)
   - Rough rice selling for $9.00 per cwt (moderate price situation) or
   - Rough rice selling for $11.00 per cwt (high price situation)
5. Estimate the cost of an insecticide application ($5.20, $8.35 or $11.50 per acre), and find the row in Table 21 that most closely corresponds to that spray cost.
6. Select the line within the proper spray cost row that corresponds to the approximate planting date of the rice field (April 1, May 1 or June 1).

The number at the intersection of the specific column (representing expected yield and marketing conditions) and row (representing spray cost and planting date) is the minimum level of adult rice stink bugs that should be present during a rice growth stage to economically justify the application of an insecticide.

Example: At **heading**, where a 6,000-pound yield is anticipated, where the crop is going into the **loan** program, where the cost of an insecticide plus application **(spray cost)** is expected to be about $8.35, and where the field was **planted** around May 1, the average number of **adult** rice stink bugs per 10-sweep sample must be **five or more** to justify the cost of the application.

Under similar conditions, except for a yield expectation of 4,500 pounds, the appropriate threshold is six adult rice stink bugs. Under the same conditions, except for a 7,500-pound yield and high expected market price ($11 per hundredweight), the threshold is four adult rice stink bugs.

These examples indicate the sensitivity of the thresholds to different rice production situations, thus encouraging producers to be flexible in their management programs.

Consider these threshold levels as only a guide. In general, if the market price of the product increases (such as in seed rice production) or the cost of an insecticide application decreases, the economic threshold level will decrease.

Insecticidal management

Research has found no resistance to carbaryl, lambda-cyhalothrin, gamma-cyhalothrin, zeta-cypermethrin or methyl parathion. Control may fail when many adults are migrating into rice, often when nearby sorghum fields are maturing or are being harvested. None of the registered products is known to repel stink bugs.

Methyl parathion provides rapid kill with little or no residual activity. Karate®Z (lambda-cyhalothrin), Prolex™ (gamma-cyhalothrin), Mustang MAX™ (zeta-cypermethrin), Sevin® (carbaryl) products and Penncap-M® (methyl parathion) provide a few days of residual activity. After initial knockdown, these products act primarily as contact insecticides, killing stink bugs only when they crawl across treated surfaces.

Treatment decisions may be complicated by uneven stands. Stink bugs prefer developing grain. In fields where much of the rice has matured, more stink bugs will be found on less mature panicles. Populations usually are higher around field margins and in weedy areas.

Sampling these areas may cause artificially high estimates of stink bug populations in the field. Unless spot treatments are feasible, decisions are best made using average sweep net sample results, as these are representative of the population across the entire field.

Try to avoid applying insecticides to wet foliage or when rain may occur before the product has dried. Rice stink bugs are more abundant on rice heads in the early morning or late evening. These times are best both for sampling and for applying insecticides.

The objective of managing stink bugs on rice should be to maintain populations at or below the threshold levels; do not expect to completely eliminate stink bug activity.

Table 21. Economic thresholds for the adult rice stink bug (RSB) based on Dynamic Programming Analysis for 1989. The numbers in the table indicate the average level of adult RSB per 10-sweep sample at which treatment is economically warranted. A value of 15+ indicates that the threshold exceeds 15 adult RSB.

(A) Adult RSB thresholds at heading

		Yield								
		4,500 lb/A			6,000 lb/A			7,500 lb/A		
		Rice price			Rice price			Rice price		
Spray cost ($/a)	Plant date	Loan	$9/cwt	$11/cwt	Loan	$9/cwt	$11/cwt	Loan	$9/cwt	$11/cwt
5.20	4/1	5	4	4	4	3	3	3	3	3
	5/1	4	4	4	3	3	3	3	3	3
	6/1	4	4	4	3	3	3	3	3	3
8.35	4/1	7	6	5	6	4	4	5	4	4
	5/1	6	5	5	5	4	4	4	4	4
	6/1	6	5	5	5	4	4	4	4	4
11.50	4/1	9	7	7	7	6	6	6	5	5
	5/1	8	7	7	6	6	6	5	5	5
	6/1	8	7	7	6	6	6	5	5	5

(B) Adult RSB thresholds at milk

		Yield								
		4,500 lb/A			6,000 lb/A			7,500 lb/A		
		Rice price			Rice price			Rice price		
Spray cost ($/a)	Plant date	Loan	$9/cwt	$11	Loan	$9/cwt	$11	Loan	$9/cwt	$11
5.20	4/1	12	9	9	10	7	7	8	6	6
	5/1	12	9	9	8	7	7	6	6	6
	6/1	11	9	9	8	7	7	7	6	6
8.35	4/1	15+	14	13	14	11	11	12	9	9
	5/1	15+	13	13	14	11	11	12	9	9
	6/1	14+	13	13	12	11	11	10	9	9
11.50	4/1	15+	15+	15+	15+	14	14	15	12	12
	5/1	15+	15+	15+	15+	14	14	15+	12	12
	6/1	15+	15+	15+	15+	14	14	13	11	12

(C) Adult RSB thresholds at soft dough

		Yield								
		4,500 lb/A			6,000 lb/A			7,500 lb/A		
		Rice price			Rice price			Rice price		
Spray cost ($/a)	Plant date	Loan	$9/cwt	$11	Loan	$9/cwt		Loan	$9/cwt	$11
5.20	4/1	9–13	10	10	8–12	8	8	8–11	7	7
	5/1	11–15+	10	10	10–12	8	8	7–11	7	7
	6/1	9–25+	10	10	8–12	8	8	7–11	7	7
8.35	4/1	11–15	14	14	10–14	11	11	9–13	10	10
	5/1	13–15	14	14	12–15+	11	11	11–15	10	10
	6/1	15+	14	14	10–15+	11	11	9–15	10	9
11.50	4/1	15+	15+	15+	11–15+	14	14	10–14	12	12
	5/1	15+	15+	15+	13–15+	14	14	12–15+	12	12
	6/1	15+	15+	15+	15+	14	14	11–15+	12	12

Table 22. Insecticides for rice stink bug control.

Active ingredient/product	Rate per acre		Timing of applications
	Active ingredient	Product	
carbaryl			Apply from heading to near harvest when adult rice stink bug populations reach threshold level.
Sevin® 50W	1.0–1.5 lb	2–3 lb	
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
methyl parathion	0.25–0.5 lb	½ – 1 pt (for 4 lb/gal product)	
Penncap-M®	0.25–0.5 lb	1–2 pt	
zeta-cypermethrin			
Mustang MAX™	0.020–0.025 lb	3.2–4.0 fl oz	

Remarks and restrictions

carbaryl

- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply propanil within 15 days of a carbaryl application.
- Do not enter treated fields for 12 hours after application.
- Do not apply more than 4 lb A.I. per acre per crop.
- Up to two applications per crop may be made but not more often than once every 7 days.
- Do not apply within 14 days of harvest.

gamma-cyhalothrin

- Prolex™ does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.06 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

lambda-cyhalothrin

- Lambda-cyhalothrin does not interact with propanil.
- Do not apply more than 0.12 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not release treated flood water within 1 week of application.
- Do not apply within 21 days of harvest.
- Do not enter treated fields for 24 hours after application.

methyl parathion and Penncap-M®

- Do not apply within 14 days of a propanil application.
- Do not enter treated fields for 48 hours after application.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 15 days of harvest.

zeta-cypermethrin

- Zeta-cypermethrin does not interact with propanil.
- Do not release treated water within 1 week of application.
- Do not apply more than 0.1 lb A.I. per acre per season.
- Do not use treated rice fields for aquaculture of edible fish and crustaceans.
- Do not apply within 14 days of harvest.
- Do not enter treated field for 12 hours after application.

For additional information on the above products, read the labels or contact the Texas Agricultural Experiment Station at 409.752.2741.

Stalk borers

Texas rice is attacked by three species of stalk borers—the sugarcane borer, *Diatraea saccharalis;* the rice stalk borer, *Chilo plejadellus;* and the Mexican rice borer, *Eoreuma loftini*.

Recent studies (2000–2002) using pheromone traps detected Mexican rice borers in all rice-producing counties south and west of Houston. In 2004, Mexican rice borers were detected in Chambers and Liberty Counties. In 2005, Mexican rice borers were detected in Jefferson County, so this insect is moving roughly 15 miles eastward toward Louisiana per year. In Calhoun, Jackson and Matagorda counties, the Mexican rice borer is becoming an increasingly damaging pest.

All three species lay eggs on rice foliage. Upon hatching, the larvae move to the protected areas between the leaf sheaths and culms. Eventually, the larvae bore into the culms and feed inside, which causes whiteheads and deadhearts. Occasionally, larvae will feed on developing panicles within boots, causing partial blanking of panicles. Pupation occurs within damaged culms followed by emergence of adult moths.

Borer populations may be reduced by low winter temperatures, heavy pasturing of stubble, fall plowing or flooding fields during the winter. Late-planted rice appears to be more susceptible to stalk borer damage. An egg parasite effectively controls sugarcane borers in parts of Texas.

Icon™ 6.2FS is registered for stalk borers in Texas. The recommended rate of the seed treatment is 0.025 to 0.05 pound of active ingredient per acre. Recent Texas data indicate that this treatment is partially effective.

Karate®Z and Mustang MAX™ also are registered for stalk borers in Texas. Karate®Z received a full federal label and Mustang MAX™ received a 2 (ee) label in 2005. Texas data show that best control is achieved when either product is applied at 1- to 2-inch panicle and/or late boot/early heading. Two applications are more effective than one. The recommended rates for Karate®Z and Mustang MAX™ are 0.03 and 0.0225 pound of active ingredient per acre, respectively.

Data collected from 2000-2005 at Ganado, Texas, show that stem borers (sugarcane borer and Mexican rice borer) cause varying damage to rice, depending on variety. Table 23 lists selected varieties and their relative susceptibility to stalk borers.

Table 23. Relative susceptibility of selected rice varieties to stem borers (sugarcane borer and Mexican rice borer).

Variety	Very susceptible	Susceptible	Moderately resistant
CL 121	✓		
Cocodrie	✓		
Francis	✓		
Lemont	✓		
Priscilla	✓		
Saber	✓		
Bolivar		✓	
Cheniere		✓	
CL 161		✓	
Cypress		✓	
Jacinto		✓	
Jefferson		✓	
Madison		✓	
Presidio		✓	
Wells		✓	
CL XP730			✓
CL XL8			✓
XL7			✓
XL8			✓
XP721			✓
XP723			✓

Karate®Z (lambda-cyhalothrin), Mustang MAX™ (zeta-cypermethrin) and Prolex™ also are registered at 0.025 to 0.04, 0.02 to 0.025 and 0.0125 to 0.02 pound of active ingredient per acre, respectively.

Leafhoppers

The blackfaced leafhopper, *Graminella nigrifrons*, is commonly found in rice but is not usually abundant. Localized high populations have occurred in Brazoria County. Infested foliage becomes discolored, and yield and quality can be lowered.

An economic threshold level has not been developed for this pest. However, several products have been evaluated for control. Of the insecticides registered for use on rice, carbaryl, applied at 1.0 pound of active ingredient per acre, has provided good suppression. In field trials, both carbaryl and the 4E formulation of methyl parathion significantly reduced leafhopper populations, while Penncap-M® did not suppress leafhopper numbers significantly.

Rice seed midges

The larvae of these insects (Order Diptera, Family Chironomidae, Genera *Tanytarsus* and *Chironomus*) are aquatic and can be very abundant in rice fields. The adults are small, gnatlike flies that typically form inverted pyramidal, mating swarms in the spring over stagnant or slow-moving water.

Female flies lay eggs in ribbons on the water surface. The larvae hatch and move downward to the flooded substrate, where they build protective "tubes" of silk, detritus and mud. These brown, wavy "tubes" are easily observed on the mud surface of rice paddies. Occasionally, the larvae will exit the tubes and swim to the surface in a whip-like fashion similar to mosquito larvae.

Midge larvae can damage water-seeded (pinpoint or continuous flood) rice by feeding on the sprouts of submerged germinating rice seeds. Damage can retard seedling growth or kill seedlings; however, the window of vulnerability to midge attack is rather narrow (from seeding to when seedlings are about 3 inches long).

Control rice seed midge problems by dry-seeding, then delayed flood, or by draining water-seeded paddies soon after planting. Thus, a pinpoint flood should reduce the potential for rice seed midge damage relative to a continuous flood. For water-seeded rice, reduce rice seed midge problems by increasing the seeding rate and planting sprouted seed immediately after flooding.

Although no Texas data are available, rice seed midge control is currently on the Icon™ 6.2 FS label (use rate: 0.025 to 0.05 pound of active ingredient per acre). Rice seed midges are important pests of rice in Australia where fipronil (active ingredient in Icon™ 6.2 FS) is effective against these insects.

Research will continue to be conducted to obtain Texas data on insecticidal control of rice seed midges.

Aphids

Recently, several species of aphids have damaged Texas rice. Aphids are small, soft-bodied insects with piercing-sucking mouthparts. The adults hold their wings rooflike over their bodies.

Both adults and nymphs move slowly and often are observed in groups feeding together. This aggregation is caused by a reproductive phenomenon called parthenogenesis, in which unmated female aphids give birth to living young.

Aphids suck the juices from rice and cause stunting and chlorosis. Young rice is particularly vulnerable; stand reductions can occur under severe aphid pressure.

Specifically, the following aphids have attacked Texas rice:

Bird cherry oat aphid (*Rhopalosiphum padi*) is mottled yellowish or olive green to black and is found feeding on foliage, often near the junction of leaf blades and sheaths. Seedling rice is very vulnerable.

Yellow sugarcane aphid (*Sipha flava*) is lemon yellow and normally found on foliage. It injects a toxin into rice plants that causes the foliage to become reddish. Because of this toxin, economic damage can result with fewer aphids than other aphid species. Again, seedling rice is very vulnerable.

Rice root aphid (*Rhopalosiphum rufiabdominalis*) is dark (sometimes purplish) and can be found feeding on foliage and/or roots where masses of aphids often can be observed. Flooding controls aphids on roots, but levee rice remains vulnerable to root feeding.

The key to aphid management is scouting. Generally, aphids are more of a threat to seedling rice, so be sure to scout fields carefully and frequently after rice emergence.

If you observe ladybird beetle adults and larvae in your rice, look carefully for aphids. These beetles are voracious predators. Their presence usually indicates high populations of their hosts—aphids.

Also, if the rice foliage is sticky and shiny, inspect it for aphids, which excrete "honeydew." This excretion is sweet and attracts ants. Thus, another indication of the presence of aphids is ants crawling on rice foliage.

When searching for aphids, remember to inspect the collar region (the junction of the leaf blade and sheath) of rice plants. Aphids are often found here because the relative humidity is high, the plant tissue is tender and concealment from natural enemies is possible.

No economic thresholds are now available for aphids attacking rice, but if the stands are threatened or the rice is yellow/reddish/stunted and aphids are present, treat the rice with an approved insecticide.

Karate®Z, Mustang MAX™ and Prolex™ are labeled for certain aphid species at the same rates as those applied for rice water weevil control (see the "Insecticides for Rice Water Weevil Control" table). Because Icon® 6.2FS seed treatment is not very effective against aphids, it is not recommended.

Four practices discourage aphid populations and damage:

- Flushing or flooding, which drowns the insects and forces them to move up the plant, where they are more vulnerable to natural control
- Controlling weeds, which prevents aphids from building-up on alternate hosts
- Establishing a healthy uniform stand of rice
- Reducing early-season stress caused by inadequate soil moisture, herbicide injury, nutrient imbalances and damage from other pest insects and diseases

South American rice miner (*Hydrellia wirthi*)

During the past 3 years, the South American rice miner and associated injury have been observed in Texas and Louisiana rice. The adult of this insect is a small gray fly that lays eggs singly on rice foliage. The eggs hatch, and larvae rasp and feed on developing foliage before the leaves unfurl. The larvae feed within leaves, resulting in mines and lesions.

Once the leaves unfurl, it is easy to see the signs of damage: relatively wide, white elongated mines or lesions (similar to adult rice water weevil feeding scars, but wider) parallel to the leaf venation. This often causes the distal portion of leaves to break off or "hang by a thread," giving the affected rice plants a ragged, tattered appearance.

The larvae are small, white and legless and can be found within the lesions or mines. Pupae, which are brown, also can be found inside the lesions or mines.

