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RICE 2005 PRODUCTION *Guidelines*

Texas Cooperative
EXTENSION
The Texas A&M University System

Texas Agricultural Experiment Station
THE TEXAS A&M UNIVERSITY SYSTEM

USDA ARS

2005 Texas Rice Production Guidelines

Revisions compiled and incorporated by
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These guidelines are based on rice research conducted by the Texas Agricultural Experiment Station, Texas Cooperative Extension and United States Department of Agriculture–Agricultural Research Service research personnel 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 2005 rice crop.

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TRRF Proposals Funded for 2003-04

Project Title: Development of Rice Cultivars for the Southern U.S.
Project Investigator: Anna McClung, Rodante Tabien
Amount: $46,906
Objective: To develop improved, conventional and specialty varieties which 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: Utilization of Winter Nursery Facilities for Development of Improved Cultivars
Project Investigator: Anna McClung, Rodante Tabien
Amount: $37,580
Objective: To utilize the winter breeding nursery facilities to their fullest extent to enhance cultivar development projects that are led by Drs. McClung and Tabien. The majority of the research effort is directed towards the development of improved conventional long grain cultivars but niche market will also be addressed.

Project Title: Development of High Yielding Rice Varieties for Texas
Project Investigator: Rodante Tabien
Amount: $84,547
Objective: The main objective of the project is 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: Direct Manipulation of Yield Determinants and Herbicide Tolerance in Rice
Project Investigator: William Park, Lloyd Wilson, J.M. Chandler
Amount: $34,500
Objective: The focus of our current work with TRRF is to ask how, on a very limited budget, we can take advantage of the flood of information and technology in genomics to do things of direct practical value to the Texas rice industry. This years efforts have been focused on three objectives: 1) further characterization of Cocodrie and Cypress plants into which we inserted the glutamine synthase 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: Physiological Bases for Texas Rice Ratoon Crop Management
Project Investigator: Lee Tarpley
Amount: $35,000
Objective: Most of the acreage in Texas is planted in varieties with good ratoon potential, thus the limitations in consistent ratoon stand are likely to be due to an interaction of environment and physiology. The bases for early, vigorous and uniform ratoon stand establishment will be addressed because there are indicators that large yield improvements can be made at this stage. Why can a low cutting height stimulate relative ratoon yield? How to further stimulate yield on top of any assumed benefit due to a low cutting height? Continue evaluation of varietal response to application of gibberellin at several days post-flowering as a tool to improve ratoon yield by enhancing ratoon tiller earliness.

Project Title: Evaluating Public and Private Rice Varieties for Production in Texas
Project Investigator: Fred Turner
Amount: $46,000
Objective: The objectives of this project are to 1) measure each variety's and each advanced experimental line's main and ratoon crop response to plant population and nitrogen rate at two locations on contrasting soil types; 2) identify potential or commercial varieties with best yield and milling when planted beyond the optimum date due to weather or other restrictions; 3) provide a single economic index or ranking calculated from each variety's main, ratoon and total crop yield and milling, thus giving a better variety evaluation than separate yield and milling values; 4) identify stand establishment, plant population and nitrogen management principles for each variety; 5) collect plant development data others can use for developing DD-50 values for predicting critical growth stages and timing inputs of each variety; and 6) provide a two-page data summary table showing each variety's physical characteristics and economic performance for main, ratoon and total crop yield in Texas.

Project Title: Water Management and Weed Science Research in Rice
Project Investigator: Garry McCauley, J.M. Chandler
Amount: $75,000
Objective: The objectives of this project are 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 ap-

plied alone and in combination with several commercial herbicides, 4) assess control of perennial grassed (perennial banyardgrass and Paspalum species) with commercial and experimental herbicides, 5) evaluate fall and spring vegetation management prior to 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.

Project Title: 2004 Entomology Research and Extension Program
Project Investigator: M.O. Way
Amount: $54,551
Objective: The broad objective of the project is 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 revision of 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: Management of Bacterial Panicle Blight Caused by Burkholderia glumae
Project Investigator: Joseph P. Krausz
Amount: $10,210
Objective: The objectives of the project are to 1) evaluate the rice cultivars and lines for reaction to panicle blight in the URRN trials at the Texas A&M Research and Extension Center at Beaumont, 2) to 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 development of a weather based predictive model for forecasting panicle blight and validate a model already developed in Korea.

Project Title: Communications, Press and Outreach for the Texas Rice Industry
Project Investigator: Jaynen Cockrell
Amount: $11,535
Objective: The objectives of this project are 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 Center and to highlight the valuable role of agriculture in Texas.

Project Title: Educational Publications for Texas Rice Producers
Project Investigator: Dale Fritz
Amount: $6,075
Objective: The objectives of this project are to 1) to provide educational information in support of the Texas rice industry; 2) to serve as a delivery method for disseminating new technology and update information to rice producers; and 3) to provide the latest rice production, management, and environmental information to producers and related agribusiness personnel.

Project Title: Texas Rice Crop Survey - 2004
Project Investigator: James Stansel
Amount: $16,000
Objective: The objectives of this project are 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 development of rice belt water planning for rice production.

Project Title: Personnel Support at Eagle Lake Station
Project Investigator: Lloyd Wilson
Amount: $60,000
Objective: To support two positions that would oversee Farm Services activities at the Eagle Lake Center.

Project Title: Eagle Lake Tractor Pay-off
Project Investigator:
Amount: $26,019
Objective: Not Applicable.
Project Title: Beaumont Tractor Payment
Project Investigator:
Amount: $9,278
Objective: Not Applicable.

Project Title: Mitsubishi Combine
Project Investigator: Rodante Tabien
Amount: $47,000
Objective: To use the combine in harvesting elite breeding materials.

Project Title: Ford F150 V8 with Tow Capacity
Project Investigator: Rodante Tabien
Amount: $14,400
Objective: To use the vehicle in on-station and off-station travels related to the Texas breeding projects. The travels include field activities, meetings / con-ferences and visits to on-farm and research sites.

Project Title: Flail Mower
Project Investigator: Lee Tarpley
Amount: $2,775
Objective: To assist research studies requiring controlled or low cutting height and/or pulverization of straw in their conductance.

Project Title: Roterra
Project Investigator: M.O. Way and Lloyd Wilson
Amount: $8,000
Objective: The roterra will be used to improve small plot seedbeds. All projects will have access to the roterra, which will be maintained and housed by Way's project.

Contents

Land and Seedbed Preparation

G. N. McCauley and A. D. Klosterboer

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 F. T. Turner

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

A. M. McClung and F. T. Turner

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.

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.

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.

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.

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.

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.

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

	2004					
Variety	**Number of Fields Reported**	**Number of Fields Reported**	**Yield lbs/Acre**	**Milling Yield %H**	**Milling Yield %T**	**Grade**
Cocodrie	245	27,398	6,395	60.9	70.8	2.1
Cypress	33	3,155	5,845	61.8	70.6	1.8
CL161	62	7,470	5,573	60.8	68.9	1.8
Dixiebelle	25	2,499	6,609	60.4	70.3	2.0
Jefferson	13	1,289	5,824	60.7	70.0	2.0
XL8	18	1,947	6,517	58.3	71.1	1.7
Wells	5	465	6,174	59.5	72.0	2.0
Cheniere	76	6,035	6,558	62.1	71.6	1.4
Total:	**477**	**50,258**				
Weighted Average:			**6,231**	**60.9**	**70.6**	**1.9**

Table 2. 2003 Texas field yields by variety (main crop).