Generally, injury occurs when rice is tillering, but in Louisiana in 2004, a late-planted rice field was severely damaged soon after emergence. In Texas, economic damage has not been observed, but be aware of this pest and report suspected injury to Mo Way (409.752.2741, extension 2231).

Channeled apple snail (*Pomacea canaliculata*)

Channeled apple snails are invertebrates that were found recently in or near rice fields in Brazoria, Galveston, Fort Bend, Harris, Waller and Chambers counties. These snails most likely were introduced from South America to Texas via the aquarium pet trade. They have become serious pests of rice in Southeast Asia, where they had been imported as a food source.

The adults are large (shell height about 3 to 4 inches), globular and banded with brown, black and yellowish-tan patterns of coloration. Although the snails feed on many types of vegetation, they prefer to feed on succulent, submerged plants. Snails in Texas rice fields have been observed feeding on alligator weed and duck salad.

The egg masses are cylindrical, pink or red and are typically observed above the waterline on rice plants, weeds or human-made structures. To date, snail damage to rice in Texas has not been documented, possibly because of the practice of delayed flooding in Texas. Be on the lookout for this potential pest and report any sightings to Mo Way (409.752.2741 extension 2231).

Other arthropod pests

Many other insects have been reported to be rice pests, but are of undetermined or minor importance:

Coleoptera
- Flea beetles
- Grape colaspis, *Colaspis brunnea*
- Cattail billbug
- Sugarcane beetle, *Euetheola rugiceps*

Lepidoptera
- Fiery skipper, *Hylephila phyleus*
- Least skipper, *Ancyloxypha numitor*
- Ocola skipper, *Ponoquina ocola*

Diptera
- Rice leaf miner, *Hydrellia griseola*

Hemiptera
- *Paramius longulus*
- *Leptocorixa tipuloides*
- Sharpshooter, *Draeculacephala portola*

Thysanoptera
- Thrips, species undetermined

Acari
- Spider mite, *Schizotetranychus oryza*

Mosquitoes

Many mosquito species breed in Texas rice lands, but four species account for most of the problems. Two of these, *Psorophora columbiae* and *Psorophora ciliata,* are floodwater mosquitoes.

Females of these species lay their eggs on moist soil that floods periodically. The eggs resist dessication and remain viable for a year or more. Hatching is stimulated by flooding during the warmer months (mid-April through October) of the year.

Two other species require standing water on which the females lay their eggs. *Culex salinarius* is common during the cooler months (from October through the winter to late June or early July).

Females lay eggs in rafts (of 200 or more eggs each) on the surface of standing water. Breeding is continuous during the cooler months as long as standing water is available. *Anopheles quadrimaculatus* females deposit single eggs equipped with floating devices on the surface of standing water.

Overlapping generations during the warmer months result in a gradual buildup of adult numbers, which generally reach a peak in late July or early August. This species is the primary vector for the agents that cause malaria and is thus a hazard to human health.

Management: The only effective way to control mosquitoes breeding in rice land is through organized, areawide control programs. Organized mosquito control districts exist in most larger urban areas in the Texas rice belt.

There is very little a rice producer can do to prevent or control mosquitoes in rice fields, other than to:

- Ensure that the fields are graded to promote good drainage when water is no longer needed.
- Remove as many off-field standing water sites as possible. Any shallow pools of water allowed to stand for more than 3 days are potential breeding sites for mosquitoes.
- Take care not to use chemicals that seriously affect aquatic predators, such as fish, back-swimmers, predaceous diving beetles, etc. These predators occur naturally in rice irrigation water and can eliminate up to 60 percent of a mosquito population.

Stored grain pests

Many insect pests attack stored rice. These can be separated into two groups: primary and secondary pests.

Primary pests attack whole kernels and complete their development inside the kernel. These include the rice weevil, *Sitophilus oryzae;* lesser grain borer, *Rhyzopertha dominica;* and Angoumois grain moth, *Sitotroga cerealella.*

Secondary pests feed on the bran coat, germ, cracked or broken kernels and grain dust generated by primary pests. These include the Indian meal moth, *Plodia interpunctella;* almond moth, *Cadra cautela;* sawtoothed grain beetle, *Oryzaephilus surinamenis;* merchant grain beetle, *Oryzaephilus mercator;* flat grain beetle, *Cryptolestes pusillus;* red flour beetle, *Tribolium castaneum;* hairy fungus beetle, *Typhaea stercorea;* cigarette beetle, *Lasioderma serricorne;* and psocids or booklice.

Management: Good management of stored grain insects requires:

- Using good sanitation practices
- Ensuring that high-quality grain is stored
- Providing proper storage conditions
- Monitoring for insect pests
- Making use of well-timed and justifiable insecticide treatments (bin treatments, grain protectants and fumigants)

Sanitation is probably the most important aspect of a good pest management program. Remove any residual material in the storage bins, including chaff, straw and dust. This helps prevent the perpetuation of previous infestations. Never put new grain on top of old grain.

Treat bins after they are cleaned with an approved insecticide, being sure to treat all inside and outside surfaces. One gallon of spray will cover 500 to 700 square feet of surface, depending upon surface characteristics (porous wood surfaces require more spray than metal). Many pests of stored grain are resistant to malathion.

Store dry, clean grain. Avoid storing grain with a high moisture content and many cracked kernels. High humidity promotes the development of certain insects, and cracked kernels lead to the development of secondary pest species.

Aeration cooling will limit insect development during storage by lowering temperatures and moisture.

Grain protectants can be applied to dry, uninfested grain before storage to prevent pest infestations. Protectants will not work if they are applied before drying. Nor will they eliminate existing pest populations. It is essential that the protectant be distributed evenly throughout the grain mass. After binning is completed, level the bin.

Top dressing or treating the top of the grain mass with an approved grain protectant can protect the grain from infestations of Indian meal moths and almond moths.

Monitor for insect populations throughout the storage period by using grain probes, pitfall traps, pheromone traps or other useful methods. Monitoring enables producers to detect pest infestations for early treatment and to evaluate the effectiveness of management tactics.

Fumigation of infested stored grain is often less expensive and more effective when done by a commercial company. Consider treatment cost on a per unit (bushel or hundredweight) basis, taking into account necessary safety and application equipment and estimated time and labor requirements.

Sealing the storage facility is essential for effective control, because successful fumigation depends on holding enough gas long enough to kill insects in all stages (particularly eggs and pupae) throughout the grain mass. Applicators must have state certification to buy and apply fumigants.

Causes of 'White Heads' in Rice

R. S. Helms and J. L. Bernhardt

The term "white head" describes rice panicles having unfilled grain. Weather tends to bleach and desiccate the damaged panicles so that they may appear as "white flags" against a green canopy of growing rice.

Damaged heads are not always white. Sometimes secondary diseases attack the damaged panicles causing a gray, brown or black color in some of the tissue. Some causes, such as straighthead or herbicides, may distort the panicle or grains although they remain green until late in the season.

This article is intended to reduce the confusion caused by the many factors associated with empty panicles.

Insects

The large, yellow differential grasshopper, often abundant along field margins, will chew the stems of rice. When plants are attacked just before panicles emerge, injured plants produce white or "blasted" heads.

In Arkansas, billbugs (*Sphenophorus* spp.) also can cause whiteheads. The female of this beetle chews a small cavity near the base of a plant in which to deposit a single egg. As the grub grows, it hollows out the interior of the rice stalk about 2 inches above and below the soil surface. The "white head" is a result of larval feeding that deprives the panicle of nutrients.

Billbug damage is limited to levees or unflooded areas of a rice field. Grubs cannot survive if submerged.

Rice stalk borer, sugarcane borer and Mexican rice borer larvae (caterpillars) also can produce "white heads." Caterpillars of the rice stalk borer generally enter the stem by chewing a single hole in the stalk. Larvae hollow out the stalk as they grow. Mature larvae are tan, about 1 inch long, and have one dark brown and one light brown stripe along each side of the body.

Slicing the stalk will reveal several small larvae, but usually only one mature larva is found per stalk. Other larvae exit and infest other nearby rice plants. The "white head" is the result of larval feeding that deprives the panicle of nutrients.

Infested plants are usually found along field edges, along levee margins, in areas with thin stands or, occasionally, randomly scattered in the field interior. Research has shown that large-stemmed cultivars and late-seeded fields are most susceptible to the stalk borer.

Some control of rice stalk borers is accomplished by timely destruction of rice stubble. Stubble destruction limits the number of larvae that survive and emerge as adults in the spring.

Diseases

Rice panicles turn white when the blast fungus infects the stems and the nodes on the necks of panicles. Sometimes only part of the panicle is affected. Rice tissue will die above the point of infection. If infection occurs before grain filling, the panicle will turn white from desiccation caused by drought stress.

Close examination of the "white heads" caused by blast will reveal a white head on a green plant that has no other symptom other than a small sooty area (about ¼ inch wide) that girdles the stem or node. This usually occurs at the first node below the panicle.

Some varieties, such as Lemont and Gulfmont, are moderately resistant. Fungicides such as Benlate® and Quadris®, applied before infection as a preventive measure, will reduce damage. Fungicides can be overwhelmed by a spore shower at the critical heading stage of rice development if weather conditions are favorable for blast at that time.

Stem rot organisms infect rice plants near the water line and eventually kill the entire plant. When this occurs before grain filling, the rice panicles sometimes bleach out.

These organisms are soil-borne and overwinter in crop stubble and as sclerotia in the soil. The sclerotia, or resting bodies, float into close contact with rice stems at the water line, the point of infection.

Look for dead, unfilled or partly filled panicles scattered in the field. Close examination of damaged panicles will reveal that the entire plants are dead. This differs from blast damage, in which plants and leaves remain green. Control consists of stalk destruction after harvest. Only rarely will sheath blight cause "white heads" because plants die slowly. Panicle damage usually consists of stunted kernels or blanking at the base of the panicle.

The keys to identification are the "rattlesnake"-like lesions on leaf sheaths and the white or brown sclerotia (about ⅛ inch in size) on the outside of the stem.

Straighthead, caused by a physiological disorder, is characterized by the empty florets and distorted grain in the panicles. Seldom does it cause a "white head" because the disease does not kill the plant. Panicles remain erect, but blank or partially filled, and retain a green color until late in the season.

Straighthead can be controlled by thoroughly drying the soil during the period predicted by the DD50 program.

Desiccation

If the soil or flood water contains a high concentration of soluble salts (salinity) at heading, the emerging panicles will be white. The rice plant will be healthy except for desiccated panicles, which is very similar to the damage caused by blast. However, there are no blast lesions at the bases of desiccated panicles ("white heads"). Salts interfere with the uptake and transfer of water through cell walls at heading, a time when the plant has a high water requirement. The result is drought stress even though the rice plants are flooded.

The key to diagnosis is the absence of any symptoms except desiccated panicles. An electroconductivity (EC) test of the water will often indicate salt levels above 1,000 microohms per centimeter.

Rice plants can be mechanically injured when workers wade through fields before heading, partially breaking stems. This stem breakage will cause "white heads." Close examination will reveal the injury that restricted water uptake.

Drought stress, or insufficient water at heading, will cause "white heads," especially if the weather is hot and windy. Keeping the soil wet may be sufficient until the heading stage, but then the demand for water is so great that flooding is the only sure way to provide enough water on most soils.

"White heads" are often found in sprinkler-irrigated fields. Several days of extremes in temperature, such as above 100 degrees F during daytime or below 50 degrees at night, will cause sterility. However, panicles will rarely turn white. Usually the florets will be empty but remain green until late in the season.

If temperature is the suspected cause of "white heads," check weather records for highs and lows 2 weeks before and at heading. This is the most critical time, when temperature extremes can seriously interfere with grain pollination and fertilization. The DD50 printouts will help pinpoint rice stages.

The rice desiccant sodium chlorate will cause "white heads" when applied to immature rice. This occurs when an immature field is accidentally sprayed. Uneven emergence or overseeding into a thin rice stand can cause immature plants in a mature field of rice. If a desiccant is the suspected cause of "white heads," check for spray patterns.

Herbicides that burn foliage will cause "white heads." These are sometimes accidently applied to or drift into fields as rice panicles begin to emerge. Minute amounts of some herbicides such as Classic®, Scepter®, Poast®, Fusilade® DX, etc., that remain in unrinsed spray tanks or drift from nearby application sites, will distort grain in various ways, but usually the damaged panicles will remain green.

When herbicides are suspected, look for an application pattern effect and check pesticide application records and the DD50 printout for stages.

When nitrogen solution is applied too late or tank-mixed with fungicides such as Benlate® or herbicides such

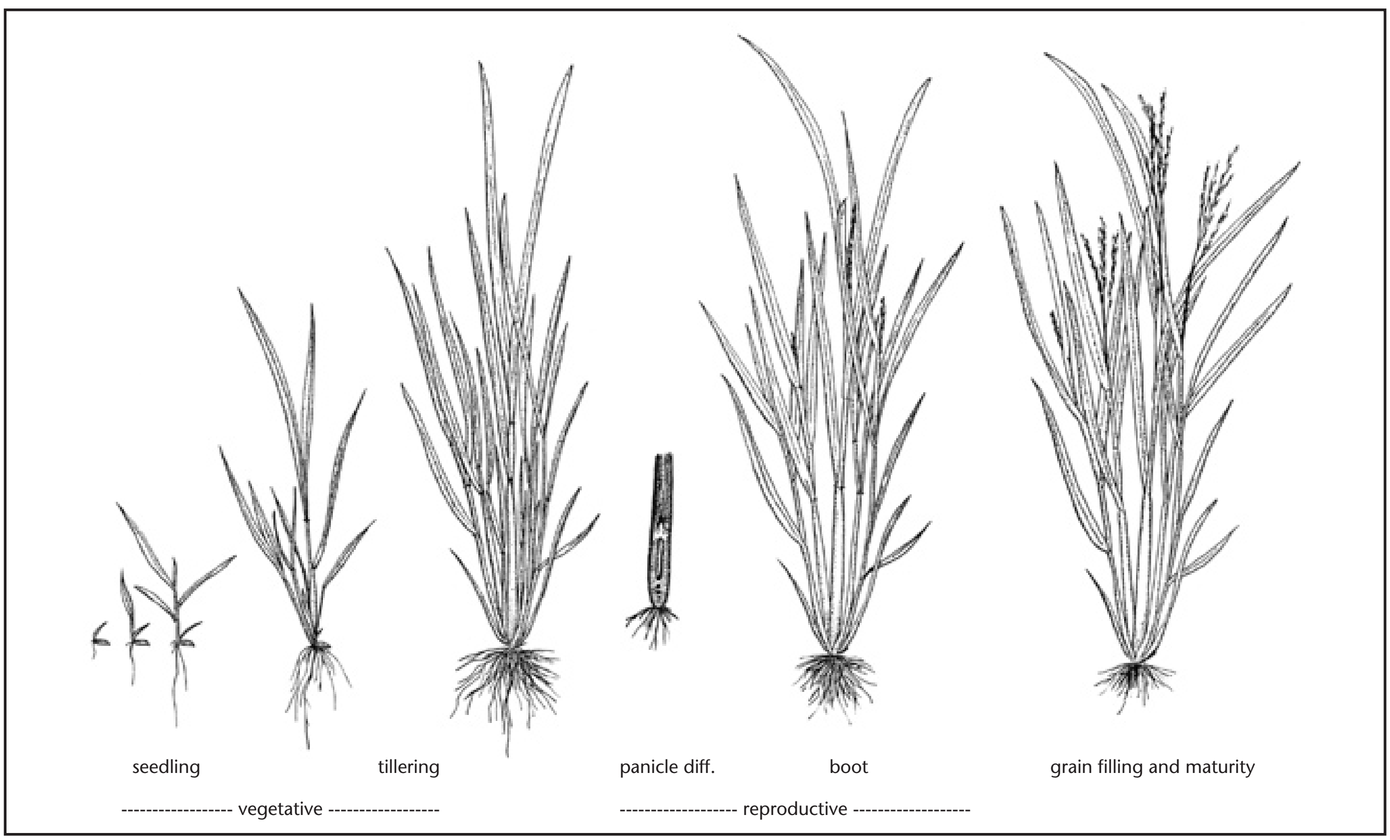

Figure 9. Rice plant development.

as propanil, 2,4-D, Blazer®, etc., it will cause foliage damage. Panicles may also be damaged if they have emerged at the time of application. Rather than the "white head" symptom, the florets and developing grain usually appear black or brown. When suspected, look for an application pattern and check records of application and rice stages.

Note: This chapter has been partially modified for Texas and is reprinted with permission from R.S. Helms and J.L. Bernhardt, Rice Information, No. 114, April 1990, by Cooperative Extension Service, University of Arkansas.

Draining for Harvest

G. N. McCauley

Properly timed drainage for harvesting is important in obtaining good-quality, high-yielding rice. The timing depends on crop maturity, soil type, weather conditions and field drainage efficiency.

Draining

To conserve water, discontinue irrigation 7 to 10 days before the anticipated drain date. Enough moisture must remain in the soil to ensure that the lower grains on the panicle fill properly before harvest, but the soil must be dry enough to support combines without severely rutting the field if the field is going to be second-cropped. The table below can be used as a guide for draining fields for harvest. Because Labelle has a smaller grain, drain fields with this variety slightly earlier (2 to 4 days).

Research from Eagle Lake Station on a Nada fine, sandy loam soil indicates that a dry period of 20 days is required for optimum ratoon crop yields. On these coarse soil types, drain 10 days before harvest (25 days after first crop heading) for highest yields and quality. It appears that a short dry period after the first crop is harvested does not adversely affect second crop yields on fine sandy loam soils.

On fine (clay and clay loam) soils such as a Beaumont clay, drain 15 days before harvest (20 days after first crop heading) for highest yields and quality. These fine soil types can be flooded immediately after first crop harvest without reducing ratoon crop yields, in contrast to the coarse soil types.

Drain time must be based on experience. Fields with historic internal and external drainage problems must be drained a few days earlier. Drain may be delayed a few days for fields with shallow coarse textured soils that dry out quickly.

Table 24 Maturity and appearance of rice panicles.

Soil type	When field is ready for drainage
Heavy soils that dry out slowly (clays)	Top half of panicles are yellow and turned downward
Lighter soils that dry out quickly (silt loams and sandy soils)	Top two-thirds or three-fourths of panicles are yellow and turned downward.

Harvesting

G. N. McCauley

Several important factors affect the harvesting of rice with a combine. Consider these factors in every instance of combining:

- Timing of harvest
- Condition of the crop and field
- Adjustment of the combine
- Skill of the operator

Timing of harvest

If the rice crop is harvested too early or too late, the quality of the rice may suffer, cutting profits considerably. Rice is a crop that fruits and matures over a long period, and the grain moisture content varies greatly. Rice is usually harvested when moisture content is between 18 and 23 percent or when the grains on the lower panicle are in the hard dough stage. Research has shown that a harvest moisture between 20 and 24 percent results in maximum yield.

Quality

Rice quality is an important factor over which producers have some control. Whole grain is worth more than broken grain. In some instances, whole grain sells for 50 to 100 percent more than broken grain. Rice breakage is preceded by fissuring of the individual grains.

Once rice grains dry to 15 percent moisture content or lower, they will fissure when subjected to a moist environment. Such environments may be found in the fields before harvest, in the combine hopper or in the holding bin after harvest. A rice field may look the same to a producer from one day to the next, but the ambient environment can cause a considerable loss in quality within 1 night.

Fissured grains in the field or in harvested rough rice are hidden inside the hull and are not visible without close inspection of individual grains. This damage does not become apparent until these grains are combined, dried and milled. Many times this damage is attributed to a mechanical operation and not to the real cause.

Adjusting the combine

Rice is harvested by direct combining and is difficult to thresh because it is hard to strip from the straw. A spike-tooth threshing cylinder is usually used because of its aggressive threshing action. Rice may be down or lodged, making harvesting more difficult.

Semidwarf cultivars such as Lemont are more difficult to combine than conventional cultivars because the panicle does not emerge above the canopy. Combines must cut extra green foliage to harvest the panicles, thus reducing threshing and separation efficiency. This requires that combine ground speed be reduced for semidwarf varieties. A harvest aid such as sodium chlorate applied at 4.5 pounds per acre may increase harvest efficiency by desiccating green foliage and weeds.

Caution: Desiccation of the first crop may reduce tillering and therefore yields of the second crop.

It is important to adjust the combine properly to maintain quality and reduce losses. Consult the operator's manual for proper adjustments of the header, reel, cylinder, sieves and fan for the crop and field conditions. After these adjustments are set and a trial run is made, be sure to measure harvest losses.

Unless the operator knows the source of grain losses, he or she cannot reduce them. Some losses are due to improper operation and others are caused by improper adjustment. Preharvest losses are those that occurred prior to harvesting. Such losses show up as a result of weather conditions and include shatter loss, grain left attached to the stubble and cut stalks not delivered into the header. Threshing losses occur when grains or panicles are not separated from the chaff and stalks in the combine.

How to determine losses in rice

- To determine preharvest losses, select a typical unharvested area of the field well in from the edges (See Table 25). Place a frame 12 inches square in the standing crop. Count all the kernels lying on the ground within the frame. Make several random samples and average them to find average bushels lost per acre. Approximately 21 to 24 rice kernels per square foot equals 1 bushel per acre.
- When checking machine losses, do not use any straw spreading device, such as a straw chopper or straw spreader, because the loss count will be inaccurate. Harvest a typical area. Allow the machine to clear itself of material and then back the combine a distance equal to the length of the machine and stop the combine. This will allow the checking of all loss points without starting and stopping the combine several times.
- To determine header losses, after backing the length of the machine, place the 1-square-foot measuring frame on the ground in front of the combine within the harvested area. Count the number of kernels found in the frame. Check several other sample areas and average the kernel count. Finally, subtract the number of kernels found in the preharvest loss check. For example, a combine has a 14-foot cutting platform and 39 kernels are within the frame. Subtracting 5 grains per square foot preharvest loss gives 34 kernels. Dividing the 34 kernels by 22 gives a header loss of 1½ bushels per acre.
- To determine threshing unit loss, after backing the length of the machine, check the ground in a few places directly behind the separator, using the 1-square-foot frame. Count all the kernels remaining on partially threshed heads. Do not include kernels lying loose on the ground. Then check the Machine Loss Chart for Small Grain (below) to determine the loss in bushels per acre. For example, if a combine with a 14-foot cutting platform and 38-inch separator were used to harvest rice and 85 kernels were found on partially threshed heads, the loss would be 1 bushel per acre. Typical threshing unit loss ranges from ½ to 1 percent of the average yield. Acceptable losses are largely a matter of operator preference.
- To determine straw walker and shoe losses, afterbacking the length of the machine, place the 1-square-foot measuring frame on the ground directly behind the separator. Then count the kernels lying loose within the frame. Do not include kernels on partially threshed heads. Subtract the number of kernels found in the header loss check and the preharvest loss check. The remaining figure will be the number of kernels lost over the straw walker and shoe. Check the Machine Loss Chart For Small Grain to find the loss in bushels per acre. Typical straw walker and shoe losses should be less than 1 percent of the average yield.

Ratoon (Second) Crop Production

L. Tarpley, G. N. McCauley and M. F. Jund

Several factors are critical to successful ratoon crop production. The earlier the ratoon crop matures, the higher its potential yields. Therefore, rapid stimulation of regrowth is an important factor. Apply the total recommended nitrogen rate immediately after harvesting the main crop and flood it into the soil to stimulate regrowth. Keep soils moist with a shallow flood until regrowth has advanced and retillering has occurred. After retillering, maintain a flood sufficient to control weeds.

Main crop cutting height

Traditionally, the main crop has been cut at about 18 inches above the ground (depending on variety). Ratoon tillers may be generated at any node below this height. Panicles from aerial nodes tend to be smaller with smaller grain. Panicles from different nodes may increase variability in maturity and decrease milling yield. Plot research and field verification tests have shown that reducing the

Table 25. Machine loss chart for small grain.

Crop	Separator width (in)	Approximate number of kernels per square foot to equal 1 bushel per acre								
		Cutting width (ft)								
		10	13	14	15	16	18	20	22	24
Rice	**29**	81	106	114	122	—	—	—	—	—
	38	—	80	86	92	98	110	123	—	—
	44	69	74	79	85	95	106	117	—	—
	55	—	55	60	64	68	76	85	94	102

cutting height will increase ratoon crop yield and uniformity. In small plots, yields increased as main crop cutting height decreased to 4 inches. Yields did not increase below 8 to 10 inches in field verification tests. Reducing main crop cutting height will delay ratoon crop maturity by 6 to 10 days. This delay can be offset by making a nitrogen application about 7 days before main crop drain and flooding immediately after harvest. The reduced cutting height can be achieved during combining or by using a flail shredder. **Note: If your ratoon crop is late, you may not want to reduce cutting height.**

Fertilization

The recommended nitrogen rate for ratoon crop production is dependent on the anticipated yield potential. That is, if all or most of the following conditions can be met, rates as high as 70 pounds of nitrogen per acre for conventional varieties and 100 pounds of nitrogen per acre for semidwarf varieties can be recommended. These conditions include: 1) harvest before August 15, 2) absence of disease in the main crop, 3) limited field rutting by equipment, 4) good weed control in the main crop, and 5) yield of the main crop lower than anticipated but good growth potential. Decrease or eliminate nitrogen if the main crop harvest is delayed; ratoon tillers are few; disease is present; fields are rutted; or weed pressure is significant. Remember, any delay in nitrogen and water application reduces the yield potential of ratoon crop rice.

Nitrogen timing on fine (heavy) soils

Splitting ratoon crop nitrogen by applying one-third to one-half at main crop heading and the remainder immediately after main crop harvest has not consistently increased yields of the ratoon crop. If nitrogen deficiency occurs during late stages of main crop development, top dressing of the main crop at this time may hasten ratoon crop tiller development and maturity. However, a near-heading application on a main crop that has sufficient nitrogen can produce excessive green foliage at main crop harvest.

Nitrogen timing and water management on (light) coarse soils

Several years of research data on a coarse soil at Eagle Lake suggest that when these types of soils remain dry for approximately 20 days after main crop harvest, ratoon crop yields can be increased by splitting the ratoon crop nitrogen (i.e., applying one-half immediately after harvest and the remaining 25 days after ratoon flood). However, if the ratoon crop flood is delayed more than 10 days after the main crop harvest, splitting the ratoon crop nitrogen does not increase ratoon crop yields. A dry period longer than 30 days between main crop harvest and ratoon crop flood can devastate ratoon crop yields on coarse soils. A dry period of 10 days or less can reduce ratoon crop yields, indicating that coarse soils, particularly those at Eagle Lake, need a dry period of 15 to 20 days and split nitrogen application to achieve optimum yields. Splitting ratoon crop nitrogen does not increase yields when the dry period between the main and ratoon crops is greater than 25 or less than 10 days.

Weed management

Herbicide use for broad leaf weeds, particularly dayflower, is of the most concern in ratoon crop rice. Several herbicides are currently labeled for use in ratoon crop rice. These include 2, 4-D, Grandstand R®, and Basagran®. Check the label for rates, timing and weeds controlled.

Gibberellic Acid Treatment to Improve Ratoon Stand

L. Tarpley

Several years of study have indicated that a gibberellic acid treatment applied at a rate of 3 to 5 grams of active ingredient per acre to the main crop starting several days after peak flowering can significantly increase ratoon yield by about 500 pounds per acre. This treatment appears to act by enhancing early growth of the ratoon tillers, and it also may enhance ratoon tiller initiation.

Based on 1 year of study, applying the same rate at soft dough was equally effective. Although there is no known negative effect from later applications up to main crop harvest, the benefit of later applications diminishes.

Gibberellic acid applied during active stem elongation can enhance active stem elongation, thus increasing plant height and the potential for lodging. Application during peak flowering can sometimes decrease main crop yield, according to research at Louisiana State University.

Main crop yield and main and ratoon crop grain quality do not appear to be harmed by the gibberellic acid treatment at early post-heading to mid-grain fill. The treatment retains efficacy when combined with some insecticide applications applied during grain filling.

The treatment's likelihood of benefit decreases when there is disease or nutritional stress on the ratoon crop. This treatment is applied to the main crop to benefit ratoon crop yield.

Texas Rice Production Practices

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Table 26 is a composite of the major disciplines and operations generally practiced by rice producers in Texas. The practices of land preparation, variety selection and ratoon crop production are not included. However, the sequence of operations through the production season has been correlated to rice plant development.

Note that the procedures listed represent the maximum level of inputs and that these practices should not be implemented unless the need arises or unless implementation can be economically justified.

This table does not constitute a recommendation of one production sequence by Texas Cooperative Extension. The scheme shown represents common rice production practices. Alterations in one discipline can greatly alter other practices. This is a generalized tabulation of rice production to provide producers with an overview and enable them to consider combining management practices when possible to make efficient use of costly trips across the fields.

Table 26. The major disciplines and operations generally practiced by Texas rice producers at various rice development stages.

Production practice	Stage of rice plant development when action is taken
Water management	
Flush as needed	Preplant to 1st tiller
Permanent flood	3rd tiller to 4th tiller
Stop pumping	Soft dough to hard dough
Flood stubble	After harvest
Fertilization	
Apply N, P and K	Preplant to 3rd leaf
Apply N	3rd leaf to (and) PD
Weed control	
Apply Propanil, Bolero®, Ordram® and/or Basagran®	Planting to PD
Apply Bolero®	Planting to 3rd leaf
Apply Prowl®	2nd to 4th leaf
Apply Phenoxys or Londax®	2nd tiller to panicle initiation
Disease control	
Seed treatments	Planting
Scout fields for sheath blight	Start at PD
Fungicide application	PD+5 days until late boot
Insect management	
Scout and apply insecticides as needed for:	
• armyworms	Emergence to maturity
• chinch bug	Emergence to tillering
• aphids	Emergence to tillering
• rice water weevil	Tillering
• rice stink bug	Flowering to maturation
• grasshoppers	Emergence to maturity
• stalk borers	PD to heading

Rice Production Economics

L. L. Falconer

The average costs of rice production are higher in Texas than in most other major rice-producing states. Despite higher costs, Texas producers have been able to remain viable because their average rice yields have been higher than those achieved in the major U.S. production state of Arkansas in 8 of the past 11 years (Fig. 10).

Even with good yields, Texas rice producers' high costs make them vulnerable to changes in economic, agronomic and climatic conditions. This vulnerability is demonstrated by less acreage, generally, being planted each year. Figure 11 shows the change in rice acreage for the major rice-producing states since 1995.

Texas' planted acreage has averaged nearly 200,000 acres in the past 4 years, with a low of 180,000 acres planted in 2003. With sharp increases in input prices, particularly for diesel and nitrogen fertilizers (Fig. 12), it is likely that planted acreage will drop below average in 2006. To reduce the unit cost of production, producers should study the production recommendations in these guidelines very carefully.

Cost of production estimates for the 2006 crop

The planning budgets shown in Tables 28 and 29 were developed with input from producers, custom service and product suppliers, Texas Cooperative Extension (TCE) specialists and TCE agents. These budgets are based on pro-jections for input and output prices for the 2006 crop year.

These budgets are intended to represent the cost structure for a hypothetical 450-acre rice operation on land that requires 18 to 20 levees per 100 acres. The budget scenario represents a high-yield, high-input conventional tillage production system with heavy pest pressure. First and second crop budgets have been separated, and all general and administrative costs, crop insurance, consulting, land and vehicle charges have been assigned to the first crop.

Annual usage rates for tractors are projected at 600 hours, with capital recovery factors calculated over an 8-year useful life. Annual usage rate for the combine was estimated at 200 hours with capital recovery factor calculated over a 10-year useful life.

The fixed costs shown in the budget represent the cost of owning machinery and equipment. They are the annualized capital recovery cost for owned durable items. No adjustment was made in aerial application costs for irregularly shaped fields. Service fees shown in the budget represent a charge for crop management consultant services.

The budgeted fertility program for the main crop includes a base fertilizer application, one pre-flood application and one topdress application. The total main crop fertilizer application is 183 units of N, 59 units of P, 39 units of K and 4.3 units of S.

The budgeted main crop herbicide program includes an initial ground-applied treatment of clomazone; an aerial application of a general tank-mix over the total planted acreage to control sedges, grasses and broadleaf weeds; and a follow-up aerial application over half of the planted acres to control escaped weeds.

The budgeted pesticide program for the main crop includes one fungicide application to control foliar diseases, a pyrethroid application to control water weevils, and two pyrethroid applications and one methyl-parathion application to control rice stink bugs.