	2003					
Variety	**Number of Fields Reported**	**Reported Acreage**	**Yield lbs/Acre**	**Milling Yield %H**	**Milling Yield %T**	**Grade**
Cocodrie	187	19,063	6,220	60.6	70.8	2.1
Cypress	64	7,257	5,926	61.2	69.5	1.7
CL161	32	4,010	5,555	60.5	68.4	1.6
Jefferson	13	1,574	6,270	56.8	69.0	2.2
XL8	11	483	5,604	56.7	68.0	1.6
Wells	2	151	7,358	62.5	73.0	2.0
Cheniere	1	592	5,703	67.0	73.0	1.0
Total:	307	32,387				
Weighted Average:			**6,065**	**60.5**	**70.1**	**1.9**

Compiled by Dr. Jim Stansel and Regina Tate, TAES-Beaumont.
Data is collected 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. 2004 Texas rice acreage by variety and county.

County	2003 Acreage	2004 Acreage	Long Grain: Cocodrie	Cypress	Jefferson	CL161	Francis	Cheniere	CL XL8	Saber	Dixie-belle	Wells	XP 710	XL8	Med.: Bengal	Other*	Change in Acreage from 2003
East Zone:																	
Brazoria	**10,646**	**15,748**	11,862	394	787	787	394	100	0	0	0	300	0	0	0	1,124	47.9%
Chambers	**10,937**	**10,024**	8,442	0	200	1,427	714	2,855	714	0	0	0	0	1,672	0	0	46.5%
Galveston	**781**	**847**	847	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5%
Hardin	**738**	**762**	382	0	0	76	38	152	38	0	0	0	0	76	0	0	3.3%
Jefferson	**15,187**	**19,954**	9,476	0	200	8,979	0	200	0	200	0	0	0	400	399	100	31.4%
Liberty	**7,788**	**10,475**	5,420	0	0	2,363	238	951	627	0	0	0	0	876	0	0	34.5%
Orange	**0**	**90**	0	0	0	0	0	0	0	0	0	0	0	0	90	0	200.0%
East Total	**46,077**	**63,900**	**36,429**	**394**	**1,187**	**13,632**	**1,384**	**4,258**	**1,379**	**200**	**0**	**300**	**0**	**3,024**	**489**	**1,224**	**38.7%**
Northwest Zone:																	
Austin	**1,684**	**2,313**	1,506	0	320	52	0	435	0	0	0	0	0	0	0	0	37.4%
Colorado	**28,572**	**33,273**	20,807	752	1,200	3,017	511	6,662	116	0	0	0	0	208	0	0	16.5%
Harris	**1,664**	**1,522**	79	0	0	0	0	277	472	0	0	0	0	694	0	0	-8.5%
Lavaca	**1,582**	**2,189**	1,673	357	0	0	0	159	0	0	0	0	0	0	0	0	38.4%
Waller	**7,300**	**7,868**	4,608	0	0	0	0	1,927	464	0	0	0	45	371	0	453	7.8%
Wharton	**46,454**	**53,413**	32,868	5,919	2,835	5,210	639	3,648	0	0	800	491	846	157	0	0	15.0%
Northwest Total	**87,256**	**100,578**	**61,541**	**7,028**	**4,355**	**8,279**	**1,150**	**13,108**	**1,052**	**0**	**800**	**491**	**891**	**1,430**	**0**	**453**	**15.3%**
Southwest Zone:																	
Calhoun	**1,897**	**2,488**	2,188	0	0	0	0	0	0	0	100	0	0	100	0	0	31.2%
Fort Bend	**6,525**	**7,933**	6,875	0	0	0	0	941	0	0	0	0	0	117	0	0	21.6%
Jackson	**13,510**	**14,734**	7,073	3,332	331	1,700	36	1,496	48	0	500	36	0	182	0	0	9.1%
Matagorda	**18,884**	**23,672**	11,939	5,416	2,444	300	0	1,712	0	0	1,861	0	0	0	0	0	25.4%
Victoria	**1,247**	**1,356**	1,256	0	0	0	0	100	0	0	0	0	0	0	0	0	8.7%
Southwest Total	**42,063**	**50,183**	**29,331**	**8,748**	**2,775**	**2,000**	**36**	**4,349**	**48**	**0**	**2,461**	**36**	**0**	**399**	**0**	**0**	**19.3%**
Northeast Zone:																	
Bowie	**1,332**	**1,510**	654	0	0	87	0	0	0	0	0	692	0	77	0	0	13.3%
Hopkins	**713**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.0%
Red River	**587**	**639**	639	0	0	0	0	0	0	0	0	0	0	0	0	0	8.9%
Northeast Total	**2,632**	**2,149**	**1,293**	**0**	**0**	**87**	**0**	**0**	**0**	**0**	**0**	**692**	**0**	**77**	**0**	**0**	**-18.4%**
2003 Total Acreage	**178,028**		127,571	17,890	6,586	17,476	1,302	0	0	923	536	938	0	1,149	566	3,091	
2003 Percentage	**100.0%**		71.7%	10.0%	3.7%	9.8%	0.7%	0.0%	0.0%	0.5%	0.3%	0.5%	0.0%	0.6%	0.3%	1.7%	
2004 Total Acreage		**216,810**	128,594	16,170	8,317	23,998	2,570	21,715	2,479	200	3,261	1,519	891	4,930	489	1,677	21.8%
2004 Percentage		**100.0%**	59.31%	7.5%	3.8%	11.1%	1.2%	10.0%	1.1%	0.1%	1.5%	0.6%	0.4%	2.3%	0.2%	0.8%	

Compiled by Dr. Jim Stansel and Regina Tate, Texas A&M University System at Beaumont. Survey data from dryers, sales offices, agribusinesses, USDA/CFSA and County Extension Agents as appropriate.
*Other varieties include: Delmatti, XL7, Milagro, CL121, Sierra, Texmati Type, XP110 & Risotto.

Table 4. Variety information update for 2005 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
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
Jasmine 85 (A)	Late	40	Higher	Lower	Lower

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

Planting Dates

A. D. Klosterboer, F. T. Turner and J. W. Stansel

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 and 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 and F. T. Turner

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.

Variety	Seeding rate (lbs./A) 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 will depend on the germination rate and planting conditions.[a]

		Seeding rate (lbs./A)										
		40	50	60	70	80	90	100	110	120	130	140
Variety	**Seed/lb.[b]**	**Seed/sq ft**										
Ahrent	20,500	19	24	28	33	38	42	47	52	56	61	66
Bolivar	18,500	17	21	25	30	34	38	42	47	51	55	59
CL XL8	23,300	21	27	32	37	43	48	54	59	64	70	75
CL161	19,800	18	23	27	32	36	41	45	50	55	59	64
Cheniere	19,800	18	23	27	32	36	41	45	50	55	59	64
Cocodire	19,200	18	22	26	31	35	40	44	48	53	57	62
Cypress	18,400	17	21	25	30	34	38	42	46	51	55	59
Dixiebelle	20,500	19	24	28	33	38	42	47	52	56	61	66
Earl	16,100	15	18	22	26	30	33	37	41	44	48	52
Francis	21,600	20	25	30	35	40	45	50	55	60	64	69
Gulfmont	16,800	15	19	23	27	31	35	39	42	46	50	54
Jacinto	21,300	20	24	29	34	39	44	49	54	59	64	68
Jefferson	16,200	15	19	22	26	30	33	36	41	45	48	52
Presidio	18,600	17	21	25	30	34	38	42	47	51	55	59
Saber	20,800	19	24	29	33	38	43	48	53	57	62	67
Wells	18,000	17	21	25	29	33	37	41	45	50	54	58
XL7	21,300	20	24	29	34	39	44	49	54	59	64	68
XL8	21,500	20	25	30	35	39	44	49	54	59	64	69
XP 710	19,500	18	22	27	31	36	40	45	49	54	58	63
XP 712	23,000	21	26	32	37	42	48	53	58	63	69	74

[a]100% to 60% of the seed would be expected to emerge depending on % germination and plainting condition.
[b]Seed/lb. values are averages and can vary as much as 10 percent depending on yield and degree of seed processing.