The budgeted irrigation program for the main crop includes 1.57 hours per acre of labor for three flushes, flood maintenance and draining. Total main crop water usage is budgeted at 2.75 acre-feet, with water charges based on projected LCRA Lakeside Irrigation System rates for 2006.

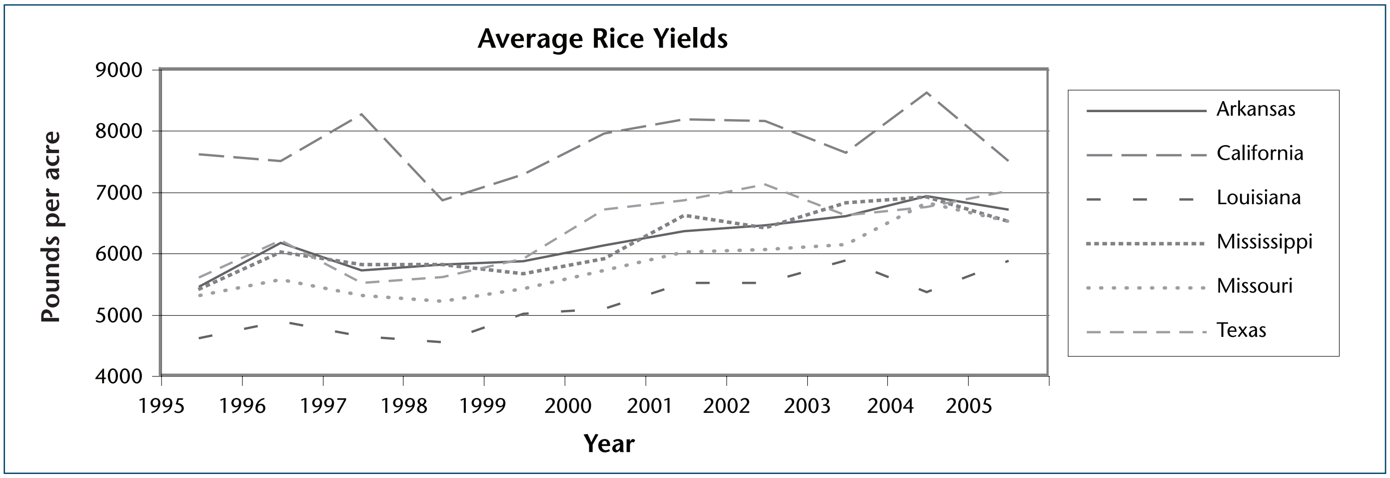


Figure 10. Average rice yields.

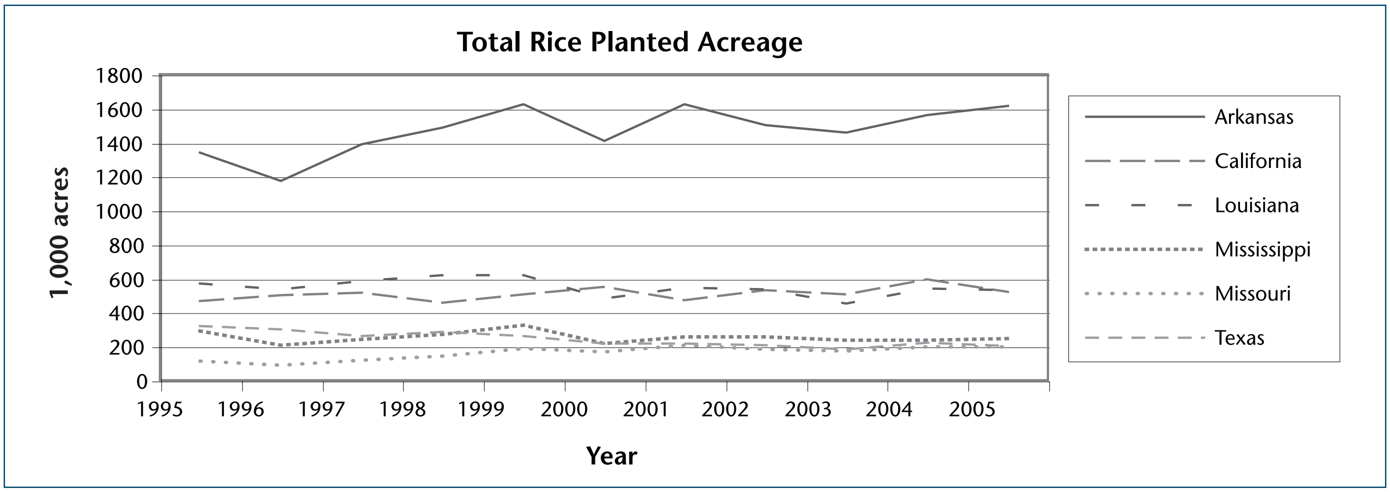


Figure 11. Total rice planted acreage.

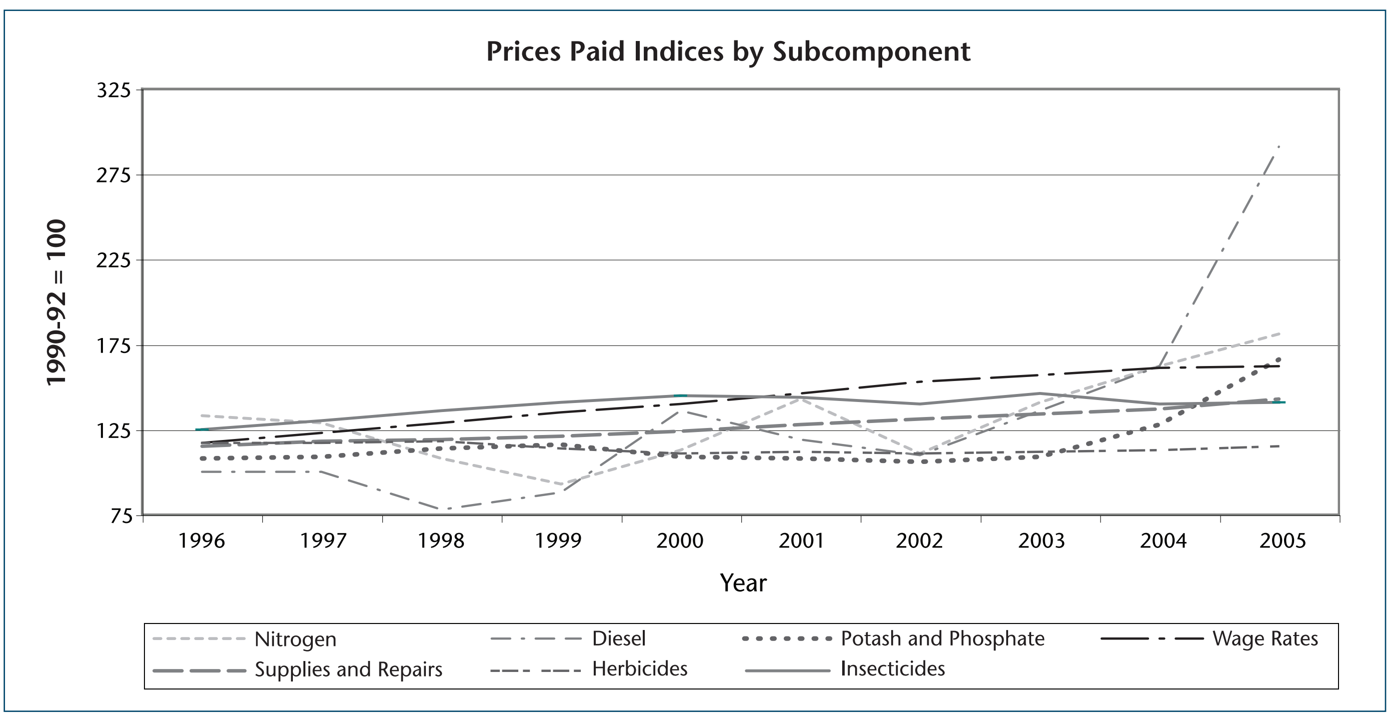


Figure 12. Prices paid indices by subcomponent.

For the second crop, the budgeted fertility program includes one top-dress application. The total second-crop fertilizer application is 69 units of N. The budgeted pesticide program for the second crop includes one application to control rice stink bugs.

The budgeted irrigation program for the second crop includes 0.71 hours per acre of labor for one flush, flood maintenance and draining. Total second crop water usage is budgeted at 1.9 acre-feet, with water charges based on projected LCRA Lakeside Irrigation System rates for 2006.

No countercyclical or direct payments from USDA are included in these budgets. The breakeven price needed to cover the budget's direct expenses for the main crop is $10.64 per hundredweight. The breakeven price needed to cover the budget's total specified expenses for the main crop is $11.92 per hundredweight.

For the second crop, the breakeven price needed to cover the budget's direct expenses is $8.45 per hundredweight. The breakeven price needed to cover the budget's total specified expenses for the second crop is $9.58 per hundredweight.

An enterprise budget is a statement of what is expected *if particular production practices are used* to produce a specified amount of product. It is based on the economic and technological relationships between inputs and outputs. The scenario shown in Tables 27 and 28 represents a general guide and is not intended to predict the costs and returns from any particular farm's operation.

For more details on these budgets, contact your local county Extension office or visit the Extension budget Web site maintained by the Texas A&M University Department of Agricultural Economics at agecoext.tamu/budgets/list.htm.

Table 27. Summary of estimated costs and returns per acre for main crop rice on a 450-acre rice farm located west of Houston.

Item	Unit	Price (dollars)	Quantity	Amount (dollars)	Your farm
Income					
Rice—Main crop loan	CWT	6.90	66.0000	455.40	________
Rice—Main crop prem.	CWT	1.00	66.0000	66.00	________
Total income				521.40	________
Direct expenses					
Adjuvants	acre	7.00	1.0000	7.00	________
Custom fertilize	acre	20.45	1.0000	20.45	________
Custom spray	acre	36.38	1.0000	36.38	________
Fertilizers	acre	96.93	1.0000	96.93	________
Fungicides	acre	25.10	1.0000	25.10	________
Herbicides	acre	68.85	1.0000	68.85	________
Insecticides	acre	18.45	1.0000	18.45	________
Irrigation supplies	acre	10.35	1.0000	10.35	________
Seed	acre	24.30	1.0000	24.30	________
Survey levees	hour	5.00	1.0000	5.00	________
Crop insurance—rice	hour	4.56	1.0000	4.56	________
Irrigation	gal	83.26	1.0000	83.26	________
Checkoff/commission	acre	10.56	1.0000	10.56	________
Drying—rice	acre	87.24	1.0000	87.24	________
Rice hauling	acre	22.76	1.0000	22.76	________
Storage—rice	acre	21.12	1.0000	21.12	________
Service fees	acre	20.00	1.0000	20.00	________
Vehicles	acre	16.17	1.0000	16.17	________
Operator labor	hour	11.25	1.3603	15.31	________
Rice water labor	hour	11.25	1.5700	17.68	________
Diesel fuel	gal	2.20	12.6673	27.87	________
Repair and maintenance	acre	31.84	1.0000	31.84	________
Interest on op. cap.	acre	31.65	1.0000	31.65	________
Total direct expenses				702.83	________
Returns above direct expenses				–181.43	________
Total fixed expenses				83.56	________
Total specified expenses				786.39	________
Returns above total specified expenses				–264.99	________
Residual items					
Rice land rent	acre	75.00	1.0000	75.00	________
G&A overhead	acre	10.50	1.0000	10.50	________
Management charge	%	521.40	0.0500	26.07	
Residual returns				–376.56	________

Note: Cost of production estimates are based on 18–20 levees per 100 acres. General and administrative (G&A) includes accounting, legal, general liability insurance and miscellaneous expenses estimated at $4,725/year. Vehicle charge is based on IRS allowance for 12,000 miles of annual use.

Table 28. Summary of estimated costs and returns per acre for ratoon crop rice on a 450-acre rice farm located west of Houston.

Item	Unit	Price (dollars)	Quantity	Amount (dollars)	Your Farm
Income					
Rice—2nd crop loan	CWT	6.90	16.0000	110.40	
Rice—2nd crop prem.	CWT	1.00	16.0000	16.00	________
Total income				126.40	________
Direct expenses					
Custom fertilizer	acre	6.80	1.0000	6.80	________
Custom spray	acre	5.75	1.0000	5.75	________
Fertilizers	acre	25.69	1.0000	25.69	________
Insecticides	acre	3.63	1.0000	3.63	________
Irrigation	acre	26.75	1.0000	26.75	________
Checkoff/commission	acre	2.56	1.0000	2.56	________
Drying—Rice	acre	22.17	1.0000	22.17	________
Rice hauling	acre	5.78	1.0000	5.78	________
Storage—Rice	acre	5.12	1.0000	5.12	________
Operator labor	hour	11.25	0.3500	3.95	________
Rice water labor	hour	11.25	0.7100	8.00	________
Diesel fuel	gal	2.20	2.7795	6.12	________
Repair and maintenance	acre	9.76	1.0000	9.76	________
Interest on op. cap.	acre	3.08	1.0000	3.08	________
Total direct expenses				135.16	________
Returns above direct expenses				–8.76	________
Total fixed expenses				18.19	________
Total specified expenses				153.35	________
Returns above total specified expenses				–26.95	________
Residual items					
Management charge	%	126.40	0.0500	6.32	________
Residual returns				–33.27	________

Note: Cost of production estimates are based on 18–20 levees per 100 acres. All general and administrative costs including accounting, legal, general liability insurance and miscellaneous expenses are charged to main crop. All crop insurance, consulting and land charges are assigned to main crop. Vehicle charges assigned to main crop.

2006 Agricultural Policy Outlook

J. L. Outlaw and L. L. Falconer

During the last 9 months of 2005, there was considerable discussion about the future direction of agricultural policy in the United States. Congress has indicated a strong desire to keep the major provisions of current farm bill (Food Security and Rural Improvement Act of 2002) intact until it expires in 2007.

However, most observers point to two primary reasons that changes are coming for U.S. policy as the 2007 farm bill debate begins in earnest in 2006: the U.S. federal budget deficit, and the Brazil World Trade Organization (WTO) case against the U.S. cotton program

First, a year ago at this time, all the talk in Washington was about getting control of the federal budget deficit and the adverse impact that war spending would have on the amount of government borrowing and the general economy. In this regard, the president asked Congress to reduce spending through budget reconciliation. As of November 2005, both the Senate and House had plans for accomplishing around a $3 billion reduction in mandatory spending over the 2006–2010 period.

Although this was definitely a modest cut, rumors in Washington are that the next reconciliation amount will be much larger. A larger cut would require the Agricultural Committees of Congress and producers and their associations to take stock as to whether the current set of programs and corresponding payments (countercyclical payments, direct payments and marketing loan payments/loan deficiency payments) are still what they want—given that less money is behind them.

We may have to wait until 2007 to find out about a future reconciliation bill, as years divisible by 2 aren't normally subject to budget reductions.

The second reason for program change is the loss in the Brazil World Trade Organization (WTO) case against the U.S. cotton program. Thus far, the United States has made minimal changes to comply with the WTO ruling with the intention of dealing with the major changes in the 2007 farm bill.

Although the loss in the cotton case is important, when you couple it with the ongoing Doha Round discussions of the WTO—something has to change. With the loss in the cotton case, the United States will not be able to stay under our existing amber box spending limit without changes in commodity programs.

If the U.S. Trade Representatives' proposed lower spending limits are approved without an accommodation of our request to change how certain program payments are categorized, then real changes, beyond most farmers' wildest imagination, will have to be made in commodity programs.

If you wonder why the U.S. negotiators would consider making significant concessions in the current trade round, think about this: Many believe that the only options are to make significant changes in the trade negotiations or face more cases against other program commodities such as rice and soybeans.

On their own, neither of the two reasons provided for change are likely to be strong enough to create a major change in agricultural policy. However, in combination they appear to be moving U.S. agricultural policy toward significant changes. Although the prospects for change appear pretty good, it should be noted that the amount of financial support for agriculture is not expected to decline appreciably—it may be provided by an alternative form of safety net.

Web-Based Information Delivery

L. T. Wilson, Y. Yang, J. Vawter, J. W. Stansel, J. Wang, P. Lu, J. Cockrell, C. Jia, F. H. Arthur, T. Siebenmorgen and T. Howell

Over the past four decades, tremendous progress has been made in our understanding of rice production. As data are accumulated, there is an increasing need to integrate knowledge from different disciplines into delivery systems that are easy to use and readily available. The Internet has provided a format that shows great promise in this regard, and we are seeing an increasing trend of developing Web-based agricultural management applications.

Web-based application offers many advantages compared to traditional stand-alone applications, including, but not limited to, greater user accessibility and information delivery, extended lifetimes of service, ease of maintenance and upgrading, and customization for different clientele groups. Web-based programs make it possible for students, researchers and scientists to explore ideas, to identify areas for research and improvement, and to step across interdisciplinary boundaries without needing to carry out the integration.

To serve the rice production community, the Texas A&M University Agricultural Research and Extension Center at Beaumont has developed several online applications. The Rice Development Advisory (RiceDevA) is a web-based program that forecasts rice growth stages for multiple varieties and different planting dates for 21 rice counties in Texas. It can be accessed at http://beaumont.tamu.edu/RiceDevA.

The Post-Harvest Grain Management (RiceSSWeb) is a web-based program that allows users to predict temperature and grain moisture changes during rice storage and the population dynamics of, and damage by, insects (the lesser grain borer and the rice weevil) inside the storage bins. It was developed jointly by Texas A&M University, the University of Arkansas, the Agricultural Research Service (Manhattan) of the U.S. Department of Agriculture, and the University of Missouri. It can be accessed at http://beaumont.tamu.edu/RiceSSWeb.

Rice Development Advisory

DOS-based DD50 (1986-2003)

In 1976, Dr. Jim Stansel developed the concept, methodology and original data for forecasting rice development based on usable heat units. In 1986, Jack Vawter (The Texas A&M University System-Eagle Lake) wrote a DOS-based computer program ("DD50") based on Stansel's concept and methodology.

The DD50 program used current daily maximum and minimum air temperature and historic temperature data to calculate usable heat units for each day. Historic air temperature data were used to predict temperatures for dates when current temperature data were unavailable. These heat units were accumulated from seedling emergence and used to predict various rice crop growth stages.

These predictions then were used to make recommendations for scheduling production practices. DD50 had since been modified and updated by various authors, including Stansel, Vawter, James Woodard, Kuo-Lane Chen and W. H. Alford.

Web-based Rice Development Advisory (RiceDevA) (Released 2004)

The DOS-based DD50 had several limitations: access to weather data for only two weather stations (Eagle Lake and Beaumont), the need to manually input up-to-date weather data, limited user interface, accessibility only by a small group of users, and the need to update the program and send out new copies every year.

A new Web-based program called Rice Development Advisory (RiceDevA) was released in April 2004. RiceDevA is a complete rewrite and replacement of the DOS-based DD50 program. It provides an improved user interface and advanced options for creating, running and displaying multiple-field growth forecasts for different rice varieties, planting/emergence dates and counties.

Major features

RiceDevA can provide growth forecasts and advisories for 21 rice counties in Texas (Fig. 13). It forecasts rice growth stages for multiple varieties, different planting dates (Fig. 14) and different rice counties. It also allows users to run multiple-field profiles at the same time and display and print results for multiple field profiles (Fig. 15).

RiceDevA allows users to choose weather stations in any Texas rice-producing county and choose weather data for a specific year or historic averages for a particular station in the county. The program provides interfaces for users to add, view and edit their own weather data and allows users to view and download county weather data.

Crop forecasting

RiceDevA uses the same simple field information that DD50 previously used to forecast development. Production data include rice variety, planting date, and 10 percent and 90 percent seedling emergence date. Additional information used by RiceDevA (but not by DD50) includes weather station data and year or historic averages for the station.

However, this program cannot predict rice crop yields nor account for changes in crop development because of other environmental factors and management practices.

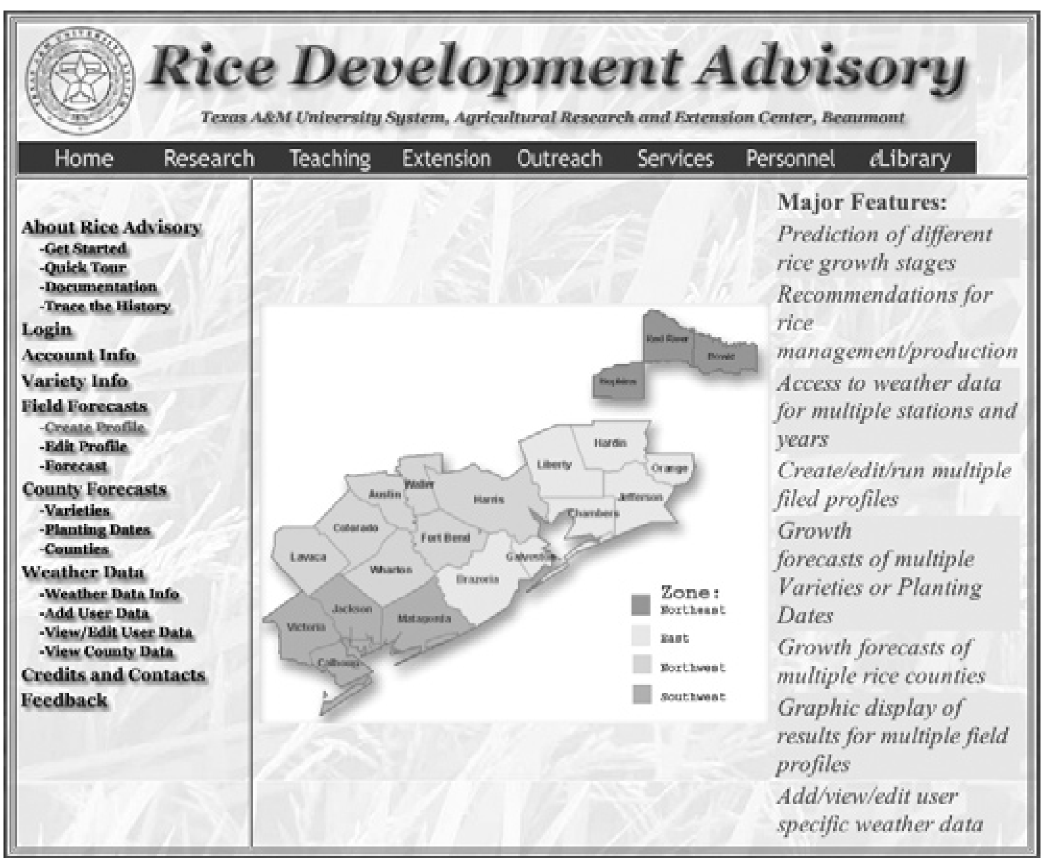


Figure 13. The RiceDevA Web site can provide growth forecasts and advisories for 21 rice counties in Texas.

Interface window

The top part of RiceDevA's window displays links to the Web site of the Texas A&M University System Research and Extension Center at Beaumont (Home, Research, Teaching, Extension, Outreach, Services, Personnel and eLibrary) (Fig. 13). The left side of the window displays links to the major features of the Rice Development Advisory (About Rice Advisory, Login, New Account, Account Info, Variety Info, Field Forecasts, County Forecasts and Weather Data). The remaining part of the window allows users to input, edit and view data or display results.

Feature access

A user can access features of the RiceDevA by clicking on a link in the left side menu and making appropriate selections.

New account creation: To create a new account, click on the New Account link, fill in the appropriate information, and click on the Submit button. Once your account is created, you are automatically logged in, and you will be presented with more options in the left side menu.

Field profile creation: A field profile is a collection of production and weather data needed to forecast rice plant growth stages. Production data include rice variety, planting date, 10 percent emergence date and 90 percent emergence date. Weather data include weather station and year or historic average for the station.

A user can create a field profile by clicking on the Create Profile button under the Field Forecasts menu on the left side and making the appropriate selections for production and weather data. Only users who have accounts with RiceDevA can save a profile or view, edit or delete existing profiles. A field profile is owned by a specific user and is accessible only by that user.

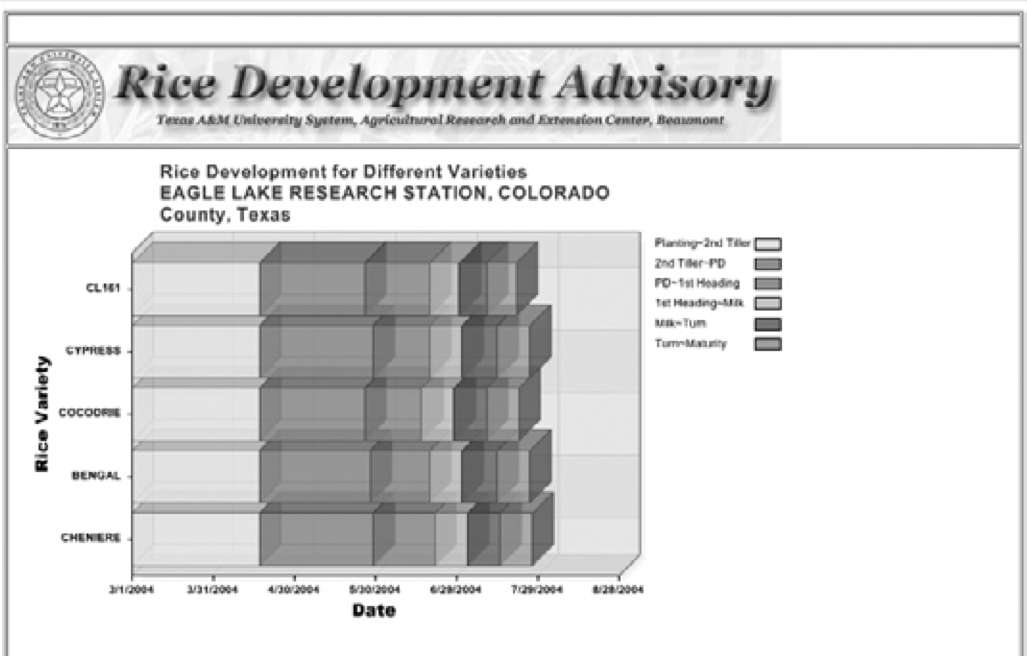
Menu descriptions

Menus to access RiceDevA features are displayed on the left side of the RiceDevA window (Fig. 13).

The *Account Info* menu displays information about a user who has registered with RiceDevA (user name, user ID, email, etc.)

The *New Account* menu allows a user to create a new account. A registered user (by creating a new account) will have access to advanced features of the RiceDevA.

The *Variety Info* menu displays information about all varieties currently in the system. The information includes heat units to different crop stages (second tiller, panicle differentiation, first heading, milk stage, panicle turning and grain maturity) and disease resistance (rice blast, sheath blight and straighthead). Varieties in the database



Variety Name	Emergence 10%	Emergence 90%	Second Tiller	Panicle Differentiation	First Heading	Milk Stage	Turning	Maturity
CHENIERE	3/19/2004	3/22/2004	4/17/2004	5/29/2004	6/21/2004	7/3/2004	7/15/2004	7/27/2004
BENGAL	3/19/2004	3/22/2004	4/17/2004	5/28/2004	6/19/2004	7/1/2004	7/14/2004	7/26/2004
COCODRIE	3/19/2004	3/22/2004	4/17/2004	5/26/2004	6/16/2004	6/28/2004	7/10/2004	7/22/2004
CYPRESS	3/19/2004	3/22/2004	4/17/2004	5/29/2004	6/19/2004	7/1/2004	7/14/2004	7/26/2004
CL161	3/19/2004	3/22/2004	4/17/2004	5/26/2004	6/19/2004	6/30/2004	7/10/2004	7/21/2004

3/1/2004~7/27/2004	EAGLE LAKE RESEARCH STATION Real Weather Data

Figure 14. The RiceDevA Web site forecasts rice growth stages for multiple varieties, different planting dates and different rice counties.

include Cypress, Cocodrie, Francis, Jefferson, Wells, Dixiebelle, Gulfmont, XL8, CL161, Saber, Cheniere, XL7 and Bengal.

The *Field Forecasts* menu provides growth forecasts for single or multiple-field profiles for the current user.

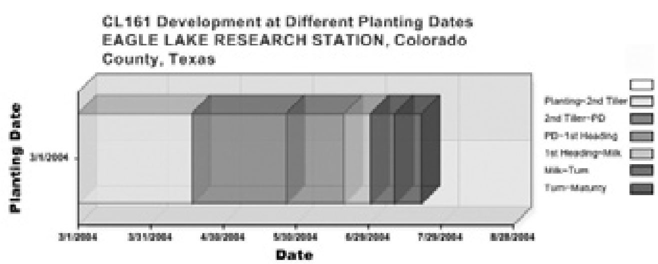
The *Create Profile* submenu allows users to create a new field profile; the **Edit Profile** submenu allows a registered user to edit his/her existing field profile(s); and the **Forecast** submenu allows a registered user to forecast rice crop growth for single or multiple field profiles.

The *County Forecasts* menu allows users to forecast rice crop growth for different varieties, planting dates and counties. The *Varieties* submenu provides growth forecasts for single or multiple rice varieties; the *Planting Dates* submenu provides growth forecasts for single or multiple planting dates; and the *Counties* submenu provides growth forecasts for single or multiple counties.

The *Weather Data* menu gives users background information about weather data and options for adding user weather data and viewing county weather data. The *Information sub*menu provides background information about weather data sources and usage; the *Add User Data* submenu allows a registered user to add user-specific weather data for new or existing user stations; the *View User Data* submenu allows a registered user to view his/her weather data; and the *View County Data* submenu allows any users to view weather data for 21 rice producing counties in Texas.

Rice Development Advisory

Texas A&M University System, Agricultural Research and Extension Center, Beaumont



Planting Date	Emergence 10%	Emergence 90%	Second Tiller	Panicle Differentiation	First Heading	Milk Stage	Turning	Maturity
3/1/2004	3/19/2004	3/22/2004	4/17/2004	5/26/2004	6/19/2004	6/30/2004	7/10/2004	7/21/2004

Check for chinch bugs on recently emerged rice
Check for fall armyworms from emergence to maturity
(For rice water weevil control (if justified) apply Icon 6.2FS as a seed treatment; or Dimilin 2L or Mustang™ MAX early postflood; or Karate® Z seven days before to five days after flood.)

Cautionary note: This program uses only air temperatures to predict rice growth stages. Any other stresses may alter the actual development of the rice plant.

	Date	Event
(1)	4/23/2004 ~ 5/17/2004	Only apply hormone herbicides after peak tillering and up to 7 days prior to PD
(2)	5/24/2004 ~ 6/3/2004	Panicle differentiation (N application for non-hybrid only; Start checking for sheath blight and stem borers)
(3)	6/7/2004 ~ 6/17/2004	First blast fungicide application
(4)	6/16/2004 ~ 6/26/2004	Date field reaches 15% heading
(5)	6/16/2004 ~ 6/28/2004	Start checking for rice stink bugs at least once a week from 50% heading to harvest
(6)	6/20/2004 ~ 6/30/2004	Second blast fungicide application
(7)	7/8/2004 ~ 7/18/2004	Drain alert
(8)	7/19/2004 ~ 7/29/2004	Approximate harvest date (20% grain moisture)
	3/1/2004~7/29/2004	Real Weather Data

Figure 15. The RiceDevA allows users to run multiple-field profiles at the same time and display and print results for multiple field profiles.

Post-Harvest Grain Management

Aeration and grain management

Once a cereal crop has been harvested, it may need to be stored for a period before it can be marketed or used as feed or seed. The length of time cereal grain can be safely stored depends on its condition at harvest and the type of storage facility being used.

Grain binned at lower temperatures and moisture contents can be kept in storage for longer periods before its quality deteriorates. Grain quality and storage duration are affected by the presence and buildup of insects, mites, molds and fungi, which are all affected by grain temperature and grain moisture content.

Although the biggest threats to stored rice are the lesser grain borer and the rice weevil, excessive moisture and temperature variations can also affect grain quality. Monitoring stored grain has depended on bin managers, requiring diligence and near-constant oversight.

The rice weevil and lesser grain borer are primary feeders that complete development inside the kernel. Because infestations are hidden, they are often undetected until populations reach damaging levels. An important component of any grain bin management program is using low-volume ambient air (aeration) to cool the grain mass to levels (60 degrees F) that will either reduce or suppress insect population development.

Aeration is the process of ventilating stored grain at low airflow rates to maintain a fairly uniform grain temperature throughout the bin. Aeration prevents moisture accumulation at the top layers of the bin because of natural convection.

Aeration may be used with field-dried grain or with grain that is harvested damp, then dried and cooled in a heated air dryer. In both cases, the grain may vary in temperature and moisture content, or it may be too warm to store safely.