Seeding Methods

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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

A. D. Klosterboer and 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

Description of damage

Blackbirds, primarily the red-winged blackbird, are pests 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 results in planting delays. Late plantings may reduce yields and quality and hinder harvesting operations. Also, late main crop harvest 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.

A study by Texas Agricultural Experiment Station and Texas Cooperative Extension personnel in Matagorda County found this type of damage to the ripening main crop to be insignificant. However, damage to the ripening ratoon crop was 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 suffer more damage.

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

Bird control on emerging rice

- Delay planting until large flocks of birds move north, and try not to plant at a time when your field is the only one in the area that has 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.
- Probably the most effective tactic is early and consistent patrolling of fields using firearms and scare devices.* 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. Once birds establish in a field, they are more difficult to move. Most feeding occurs during the early morning and late afternoon. However, patrol the fields as long as birds are present.
- Use of continuous flood 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

- For the ripening ratoon crop, plant an early-maturing variety so that ratoon crop harvest occurs before flocks increase to damaging numbers. Late plantings increase the chance of bird damage to the ratoon crop.
- Again, habitat management and early, consistent patrolling are most important.
- 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, protecting ripening rice is imperative.

In the fall of 2002, the U.S. EPA 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 currently 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 lbs 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

A. D. Klosterboer and 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

F. T. Turner

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

Fertilizer can profoundly influence rice yield and is a major cost for rice production. Of the three primary nutrients (nitrogen, phosphorus and potassium), nitrogen has the greatest effect on Texas rice yield; 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.

Soil testing to predict fertilizer needs

An accurate soil test gives you confidence in your fertilizer recommendations and helps you develop an economical fertilizer management program.

The rapid and constant changes in soil nitrogen availability make soil testing useless for determining nitrogen rates for rice. Recommended nitrogen rates for each rice variety are determined by nitrogen fertilizer response in research tests. The general nitrogen recommendations are given in Table 8 of this section.

Soil testing is useful for predicting phosphorus, potassium and micronutrient needs for rice and in developing economical fertilizer rates. Accurate fertilizer management calls for a knowledge of 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 months so that test results may be obtained from the soil testing laboratory 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 samples from each uniform field or area and remove a pint as a composite sample.

Send a "control soil" or "reference" sample with your field samples to provide a way 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 phosphorus or less on sandy soils, 10 ppm phosphorus or less on clay soils.
- Apply potassium when the soil test shows 50 ppm potassium or less.

Using this approach to develop your rice fertilizer program for each field helps you take advantage of the fact that fertilizers applied when needed will increase income, but when applied in excessive rates and when 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
Texas A&M Univ. System - Soil & Crop Sciences Dept.
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

Understanding the behavior of plant nutrients in flooded soils is important to establishing plant nutrition efficiency and developing economical fertilizer programs. The interaction of nutrient source, water management, application rate and timing determine the fertilizer efficiency.

Nitrogen

Although rice can use both ammonium and nitrate sources of nitrogen, the nitrate form is unstable under flooded conditions and is lost from the soil by leaching and by 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.

Draining soils for several days can result in the conversion of urea and ammonium sulfate 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.

Phosphorus

Flooding soils (saturating with water) increases the phosphorus availability. Flooding releases native soil phosphorus and increases phosphorus mobility. Flooding results in a soil pH change toward neutral, which converts unavailable phosphorus to the more available form. Phosphorus fertilizer will usually increase yields on clay soils testing below 10 ppm phosphorus and on sandy soils testing less than 15 ppm phosphorus.

Potassium

Potassium, unlike phosphorus, 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; and
- 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); and
- 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 foliar sprays.

Soil and plant additives

Soil additives, foliar-applied 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 $^1/_3$ of nitrogen and all phosphorus and potassium applied preplant, or by the three-leaf growth stage, $^1/_3$ 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 planting date, variety grown, water management, location and soil conditions. See location and variety adjustment in Table 8.

Yield potential of the semidwarf plant types is decreased each day they exhibit nitrogen deficiency (yellowing); therefore, do not delay nitrogen topdressing when plants become nitrogen-deficient.

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 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 an excessive amount of 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; and
- 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.

Timing fertilizer applications 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 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 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, nitrogen applications made after flood establishment should be less than 60 pounds nitrogen per acre. This limitation may influence the number of nitrogen applications.

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

Fertilization management for main and ratoon crop Jefferson planted April 1

Nitrogen fertilizer management for Jefferson will be similar to fertilizer management for Lemont and Gulfmont but adjusted for the following conditions.

A uniform and recommended plant population of 20 to 25 Jefferson seedlings per square foot with good water management will require a minimum of 150 pounds nitrogen per acre in sandy loam and 170 pounds nitrogen per acre on clayey soils on the main crop.

Apply about 33 percent of the nitrogen preplant, 33 percent on dry soil just before flooding and the remaining nitrogen at PD or earlier if needed. When ratoon yield potential is high, 100 pounds nitrogen per acre is recommended. Applying 20 to 40 pounds nitrogen per acre near main crop heading and the remainder just before ratoon flood optimizes ratoon yields.

Adjust the recommended nitrogen rates and timing for specific conditions:

- Increase main-crop early nitrogen applications (and total nitrogen) 20 to 30 pounds per acre when plant populations are less than the optimum 20 to 25 seedlings per square foot to increase tillering and ensure canopy closure by heading stage.
- Be aware that Jefferson, like Gulfmont, has broad dark green leaves compared to Cypress, so don't base topdress nitrogen rate solely on leaf color. Vegetative cover can also be used as an indicator of the need to topdress N, with the goal of achieving 95 percent canopy closure by heading. Also using the chlorophyll meter to help maintain a reading of 41 to 42 at PD stage will identify the need for topdress nitrogen.
- Low seedling rates (plant populations of 15 or fewer seedlings per square foot) and low initial nitrogen rates prevent excessive vegetation and suppress sheath blight in Cypress without restricting yield. However, these practices are not recommended for Jefferson because excessive vegetation in Jefferson is generally not likely unless plant population exceeds 30 plants per square foot. Also, Jefferson has some sheath blight tolerance.

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

Variety	Western rice belt[a] fine (clayey)	Western rice belt[a] coarse (sandy)	Eastern rice belt fine (clayey)	Eastern rice belt coarse (sandy)
Long grain				
Bolivar	170	150	170	150
Cypress[b]	170	150	170	150
Cheniere	170	150	170	150
CL161	170	150	170	150
Cocodrie	170	150	170	150
Dellmont	170	150	170	150
Dellrose	170	150	170	150
Dixiebelle	170	150	170	150
Gulfmont	170	150	170	150
Jefferson	170	150	170	150
Lemont	170	150	170	150
Madison	170	150	170	150
Presidio	170	150	170	150
Saber	170	150	170	150
Francis	160	140	160	140
Drew	150	130	150	130
Wells	150	130	150	130
Jasmine 85	150	130	150	130
Della	100	80	110	100
Hybrid rice[c]				
XL7	180	150	180	150
XL8	180	150	180	150
CL XL8	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.

Maximizing benefits of preplant, preflood and panicle differentiation (PD) 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 preflooding application. High weed populations may make a postemergence nitrogen application more economical than a broadcast preplant application by not stimulating 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 into the root zone away from air — 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.)

Panicle differentiation (PD) application

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

Using chlorophyll meter to determine topdressing needs

Because the green color of rice plants as detected by the human eye varies with the time of day and cloudiness, 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 show (see Fig. 1) 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 not likely to benefit from nitrogen topdressings. Fields having lower chlorophyll values will benefit from topdressing nitrogen (see figure below).