Variations in grain temperatures are also caused by changes in the outside air temperature after the grain is stored. The amount of air required to change the temperature of the grain may not affect grain moisture content because of the low airflow rates used in aeration. Although bin aeration is not intended to be a grain-drying system and should not be considered as such, some drying can occur when the weather is very dry and the fan is run for a long time.

Fan operation should be controlled by maintaining a difference of less than 10 degrees F between grain temperature and the average outside air temperature. Grain is cooled in the fall, kept at low temperatures in the winter and warmed in the spring.

Improper aeration leads to mold development. Early signs of mold growth can be detected by smelling the first air that is exhausted from storage after fans are turned on.

Generally, fans can be operated when the outside relative humidity ranges from 55 to 70 percent. If the airflow rates are high, humidity below a recommended range could overdry the grain; humidity above the range may raise the grain moisture to unsafe levels.

These levels are determined by the equilibrium moisture content (EMC) of the grain, a point at which the grain is neither gaining nor losing moisture. If the relative humidity is constant, a rise in air temperature will lower the EMC. Likewise, if the temperature is constant, a rise in relative humidity will raise the EMC.

At 77 degrees F and 75 percent relative humidity, rough rice has an EMC of 11.89; the EMC for brown rice is 13.01; and for milled rice, it is 13.04. These numbers may change slightly with different varieties and grain types, as lipid levels in the bran affect the EMC.

Most moisture meters read the surface moisture of the grain. Rice just coming out of a dryer may read 13 percent, but afterward that reading could go up by 1 or more percentage points. This is known as the “rebound effect,” and should be considered as grain goes in to storage. Fissuring occurs when the moisture gradient between the kernel and the air is high, and moisture rapidly enters the grain.

During fan operation, the air temperature should be cooler than the grain in the fall and warmer than the grain in late spring. Some aeration controllers automatically start and stop fans based on grain and air temperatures; some also control on the basis of air humidity.

The minimum airflow rate for grain aeration is 0.05 to 0.2 cubic foot per minute per bushel (CFM/Bu). Grain with low initial moisture content requires a lower airflow rate. For larger fans, this will speed up the cooling process as more air is moved through the grain.

Warm air rising in the center of the bin cools when it reaches the cold grain near the surface. This results in an increase in moisture content near the surface, which can lead to rapid spoilage.

A common symptom of moisture migration is crusting on the surface of stored grain. Significant migration can occur in cereal grains at moisture contents as low as 12 percent wet weight basis (w.b.), if the grain is placed into storage at a high temperature and not cooled.

Grain in storage is subject to moisture migration caused by differences in grain temperature. This is particularly true for grain stored in metal bins. In late fall and early winter, stored grain tends to be warmer than the outside air. Warm air rises slowly out of the center grain. When this air contacts the cold grain on the top of the bin, it cools, increases in relative humidity and causes the top grain to gain moisture.

Sometimes the temperature differences are enough to cause condensation on the top grain. Air and grain that are close to cold walls or floors also cool. The air increases in humidity, sometimes causing the grain closest to the cold metal to gain enough moisture to cause spoilage.

Moisture migration is slowed by aeration, regularly forcing outside air through the grain to reduce the temperature difference between the grain and the outside. The grain temperature should be within 10 degrees F of the average outside air temperature.

During the fall, aeration is used to cool the grain and maintain moisture uniformity. In the winter, aeration is needed just to maintain moisture uniformity.

Keep the grain temperature as low as possible during the spring to reduce insect damage. Insects become active when grain temperature rises above about 65 degrees F, and infestation and damage are likely when the grain temperatures are between 75 and 90 degrees F, which is the optimum range for growth and development of stored-grain insects.

To summarize, good storage practices can prevent losses in grain quality by:

- Keeping the moisture content of grain below about 12.5 percent, which corresponds to about 65 percent relative humidity
- Keeping the grain temperature within 10 degrees F of the average monthly air temperature and below 60 degrees F as long as possible during the year
- Designing and operating an aeration system to maintain uniform grain moisture and temperature
- Storing only well-cleaned grain. Fungi (mold) growth is minimal below 65 percent relative humidity and bacteria growth is minimal at even higher relative humidity.
- Reducing the occurrence of rapid shifts in temperature, thereby controlling grain fissuring
- Monitoring and reacting appropriately to any changes that may occur

Safe, long-term storage moisture for grain is based on how dry it is. Although grain can be stored above about 12 percent moisture content, the risk of noticeable mold growth increases as moisture, storage time and grain temperature rise. During storage, inspect the grain weekly. Test the discharge air for off-odors, any increases in temperature within the grain, and increases in moisture, which generally indicate a problem.

Web-based post-harvest grain management tool RiceSSWeb

The Post-Harvest Grain Management program (http://beaumont.tamu.edu/ RiceSSWeb) is a web-based grain management tool (Fig. 16). It allows users to create different scenarios of bin and fan configurations and different initial conditions of pest infestations. It also allows users to simulate changes in grain temperature and moisture content and the resulting pest density and grain damage.

The tool was developed jointly by scientists from Texas A&M University, the University of Arkansas, the Agricultural Research Service (Manhattan) of the U.S. Department of Agriculture, and the University of Missouri.

The web-based program is directly linked to a weather database that contains data for southern rice-growing region (Arkansas, Louisiana, Mississippi, Missouri and Texas). The weather database is updated automatically with data from several sources, mainly weather data from the National Oceanic and Atmospheric Administration (NOAA).

Major features. The RiceSSWeb has the following major features:

- Prediction of grain temperature and moisture dynamics
- Prediction of rice weevil and grain borer dynamics
- Sensitivity analysis of different bin configurations
- Sensitivity analysis of different pest configurations
- Ability to create, edit and run multiple bin profiles
- Graphic display of results for aeration/pest dynamics
- Access to weather data for multiple stations and years
- Ability to add, view and edit user specific weather data

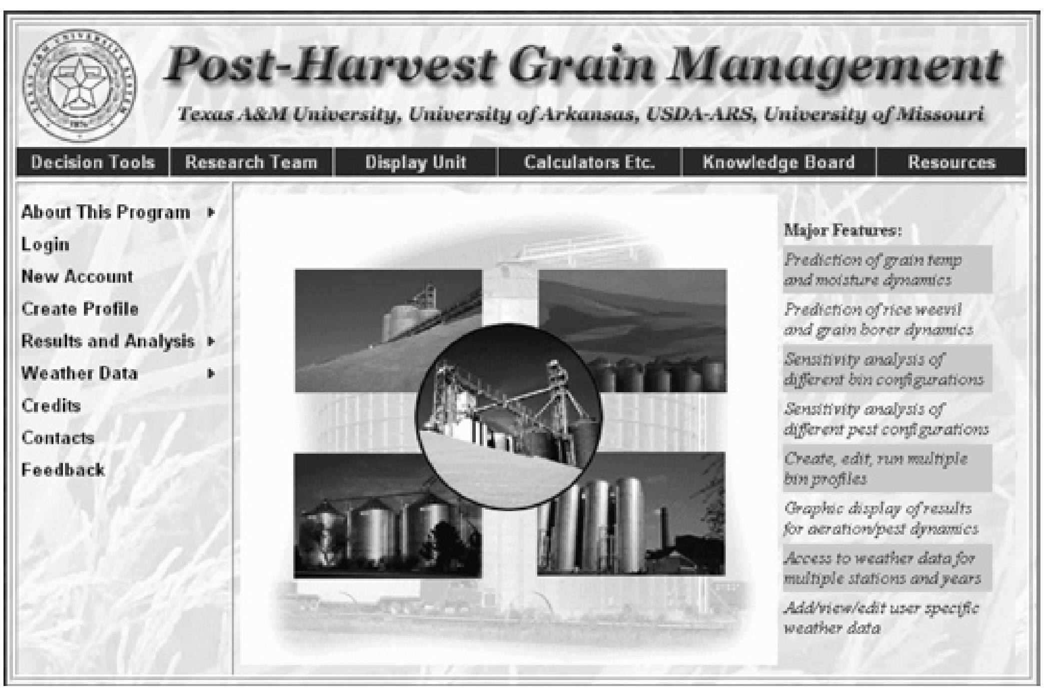


Figure 16. RiceSSWeb main page.

Interface windows. The Web interface window (Fig. 16) has three major parts. The left side of the window displays links to the major features of the Post-Harvest Grain Management program *(About This Program, Login, New Account, Create Profile Profile, Results and Analysis, and Weather Data)*.

Four additional features *(Account Info, Bin Info, View/Edit Profile and Run Profile)* are available for users who have logged in. The top banner of the window displays links to information that is relevant to the Post-Harvest Grain Management program *(Decision Tools, Research Team, Display Unit, Calculators Etc., Knowledge Base, and Resources)*. The remaining part of the window allows users to input, edit and view data and display results.

Feature access. A user can access features of the Post-Harvest Grain Management program by clicking on a link on the left side menu and making appropriate selections.

New Account Creation: To create a new account, click on the New Account link, fill in the appropriate information, and click on the Submit button. Once your account is created, you are automatically logged in, and more options will appear on the left side menu.

Bin Profile Creation. A bin profile is a collection of bin and pest configuration and weather data needed to forecast dynamics of grain temperature and moisture, and pests (Figs. 17-19). Bin configuration includes bin diameter, grain depth, initial grain temperature and moisture. Pest configuration includes pest species and initial pest density. Weather data include weather station and year or historic average for the station.

A user can create a bin profile by clicking on the Create Profile submenu under Bin Profiles on the left sidebar and making the appropriate selection for the bin, pest and weather data.

Only users who have accounts with the program can save the profile and view, edit or delete existing profiles. A bin profile is owned by a specific user and is accessible only by that user. Also, only registered users can add, edit or view their own weather data.

Menu descriptions. Menus to access RiceSSWeb features are displayed on the left side window (Fig. 17).

The *Account Info* menu displays information about a user who has registered with RiceSSWeb (user name, user ID, email, etc.)

The *New Account* menu allows a user to create a new account. A registered user (by creating a new account) will have access to advanced features of the RiceSSWeb.

The *Bin Info* menu allows a user to add a new bin or view and edit existing bins.

The *Create Profile menu* allows users to create a new bin profile; the *Edit/Run Profile* menu allows a registered user to edit his or her existing bin profile(s); and the *Run Profile* menu allows a registered user to forecast dynamics of bin temperature, moisture, pests, and pest damage for single or multiple profiles.

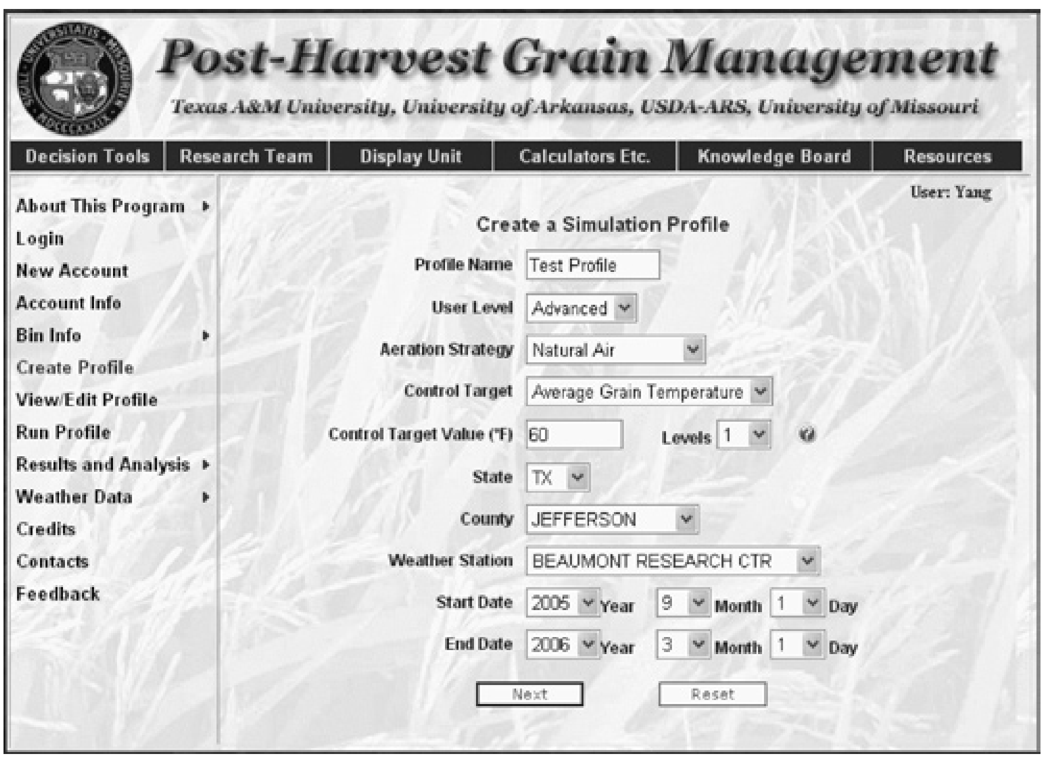


Figure 17. Create Profile – general and weather data.

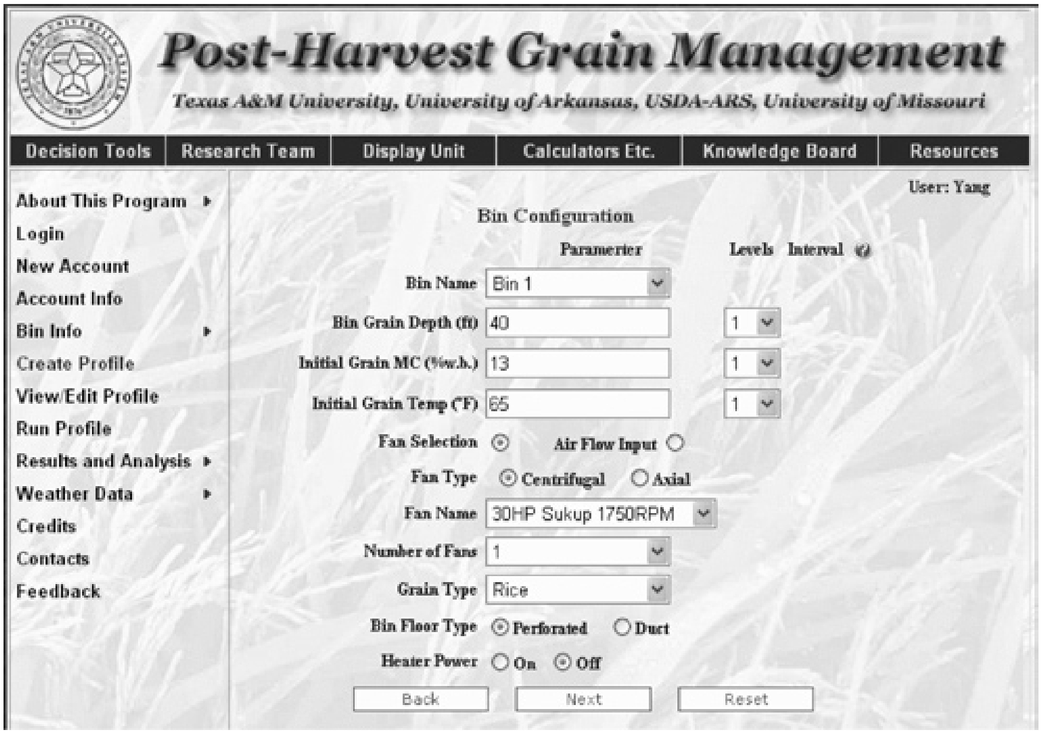


Figure 18. Create Profile – bin configuration.