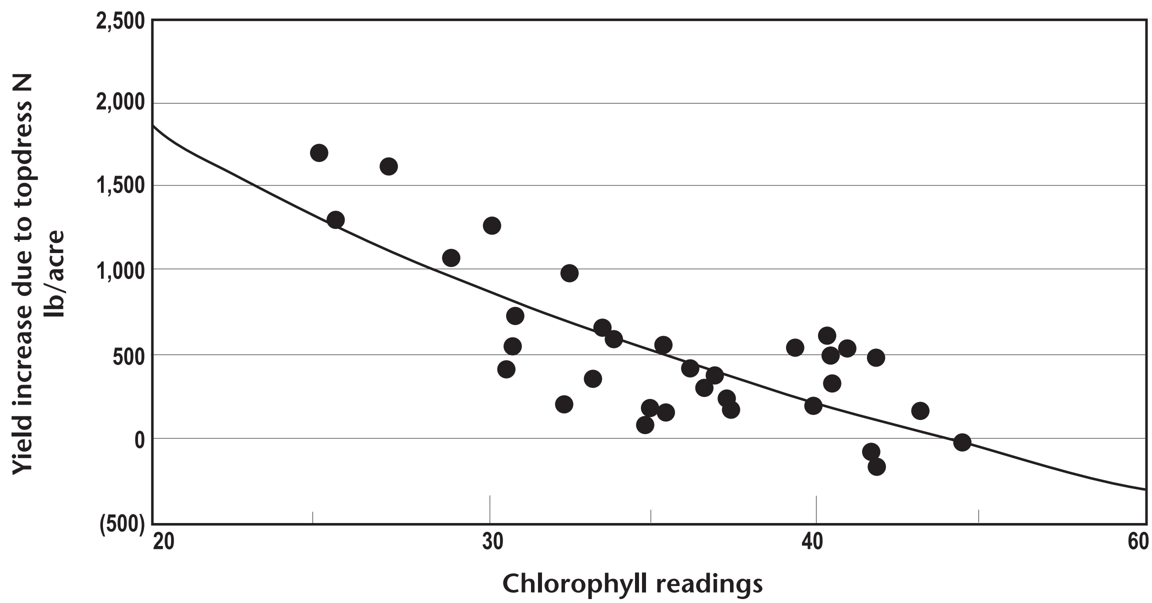


Figure 1. Relationship between yield increase and chlorophyll readings.

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

Another factor influencing 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, position of leaf on plant and location on leaf where reading is taken. It also is important to keep in mind that cool weather as well as deficiencies of phosphorus, zinc and iron may influence chlorophyll readings.

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

Variety	Chlorophyll reading
Gulmont, Jefferson and Francis	41–42
Lemont, Dixiebelle and Priscilla	39–40
Cocodrie, Saber and CL161	38–39
Cypress	37–38

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 lbs. 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 lbs. 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 lbs. 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 lbs. 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 lbs a.i./acres

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 lbs. 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 lbs. 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 lbs. 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 lbs. 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 lbs. a.i./acre + COC

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

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

Duet® 2-4 qts./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 lbs. 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 lbs 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® 0.0625-0.07198 lbs a.i./acre + COC

Strengths:
- Residual control for some weeds
- Broad spectrum weed control
- Excellent control of alligatorweed

Weakness:
- Cannot be tankmixed with Propanil

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 lbs 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 lbs. 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 lbs + 0.025-0.05 lbs 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 lbs. 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 lbs. 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 lbs. 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 lbs. 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

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 pints 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 lbs a.i./acre + surfactant

Strengths:
- Very economical
- Good control of broadleaf weeds

Weaknesses:
- Timing of application critical
- No residual control

Ordram® 15G 2.0-3.0 lbs 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 lbs. 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 lbs. a.i./acre + COC

Strengths:
- Control 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
- $^2/_3$ of red rice must be exposed at application

Table 10. 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	F	G	P	F	G	G	G	P	G	F	G	G	P	G	E
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
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

Metering Ordram® 8EC in the Floodwater

A. D. Klosterboer

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 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.

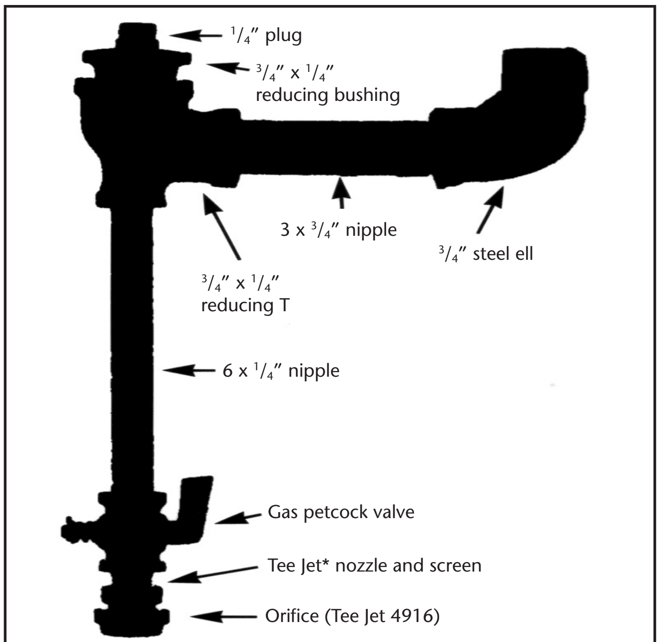


Figure 2. A metering device or spigot used to apply the Ordram® 8EC at the point where the water enters the field. *Not an endorsement for this specific product; other similar products also are suitable.

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).

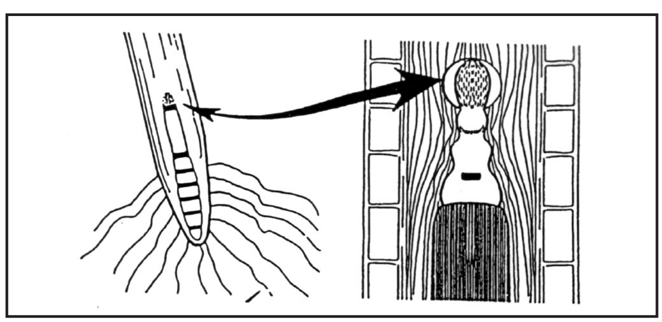


Figure 3. Panicle differentiation (PD).

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 3/4-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.

Table 11. 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%

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.

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.

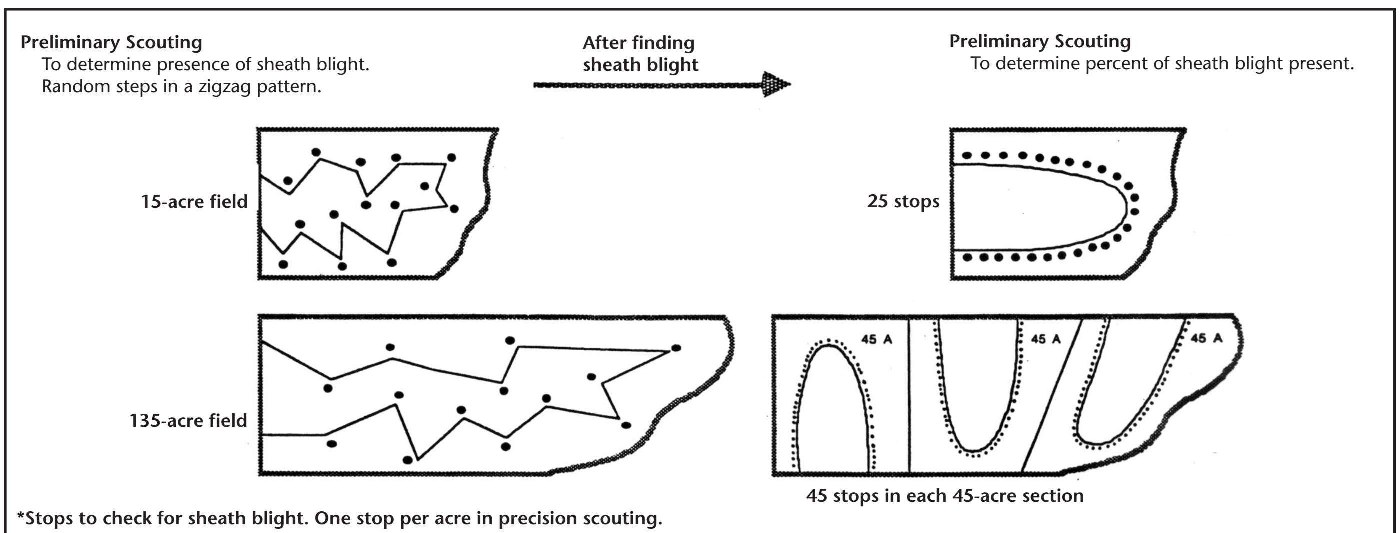


Figure 4. Suggested scouting procedure for sheath blight.

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.*

Table 12. 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.

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.

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 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 $^1/_2$-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 indi-

Table 13. 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.

cates 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

Management practices and cultural control

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. 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 survival of the larvae.

One method of suppressing an infestation is to drain the field and allow the soil to dry during larval development. However, soil must dry until it cracks before larval mortality occurs. Also, in general, applying the permanent flood early relative to rice emergence can increase the severity of rice water weevil damage.

Fall armyworm and chinch bug populations could be much more damaging in the absence of 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 stalkborers. Rice planted early or late in relation to the emergence of adult rice water weevils is likely to escape heavy infestation. 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 predispose rice to less 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 weevil, but also because certain varieties show some resistance to rice water weevil, rice stink bug and stem borer feeding. 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 rice heads develop. Thus, sound weed control can delay or reduce rice stink bug infestation in rice fields.

Rice stand has a major impact on rice water weevil populations. In general, thinner stands are associated with higher densities of rice water weevil and more damage. Thin rice stands result in more weeds, including grasses, which can harbor high populations of rice stink bug. Thin stands also are susceptible to chinch bug, fall armyworm and rice whorl maggot damage. Thus, to discourage insect problems, growers should employ production practices that ensure strong, uniform stands.

These production practices include:

- Preparing a good seedbed;
- Planting high quality seed at the proper depth, time and rate;
- Eliminating early weed competition; and
- 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. 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, can cause foliar burn.

Recent insecticide regulatory actions

Be aware that granular carbofuron (Furadan® 3G) cannot be applied on rice. The U.S. Environmental Protection Agency 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. Environmental Protection Agency for control of rice water weevil, fall armyworm, chinch bug, rice stink bug, grasshoppers, leafhoppers, selected aphid species and stalk borers. For the 2004 growing season, Karate® will be replaced by Karate® Z, which is more concentrated (2.08 versus 1.0 lb. A.I./gal.), less susceptible to breakdown by sunlight, safer for handlers and more rainfast than Karate®.

Texas data show Karate® Z to be as, if not more, effective as Karate® (for more information see "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. Environmental Protection Agency for control of rice water weevil, chinch bug and stem borers.

Texas data show that Icon™ 6.2FS, when applied as a seed treatment, provides excellent control of rice water weevil and chinch bug. Texas data 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 rice fields to be pinpoint flooded and planted with Icon™ 6.2FS-treated, pregerminated seed 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 seed is dripping wet. Wait until seed is drier to ensure maximum effectiveness of the insecticide.

In addition, Texas studies indicate that water seeding Icon™ 6.2FS-treated seed immediately after application of insecticide may reduce efficacy of the seed treatment. Give the treatment time to adsorb to seed before water seeding (for more information, see "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 weevil, fall armyworm, chinch bug, rice stink bug, 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 the zeta-cypermethrin in Fury®. Therefore, for equivalent control, less zeta-cypermethrin is applied when using Mustang MAX™ compared to Fury®. Clearly, this technology is better for the environment.

For more information, see "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. Environmental Protection Agency approved the use of Dimilin® 2L for rice water weevil control. 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 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. Environmental Protection Agency 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 "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

These $^1/_8$-inch-long, brown beetles 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.

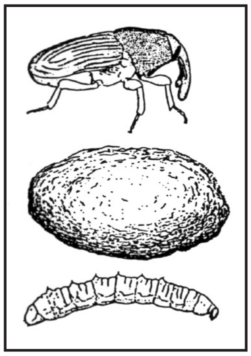


Figure 6. Rice water weevil life stages: adult, $^1/_8$ inch long (top); pupal cell, $^1/_3$ inch long; and larva, $^1/_3$ inch long (bottom).

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

Root maggots are aquatic, requiring saturated soils to survive, and feed on the roots of young plants. They are white and grow to nearly $^1/_3$ inch long just before pupating inside mud cells attached to the 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 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 yield of the ratoon crop.

In general, if rice in a field harbors an average of one larva per plant then yield losses of about 80 and 20 pounds per acre for the main and ratoon crops, respectively, can be expected. This relationship is linear, which means 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.

Data indicate that rice water weevil feeding does not affect milling quality.

Sampling for larvae

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

The core sample containing plants and soil is placed in the bucket, which is submerged so that it is partially filled with water. The sample is washed 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 they are counted.

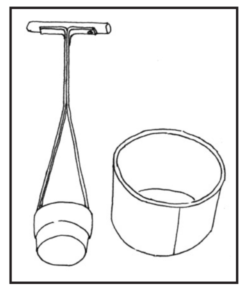
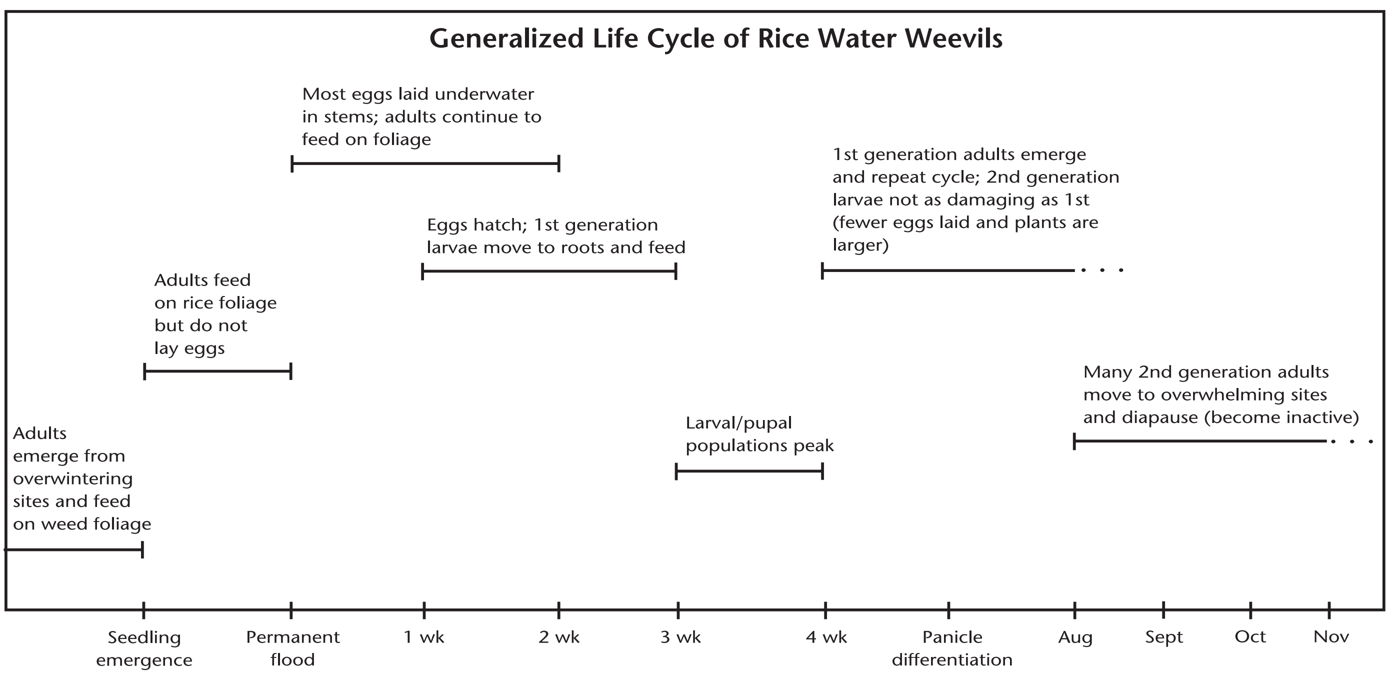


Figure 7. Core sampler and screen bucket.