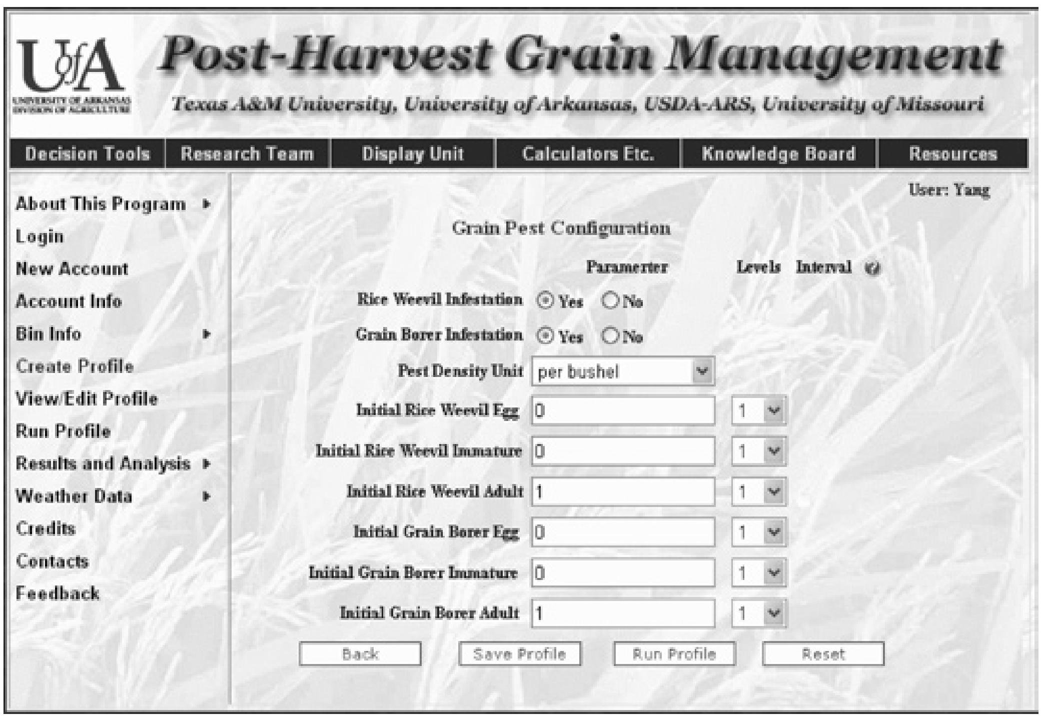


Figure 19. Create Profile – pest configuration.

The *Results and Analysis* menu has three submenus: *Aeration Dynamics, Pest Dynamics* and *Sensitivity Analysis*. The *Aeration Dynamics* submenu displays the dynamics over time for grain temperature, grain moisture, relativity humidity and fan power consumption. It also displays data animation for grain temperature and moisture (Fig. 20).

The *Pest Dynamics* submenu displays dynamics and damage of rice weevil and/or grain borer over time (Fig. 21). The *Sensitivity Analysis* submenu displays results at different levels of values for a selected set of bin and pest attributes and graphically examine the differences in grain temperature and moisture, power consumption, pest density or pest damage (Figs. 22 and 23).

The *Weather Data* menu gives users background information about weather data and options for adding user weather data and viewing county weather data. The Information submenu provides background information about weather data sources and usage.

The *Add User Data* submenu allows a registered user to add user-specific weather data for new or existing user stations. The *View User Data* submenu allows a registered user to view his/her weather data; and the *View/Download County Data* submenu allows any users to view available weather in the database.

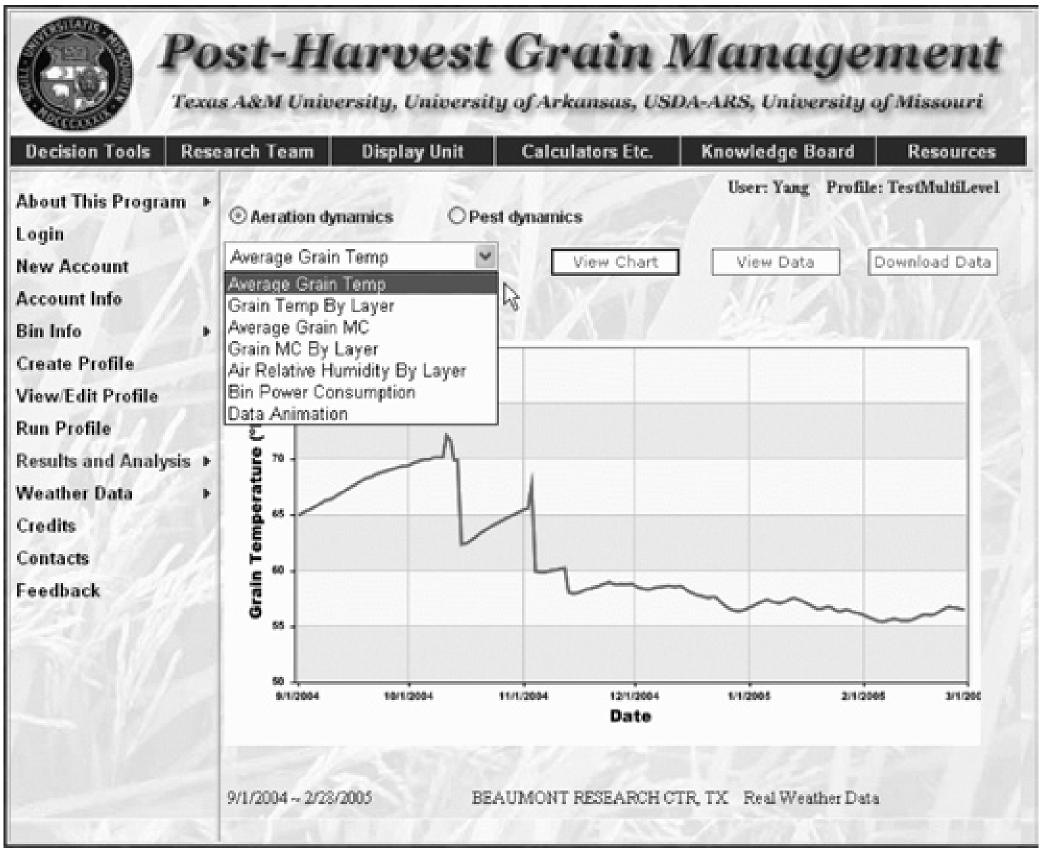


Figure 20. Simulation results for aeration.

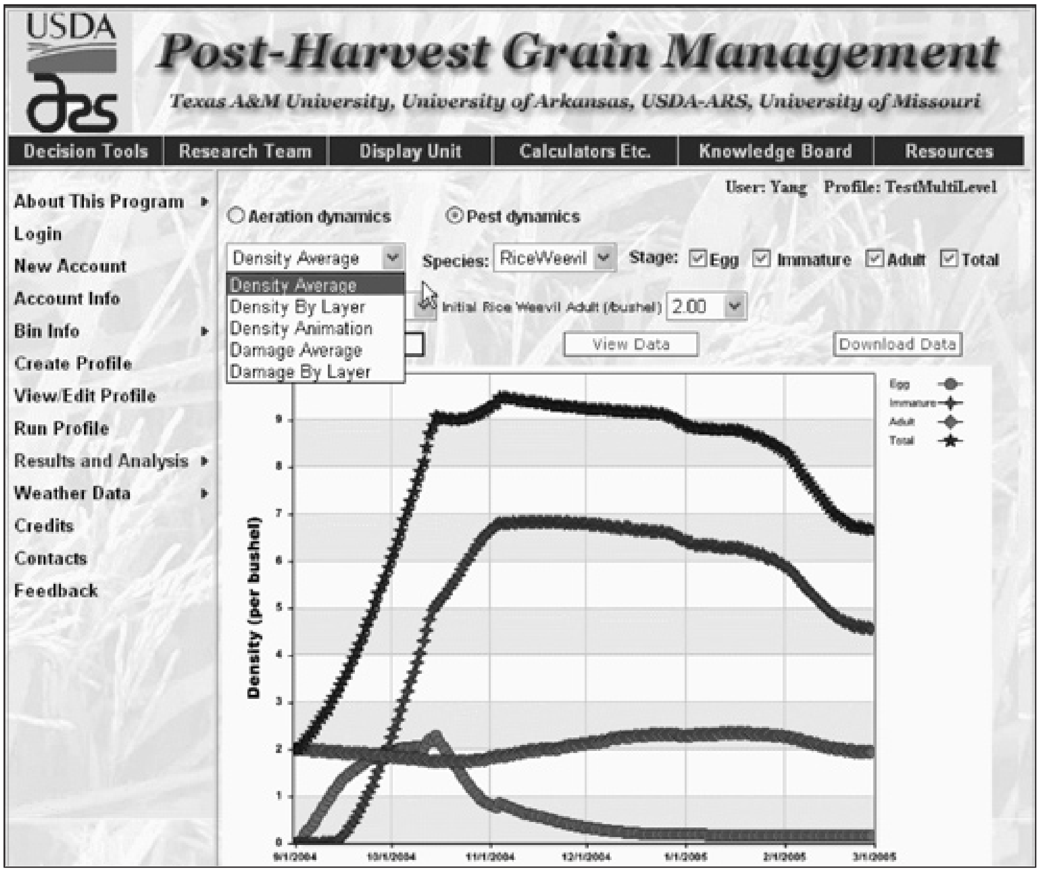


Figure 21. Simulation results for pest population and grain damage.

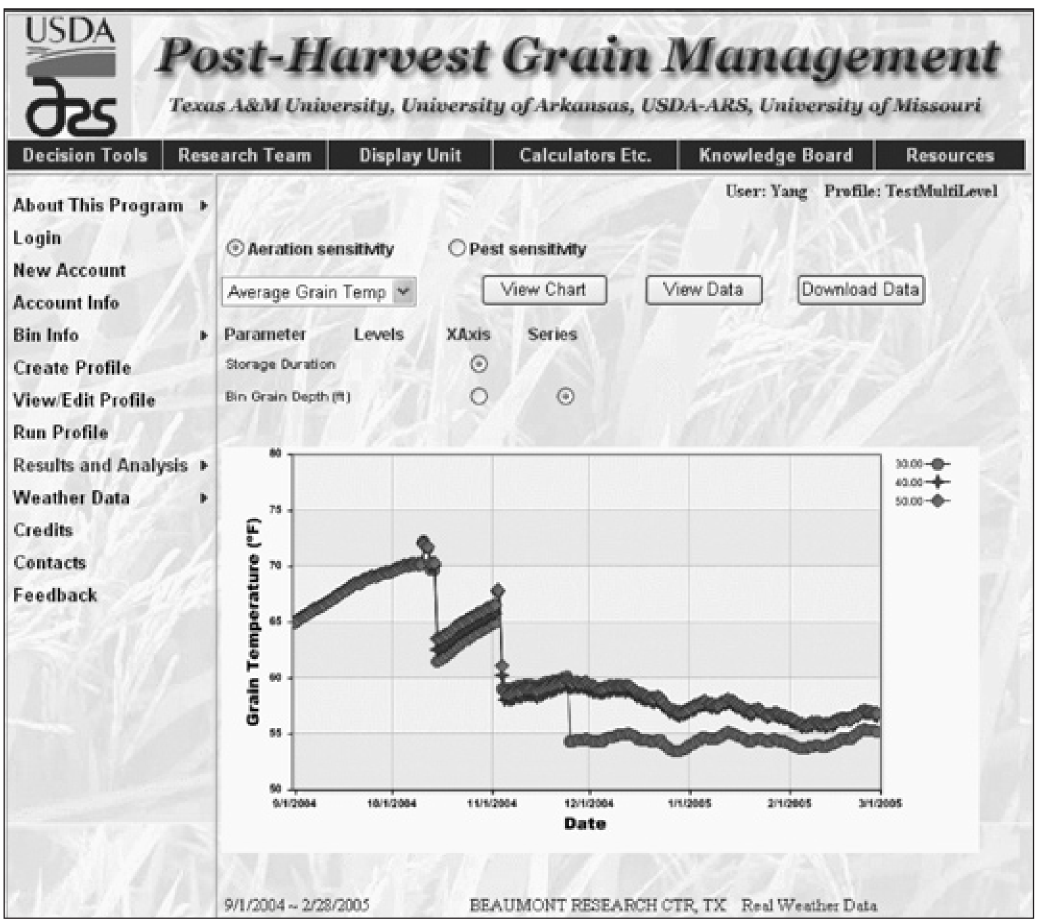


Figure 22. Bin temperature vs. bin grain depth.

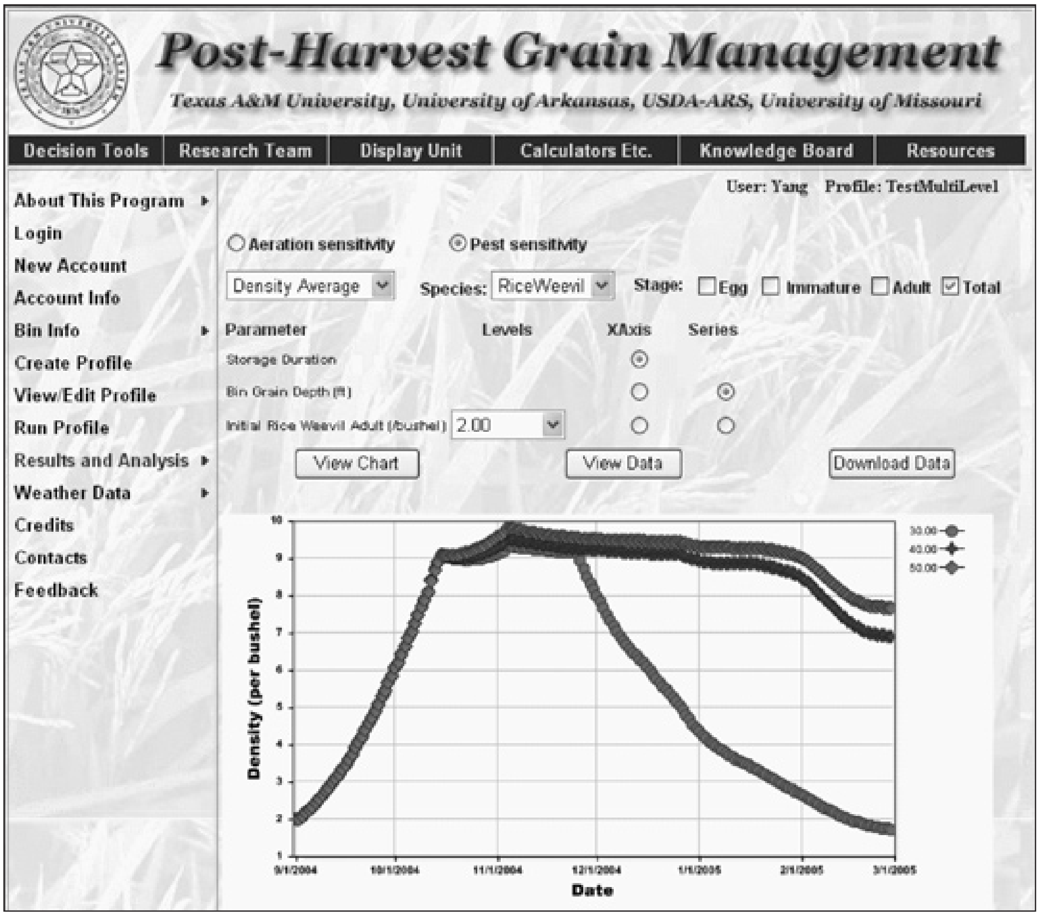


Figure 23. Pest density vs. bin grain depth.

Historical Texas Rice Production Statistics

J. W. Stansel and B. Morace

Table 29. 12-year Texas rice acreage, yields and production comparison.

Crop year	Planted acres*	Yield (lb/A) main crop**	Yield (lb/A) ratoon crop**	Main crop ratooned**	Yield (lb/A) total**	Production***	
1993	296,193	5,054	1,168	34%	5,451	14,383,037	
1994	345,680	5,944	984	43%	6,195	22,089,662	
1995	315,108	5,474	1,269	32%	5,340	16,826,875	
1996	263,407	5,942	1,402	46%	6,587	17,350,830	
1997	256,944	5,282	916	42%	5,608	14,408,971	
1998	271,989	5,472	1,200	54%	5,842	15,891,008	
1999	246,227	5,818	1,362	26%	6,172	15,196,150	
2000	209,679	6,252	1,375	37%	6,761	14,176,944	
2001	213,704	6,276	1,269	49%	6,898	14,741,250	
2002	205,748	6,685	1,015	37%	7,061	14,526,940	
2003	178,027	6,065	1,600	38%	6,673	11,880,000	⋆
2004	216,810	5,966	2,314	35%	6,776	14,690,000	⋆
Avg. 1993–2004	**251,626**	**5,853**	**1,323**	**39%**	**6,280**	**15,513,472**	
2005	200,937	6,795	1,968	27%	7,326	14,720,600	⋆⋆

*USDA–FSA certified planted acres
**TAMUS–Beaumont Crop survey data
***U.S. Rice Producers Association—check-off collections
⋆Modified to account for carryover stocks
⋆⋆Estimated

Table 30. 12-year Texas rice-planted acres comparison.