Time line not to scale.

Figure 5. Rice water weevil occurrence during rice production in Texas.

Samples should be taken 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.** Currently registered rice water weevil insecticides are applied as seed treatments or close to the time of the permanent flood.

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 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, reducing the probability of producing a ratoon crop.

In general, delaying application of the permanent flood can reduce rice water weevil populations and damage. 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 2000-2004 show that rice water weevils develop varying population densities on different rice varieties. Table 14 lists selected varieties in order of their relative susceptibility to rice water weevil.

Table 14. 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		✓	
Dixiebelle		✓	
Gulfmont		✓	
Pirogue		✓	
Wells		✓	
CL XL8			✓
Jefferson			✓
Lemont			✓
Priscilla			✓
XL8			✓
XP 723			✓

Table 15. Insecticides for rice water weevil control.

Active ingredient/product	Rate per acre		Timing of applications
	Active ingredient	Product	
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.

Table 15. IInsecticides for rice water weevil control (continued).

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.
- 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 organi 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 prior to harvest.
- Do not plant leafy vegetables within 1 month following planting of treated rice seed.
- Do not plant root crops within 5 months following planting of treated rice seed.
- Do not plant small grains, other than rice, within 12 months following 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 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. Turn the insect on its back to see the long, strawlike mouthparts usually held between its legs.

Adults overwinter and can move into fields upon emergence of rice. Females lay elongate orange eggs about $^1/_{16}$ inch long on rice stems, between leaf sheaths and stems, and in soil. In the spring, eggs typically hatch in about 12 days.

First-instar nymphs are orange and about $^1/_{16}$ inch long. Five instars 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 damage include striping, stippling, and yellowing of leaves. Severely affected seedlings turn brown and die. Inspect 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, reduction in height, and delay in maturity of surviving plants. If populations on seedling rice approach an average of one adult per two plants, quick control is suggested.

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 regarding the relationship between chinch bug densities and damage to older rice.

Table 16. **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	$1^1/_4$ – $1^7/_8$ lb	
Sevin® 80S	1.0–1.5 lb	$1^1/_4$ – $1^7/_8$ lb	
Sevin® XLR	1.0–1.5 lb	1–$1^1/_2$ qt	
Sevin® 4F	1.0–1.5 lb	1–$1^1/_2$ 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.

Fall armyworm (*Spodoptera frugiperda*)

Identification, biology and damage

All life stages of the fall armyworm can survive along the Gulf Coast during winter months 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 move into rice from adjoining areas. Caterpillars or larvae are light tan to greenish or brownish and are about $1^1/_2$ inches long when fully grown. They have three yellowish-white, hair-like 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

Table 16. Insecticides for chinch bug control (continued).

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 lbs. 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 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.
- 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 Texas Agricultural Experiment Station at 409.752.2741.

pounds per acre. Many producers detect infestations of partially grown larvae by observing cattle egrets in the field or by observing larvae adhering to rubber boots when walking through fields during morning hours.

When an infestation is detected, the field can be flooded to force larvae up onto 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

Caterpillars attacking rice seedlings before flooding can reduce stands. Yield reductions can occur when defoliation is greater than 25 percent 2 or 3 weeks before heading.

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 17. Insecticides for fall armyworm control.

Active ingredient/product	Rate per acre: Active ingredient	Rate per acre: Product	Timing of applications
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	$1^1/_4$ – $1^7/_8$ lb	
Sevin® 80S	1.0–1.5 lb	$1^1/_4$ – $1^7/_8$ lb	
Sevin® XLR	1.0–1.5 lb	1–$1^1/_2$ qt	
Sevin® 4F	1.0–1.5 lb	1–$1^1/_2$ 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 lbs. 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

- 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 larger (1 1/4 to 1 1/2 inches long), light brown to yellowish grasshopper with two black bands on the inside of each jumping leg can be more serious. This species is called the differential grasshopper, *Melanopsis differentialis*. It 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, 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 18. Insecticides for grasshopper control.

Active ingredient/product	Rate per acre: Active ingredient	Rate per acre: Product	Timing of applications
carbaryl			Generally, grasshoppers do not cause economic damage, apply when defoliation or stem and panicle damage is excessive.
Sevin® 50W	1.0–1.5 lb	2–3 lb	
Sevin® 80WSP	1.0–1.5 lb	1 1/4 – 1 7/8 lb	
Sevin® 80S	1.0–1.5 lb	1 1/4 – 1 7/8 lb	
Sevin® XLR	1.0–1.5 lb	1–1 1/2 qt	
Sevin® 4F	1.0–1.5 lb	1–1 1/2 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 lbs. 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 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 spring, the straw-colored, 3/8- to 1/2-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 in the process of producing seed.

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

As 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 percent "peck" has also been correlated with reduced head yield and increased percent of broken kernels in milled rice.

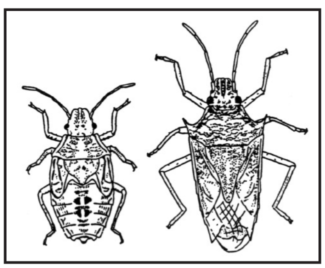


Figure 8. Rice stink bug, nymph and adult.

The percent "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 rice stink bug damage called "peck."

Sampling techniques and economic thresholds

Because single applications of labeled pesticides (carbaryl, lambda-cyhalothrin, gamma-cyhalothrin, zeta-cypermethrin, malathion or methyl parathion) do not have enough residual activity to protect the kernels during their entire development, preventive treatments are usually not justified and their cost can be prohibitive except for seed crop production. Rice fields should be scouted from heading to dough and insecticides applied 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 the use of a 15-inch-diameter insect sweep net. When 50 percent of the panicles have emerged (headed), sample fields weekly or twice a week until harvest.

Rice stink bugs are most active and abundant on rice heads in the early morning or late evening. These are the best times for sampling (sample when foliage is not wet from dew).

Make 10 consecutive (180-degree) sweeps while walking through the field. 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 mid-day.

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 fields with a standard 15-inch-diameter heavy-duty sweep net. Ten-sweep samples are made in at least 10 randomly selected sites within the field, and the average number of adult rice stink bugs per 10-sweep sample is determined. 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 19 (A, B or C). The milk stage occurs about 15 days after heading.
3. Estimate your expected yield (4,500, 6,000 or 7,500 pounds per acre) and find appropriate columns in Table 19.
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/cwt (moderate price situation); or

- Rough rice selling for $11.00/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 19 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.

Table 19. 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								
		4500 lb/A			6000 lb/A			7500 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								
		4500 lb/A			6000 lb/A			7500 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								
		4500 lb/A			6000 lb/A			7500 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 20. 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	$1^1/_4$ – $1^7/_8$ lb	
Sevin® 80S	1.0–1.5 lb	$1^1/_4$ – $1^7/_8$ lb	
Sevin® XLR	1.0–1.5 lb	1–$1^1/_2$ qt	
Sevin® 4F	1.0–1.5 lb	1–$1^1/_2$ 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	$^1/_2$ – 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 lbs. 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 Texas Agricultural Experiment Station at 409.752.2741.

Under similar conditions, except for a 4,500-pound yield expectation, 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/cwt), 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.

These threshold levels should be considered only as 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 decreases.

Insecticidal management

No resistance to carbaryl, lambda-cyhalothrin, gamma-cyhalothrin, zeta-cypermethrin or methyl parathion has been documented. 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 knock-down, 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 hours. 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.

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 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, larvae move to the protected areas between leaf sheaths and culms. Eventually, larvae bore into 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.

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

Icon™ 6.2FS is registered for stalk borers in Texas. The recommended rate of the seed treatment is 0.025 - 0.05 lb. (A.I.)/acre. Recent Texas data indicate that this treatment is partially effective. Karate®Z also is registered for stalk borers at the rate of 0.03 lb a.i./acre. Apply Karate®Z at 1-2 inch panicle and/or late boot/early heading. Two applications are more effective than one.

Data collected from 2000-2004 at Ganado, Texas, show that stem borers (sugarcane borer and Mexican rice borer) cause varying damage to rice depending on variety. Table 21 lists selected varieties and their relative susceptibility to stalk borers.

Table 21. 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		✓	
Wells		✓	
CL XL8			✓
XL7			✓
XL8			✓
XP 723			✓

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 lb. A.I. 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.

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 0.0125-0.02 lb. A.I. per acre, respectively.

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, gnat-like 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. 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, larvae will exit tubes and swim to the surface in a whip-like fashion similar to mosquito larvae.

Midge larvae 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).

Rice seed midge problems can be controlled by dry-seeding followed by 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, increasing the seeding rate and planting sprouted seed immediately after flooding will help reduce rice seed midge problems.

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 lb. A.I. 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 in an effort to obtain Texas data on insecticidal control of rice seed midges.

Aphids

Recently, several species of aphids have been observed causing damage to Texas rice. Aphids are small, soft-bodied insects with piercing-sucking mouthparts. The adults hold their wings roof-like over their bodies.

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

Aphids suck the juices out of rice and cause stunting and chlorosis. Young rice is particularly vulnerable; stand reductions can occur under severe aphid pressure. Specifically, the following aphids have been observed attacking 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 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 rice foliage is sticky and shiny, inspect foliage for aphids, which excrete "honeydew." This excretion is sweet and attracts ants. Thus, ants crawling on rice foliage is another indication of the presence of aphids.

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

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

Karate®Z, Mustang MAX™ and Prolex™ are labeled for certain aphid species at the same rates applied for rice water weevil control (see "Insecticides for Rice Water Weevil Control" table). Icon® 6.2FS seed treatment is not very effective against aphids and 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; and
- Reducing early-season stress caused by inadequate soil moisture, herbicide injury, damage from other pest insects and diseases, and nutrient imbalances.

Rice whorl maggot (*Hydrellia* sp.)

During the past 2 years, rice whorl maggot and associated injury have been observed in Texas and Louisiana rice. The adult of this insect is a small, gray fly that lays single eggs on rice foliage. Eggs hatch, and larvae rasp and feed on developing foliage before leaves unfurl. The larvae feed within leaves, resulting in mines and lesions. Once leaves unfurl, signs of damage are easily observed. Relatively wide, white elongated mines or lesions (similar to adult rice water weevil feeding scars, but wider) parallel to the leaf venation are evident. Frequently, this causes the distal portion of leaves to break off or "hang by a thread", giving the affected rice plants a ragged, tattered appearance.

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 ext. 2231).

Channeled apple snail (*Pomacea canaliculata*)

These invertebrates recently were found 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 3-4 inches), globular and banded with brown, black and yellowish-tan patterns of coloration. The snails feed on many types of vegetation but prefer to feed on succulent, submerged plants. Snails in Texas rice fields have been observed feeding on alligator weed and duck salad. Egg masses are cylindrical, pink or red and typically observed above the waterline on rice plants, weeds or man-made structures. To date, snail damage to rice in Texas has not been documented, possibly due to the practice of delayed flooding in Texas. Be on the look-out for this potential pest and report any sightings to Mo Way (409.752.2741 ext. 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
- Rice skipper, leaf roller, *Anycyloxrpha numitor*
- Least skipper, *Ancyloxypha numitor*

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 flood water mosquitoes.

Females of these species lay their eggs on moist soil that floods periodically. Eggs are resistant to 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 adults, generally reaching 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, area-wide 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 a prevent or control mosquitoes in rice fields, other than to:

- Ensure that 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 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; and
- 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 applied before drying. Nor will they eliminate existing pest populations. Even distribution of the protectant throughout the grain mass is essential. After binning is completed, level the bin.

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

Monitor for insect populations throughout the storage period by using grain probes, pitfall traps, pheromone traps or other useful methods. Monitoring makes it possible 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 (bu. or cwt.) 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 purchase 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 $^1/_4$ 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 $^1/_8$ 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.

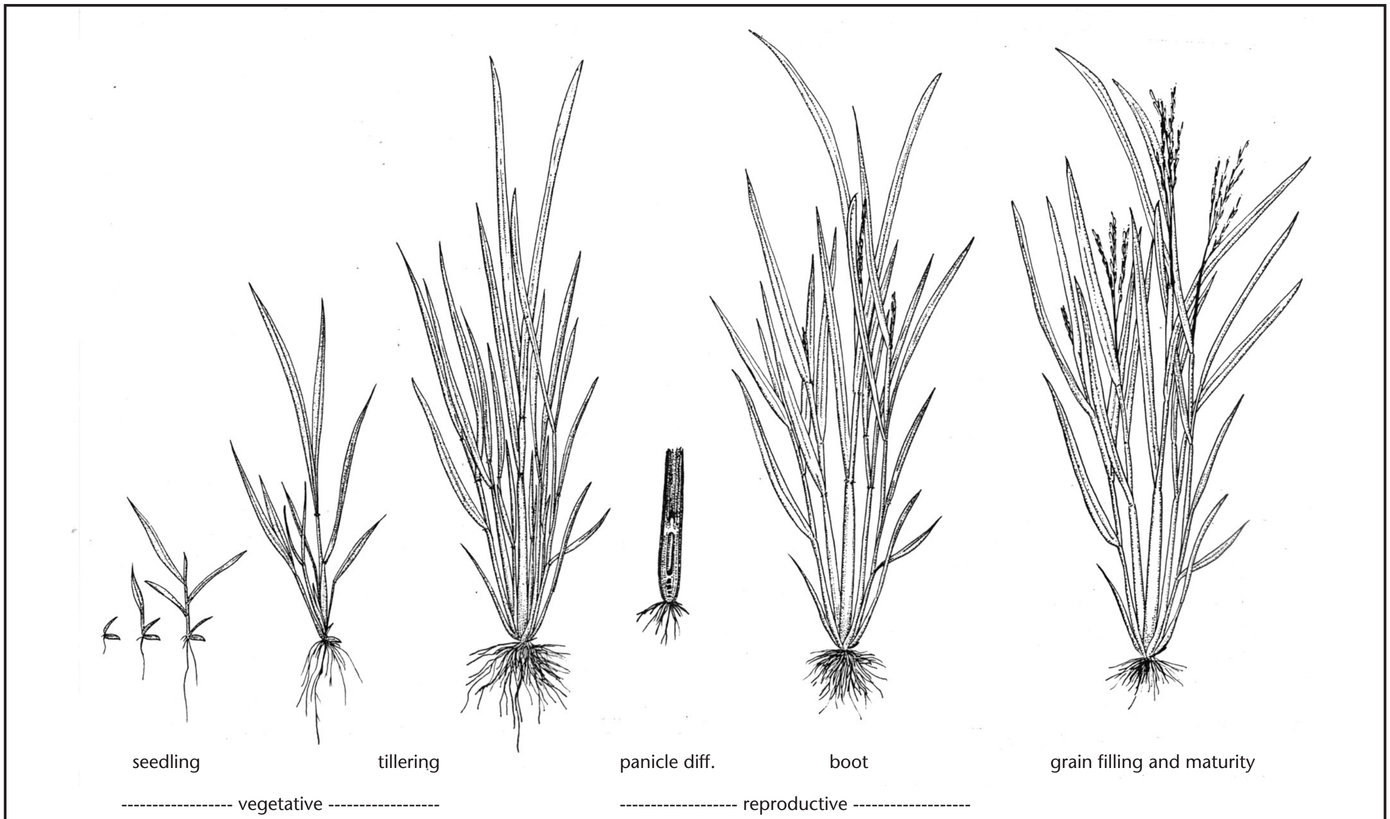


Figure 9. Rice plant development.