County	Rice-planted acres*											
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Austin	3,172	2,366	2,479	2,878	2,673	2,702	2,435	2,601	1,694	1,684	2,313	2,359
Bowie	1,459	1,600	1,600	1,136	1,329	1,538	1,030	1,435	1,287	1,332	1,510	2,054
Brazoria	32,701	29,975	16,818	21,888	18,718	19,241	17,163	15,279	14,969	10,395	15,748	15,975
Calhoun	5,682	4,875	4,760	2,502	3,851	3,164	1,568	1,468	1,498	1,897	2,488	2,439
Chambers	29,932	28,217	20,906	20,411	21,672	17,197	11,432	13,438	12,692	10,937	16,024	12,792
Colorado	41,783	37,551	36,200	36,091	35,698	33,522	31,136	32,110	30,726	28,572	33,273	30,903
Fort Bend	11,499	11,207	9,418	10,680	10,179	9,006	8,894	8,652	8,615	6,071	7,933	6,409
Galveston	3,780	2,993	2,144	2,110	1,993	1,590	1,360	768	1,166	781	847	833
Hardin	752	463	714	900	1,185	1,052	1,093	801	633	738	762	298
Harris	9,363	8,095	6,654	6,484	6,187	4,875	2,957	1,975	2,083	1,664	1,522	1,067
Hopkins	600	750	700	1,563	1,563	1,141	1,562	1,473	1,034	713	0	0
Jackson	30,920	27,561	25,235	20,521	20,128	18,355	16,208	14,953	13,214	13,057	14,734	12,713
Jefferson	33,849	32,324	26,102	24,947	24,422	22,655	18,519	18,575	18,389	15,037	19,954	19,355
Lavaca	4,040	3,572	3,703	2,682	2,452	2,006	2,523	1,746	1,690	1,582	2,189	1,804
Liberty	23,854	19,386	11,071	14,074	18,706	14,328	8,740	12,705	9,073	7,949	10,475	9,381
Matagorda	35,409	30,246	26,692	26,814	30,518	28,598	23,036	24,958	24,516	18,878	23,672	21,863
Orange	1,520	1,301	732	750	2,248	362	531	354	414	0	90	0
Red River	1,000	1,050	47	951	941	1,100	709	965	1,017	587	639	639
Victoria	4,190	3,824	2,775	2,941	3,302	2,401	1,937	1,977	1,748	1,247	1,356	1,705
Waller	7,343	6,785	5,677	6,741	6,694	6,142	6,206	6,951	6,917	7,168	7,868	7,672
Wharton	63,433	61,118	58,930	50,737	57,530	55,253	52,205	50,520	49,139	41,664	53,413	50,678
Total	**346,280**	**315,259**	**263,357**	**257,799**	**271,989**	**246,227**	**211,241**	**213,703**	**202,514**	**171,952**	**216,809**	**200,937**

*USDA–FSA certified plant acres

Table 31. Texas crop rice development statistics (date at 50% by development stages).

50% planted				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
2005	15–Apr	1–Apr	8–Apr	8–Apr
2004	23–Apr	1–Apr	4–Apr	6–Apr
2003	20–Apr	26–Mar	6–Apr	6–Apr
2002	1–Apr	28–Mar	1–Apr	1–Apr
2001	20–Apr	8–Apr	2–Apr	9–Apr
2000	11–Apr	10–Apr	24–Mar	27–Mar
1999	12–Apr	8–Apr	29–Mar	7–Apr
Overall average	**14–Apr**	**2–Apr**	**1–Apr**	**4–Apr**

50% headed				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
2005	15–Jul	1–Jul	8–Jul	8–Jul
2004	27–Jul	9–Jul	10–Jul	11–Jul
2003	17–Jul	29–Jun	9–Jul	1–Jul
2002	27–Jun	24–Jun	24–Jun	25–Jun
2001	8–Jul	1–Jul	27–Jun	3–Jul
2000	30–Jun	1–Jul	1–Jul	1–Jul
1999	8–Jul	27–Jun	27–Jun	5–Jul
Overall average	**10–Jul**	**30–Jun**	**2–Jul**	**3–Jul**

50% main crop harvested				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
2005	26–Aug	19–Aug	19–Aug	19–Aug
2004	20–Aug	15–Aug	17–Aug	23–Aug
2003	25–Aug	10–Aug	10–Aug	23–Aug
2002	14–Aug	3–Aug	2–Aug	4–Aug
2001	21–Aug	9–Aug	8–Aug	11–Aug
2000	12–Aug	4–Aug	4–Aug	6–Aug
1999	14–Aug	4–Aug	2–Aug	10–Aug
Overall average	**18–Aug**	**9–Aug**	**8–Aug**	**13–Aug**

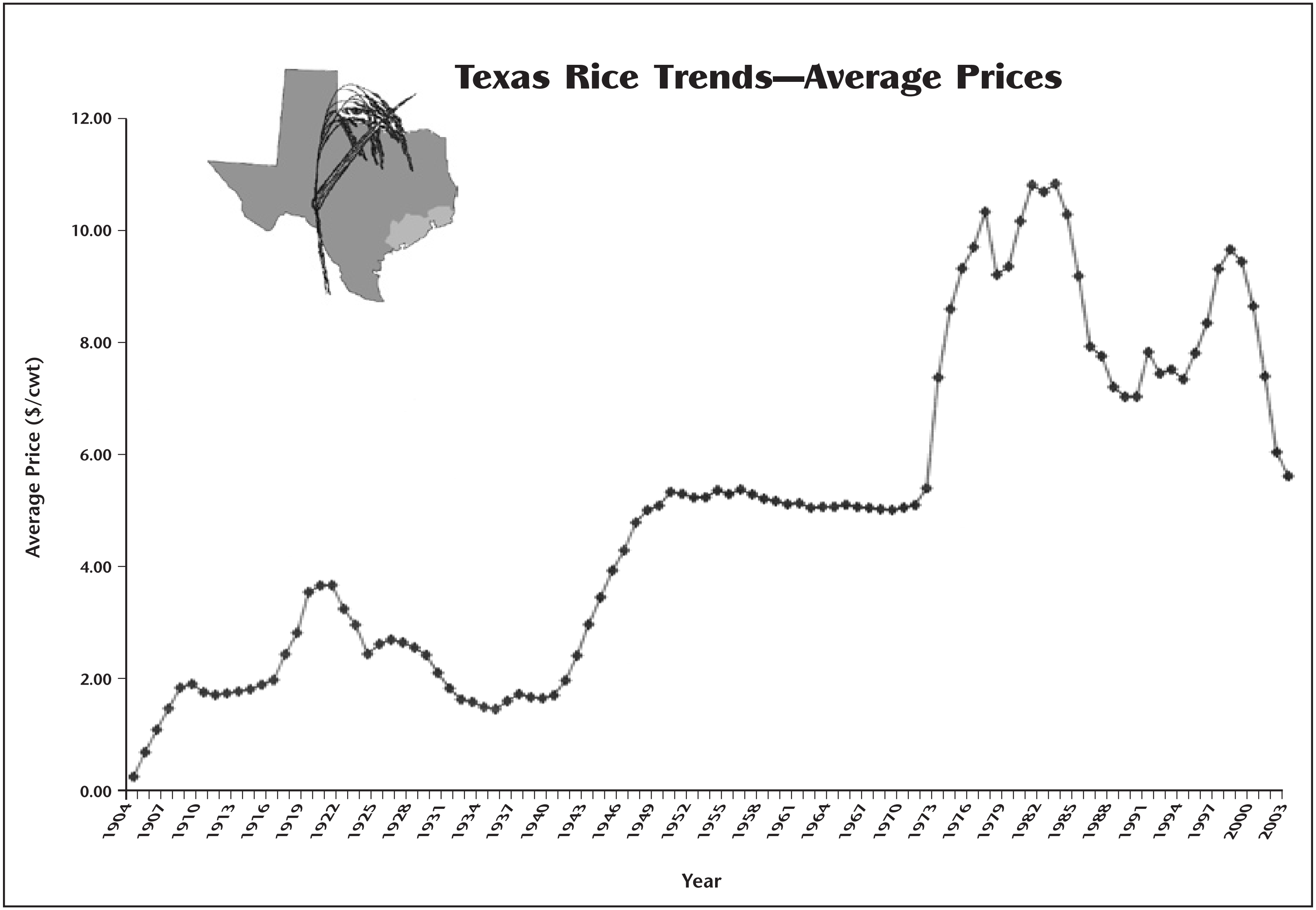


Figure 24. Texas Rice — Average Price Trends (1904-2004).

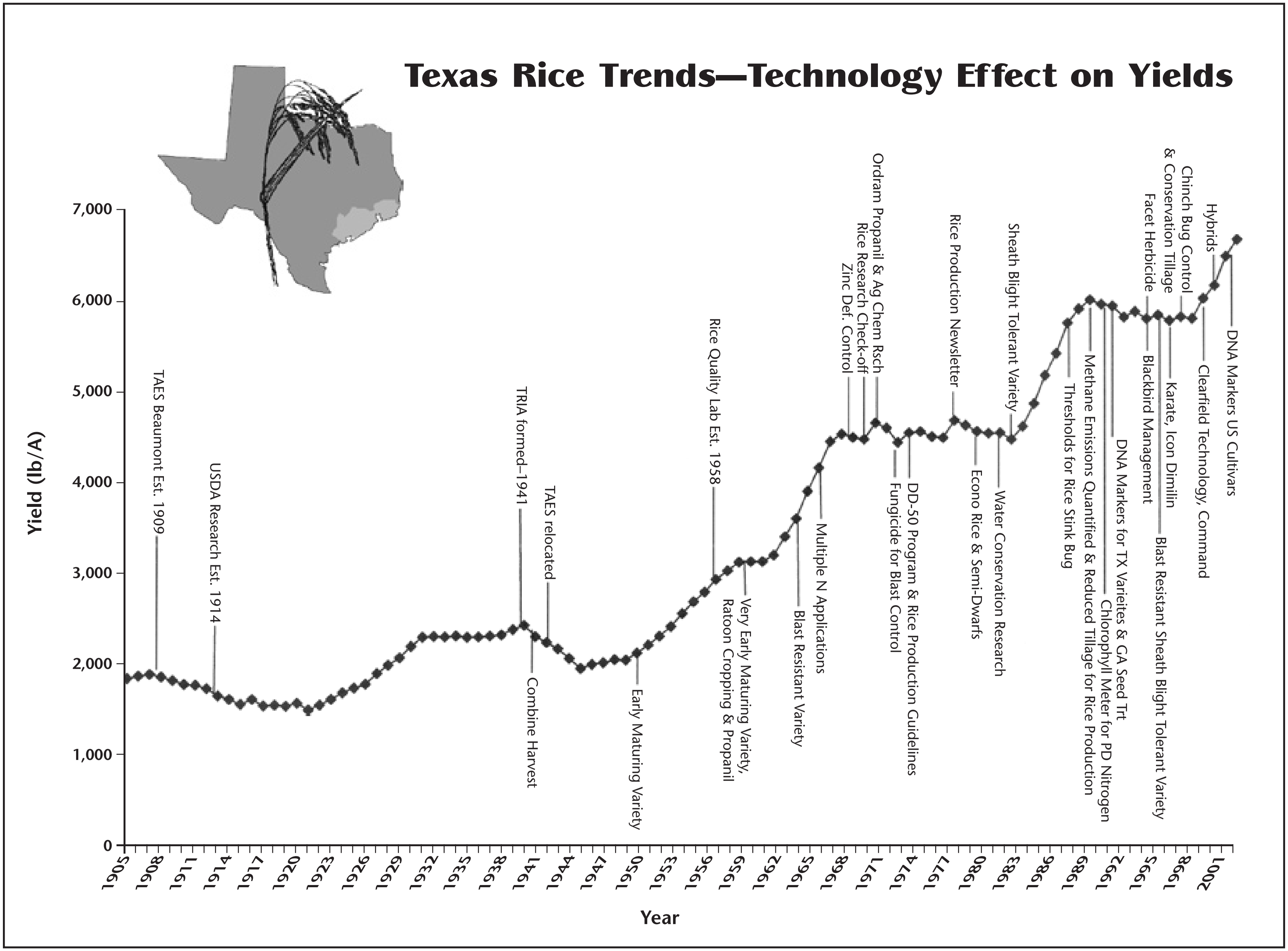


Figure 25. Texas Rice — Technology Trends effect on yields (1904-2004).

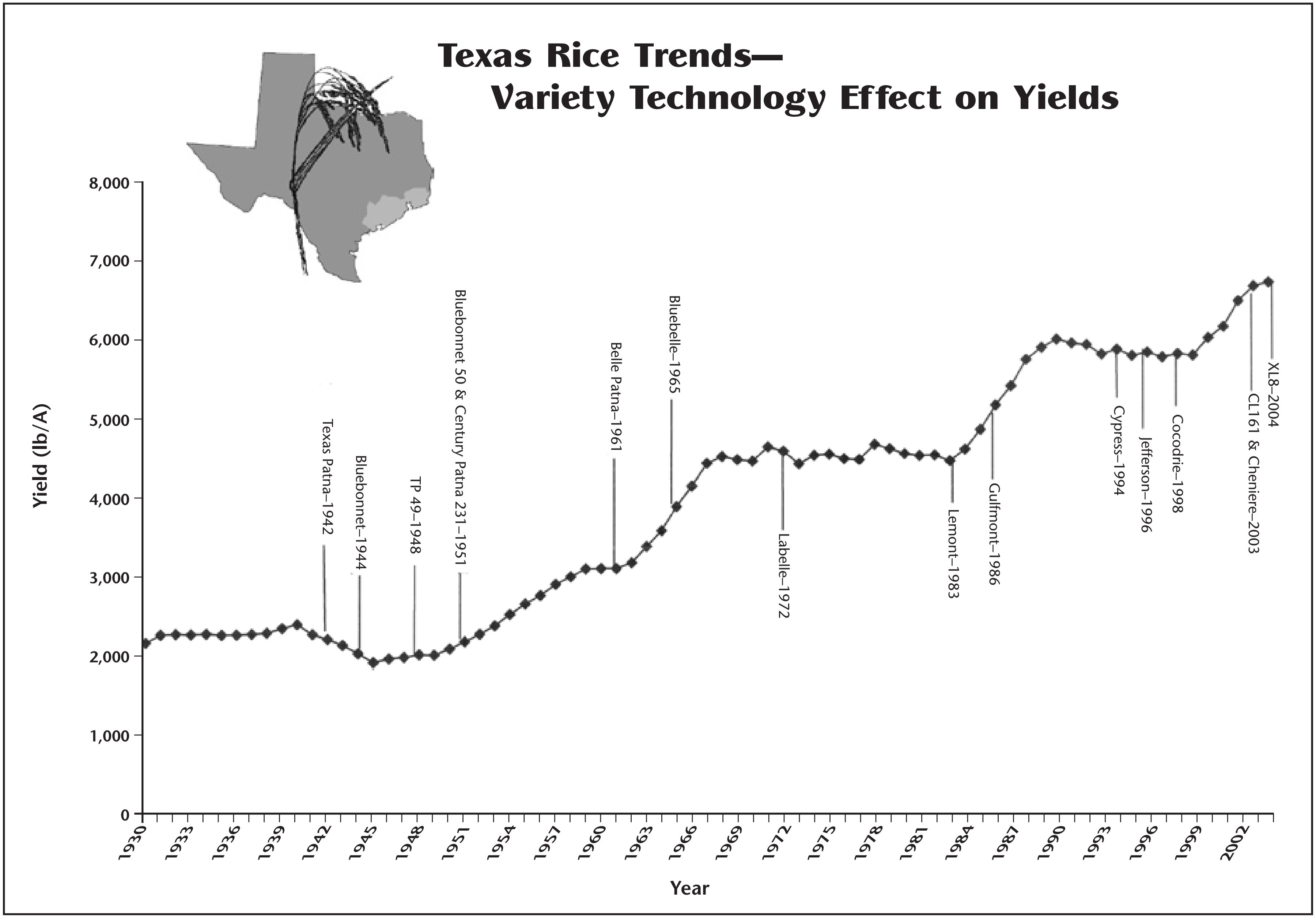


Figure 26. Texas Rice — Variety Technology Trends effect on yields (1930-2004).

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