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 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

A. D. Klosterboer and 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 22. 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

A. D. Klosterboer and 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; and
- 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 23). 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 $1^1/_2$ 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 $^1/_2$ 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

F. T. Turner and G. N. McCauley

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 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.

Table 23. 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

Gibberellic Acid Treatment to Improve Ratoon Stand

L. Tarpley

Two years of study have indicated that ratoon yield can be increased significantly by about 500 pounds per acre when a gibberellic acid treatment is applied to the main crop at a rate of 3 to 5 grams of active ingredient (a.i.) per acre starting several days after peak flowering. This treatment appears to act by enhancing early growth of the ratoon tillers and possibly by enhancing ratoon tiller initiation.

Although later applications up to main crop harvest have no known negative effect, the benefit of later applications diminishes. Applications earlier in development do not appear to be beneficial, but neither do they appear to harm the main crop except if applied during active stem elongation. A gibberellic acid treatment can enhance active stem elongation, thus increasing plant height and lodging potential.

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

J. M. Chandler, F. T. Turner, G. N. McCauley, J. W. Stansel, J. P. Krausz and M. O Way

Table 24 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 24. 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

Economic Impact of the Texas Rice Industry

D. P. Anderson, G. K. Evans and J. L. Outlaw

Although rice acres in Texas have declined over time, rice remains an important part of the agricultural and overall economy in Texas. A study was conducted on the economic impact of the industry on the Texas state economy from 1998 to 2001.

In the study, a model of the Texas rice industry was developed using the IMPLAN model with USDA and Census Bureau data. IMPLAN is an input-output model widely used to estimate the effect of changes in an economic area.

The study found that average value of the Texas rice crop was estimated to be $255.3 million annually from 1998-2001 (Table 25). Average agricultural value is used to mitigate the effect of large fluctuations in agricultural production and prices that are not present in other industries. Rice crop value includes contributions from federal government agricultural program payments.

The rice production sector's direct contribution to the state's gross state product (GSP) is estimated to be $114.9 million. This figure reflects gross revenue less the cost of goods sold. Because it is the direct contribution, it represents that gross state product directly attributable to rice production.

The rice production sector's total contribution to GSP is $234.4 million. That includes direct and indirect contributions to GSP. *The total contribution to GSP can be thought of as the value added to the economy by rice production in Texas.* The indirect contribution includes value produced in other economic sectors because of the rice industry in Texas.

Total output is the total direct, indirect and induced impact of the rice production sector on the economy. It totals $456.1 million. This figure differs from the contribution to GSP because it represents total output; contribution to GSP indicates value added (it might be thought of as a gross impact versus a net impact concept).

Economic impact studies of this type include the industry in question and all of the inputs to that industry. The Texas rice industry has a rice milling industry that must also be considered. The total contribution of the milling industry to Texas' gross state product was estimated to be $256 million. The milling industry directly contributes $43.6 million in value added (less cost of goods sold which includes the value of the rice purchased) to the economy.

Total output for milling is the total direct, indirect and induced impact of the rice milling sector on the economy. It totals $742.0 million. By definition, the milling industry's output value includes the rice it bought from Texas producers and therefore includes the value of the rice production.

These estimates do not include the economic impact of the wholesale and retail distribution system. No data to estimate these figures are available. In 1993, however, that value was estimated to be an additional $100 million.

In terms of total contribution to GSP, the rice production sector is the ninth largest agricultural commodity in the state. This study does not include the impact of related economic enterprises like hunting. Even though acreage has declined, the contribution of the rice industry to the Texas economy remains substantial.

Table 25. The annual economic impact of the Texas rice industry on the Texas economy (data from 1998-2001).

	Value of output ($ Mil)	Total output ($ Mil)	Employment	Direct contribution to GSP ($ Mil)	Total contribution to GSP ($ Mil)
Rice production	255.3	456.1	8,136	114.9	234.4
Rice milling	370.4	742.0	3,465	43.6	256.0
Total	na*	na*	11,601	158.5	490.4

*To avoid double counting, do not total these columns. The major input to the milling industry is the rice. As a cost of good sold to the milling industry, it is excluded from the value-added GSP calculation.

Rice Production Economics and Marketing

L. L. Falconer, R. L. Jahn and D. P. Anderson

The average costs of rice production in Texas are higher than in most of the other major rice-producing states. In spite of higher costs, Texas producers have been able to remain viable because their average rice yields are equal to or above the U.S. average and the averages of other states in the Southeast (See 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 since 1987 for the major rice-producing states. It's important to note that Texas acreage increased to 217,000 acres in 2004. The increase was in large part due to higher rice prices.

To reduce unit cost of production, producers should study the production recommendations in these guidelines very carefully.

Costs of production estimates for the 2005 crop

The planning budgets shown in Tables 26 and 27 were developed with input from producers and custom service and product suppliers, Texas Cooperative Extension (TCE) specialists and TCE agents. These budgets are based on projections for input and output prices for the 2005 crop year. These budgets are intended to represent the cost structure for a hypothetical 450-acre rice operation on land that requires 18-20 levees per 100 acres. The budget scenario represents a high-yield, high-input conventional tillage production system with heavy pest pressure. Main and ratoon crop budgets have been separated, and all general and administrative costs, crop insurance, consulting, land and vehicle charges have been assigned to the main crop.

Annual usage rates for tractors are projected at 600 hours, with capital recovery factors calculated over a 14-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. Fixed costs shown in the budget represent the cost of owning machinery and equipment and are the annualized capital recovery costs 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 incudes a base fertilizer application, one pre-flood application and two top-dress applications. The total main crop fertilizer application is comprised of 215 units of N, 33 units of P and 28 units of K. The budgeted main crop herbicide program includes an initial ground-applied treatment of clomazone and an aerial application of a general tank-mix over the total planted acreage to control sedges, grasses and broad-leaf weeds, along with a follow-up aerial application over one-half the planted acres to control escaped weeds. The budgeted pesticide program for the main crop includes one fungicide application to control foliar diseases, a pyrethroids application to control water weevils, and three applications 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 2005.

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

The budgeted irrigation program for the ratoon crop includes 0.71 hours per acre of labor for one flush, flood maintenance and draining. Total ratoon crop water usage is budgeted at 1.9 acre-feet; with water charges based on projected LCRA Lakeside Irrigation System rates for 2005.

No counter-cyclical or direct payments for USDA are included in these budgets. The breakeven price level needed to cover the budget's direct expenses for the main crop is $9.94 per cwt. The breakeven price level needed to cover the budget's total specified expenses for the main crop is $10.97 per cwt. The breakeven price level needed to cover the budget's direct expenses for the ratoon crop is $7.76 per cwt. The breakeven price level needed to cover the budget's total specified expenses for the ratoon crop is $8.88 per cwt.

An enterprise budget is a statement of what is expected if particular production practices are used to produce a specified amount of product and is based on the economic and technological relationships between inputs and outputs. The scenario shown in Tables 26 and 27 represent a general guide and is not intended to predict the costs and returns from any particular farm's operation. For more details related to these budgets, contact your local county Extension office or go to the Extension budget Web site maintained by the Texas A&M University Department of Agricultural Economics at agecoext.tamu./budgets/list.htm.

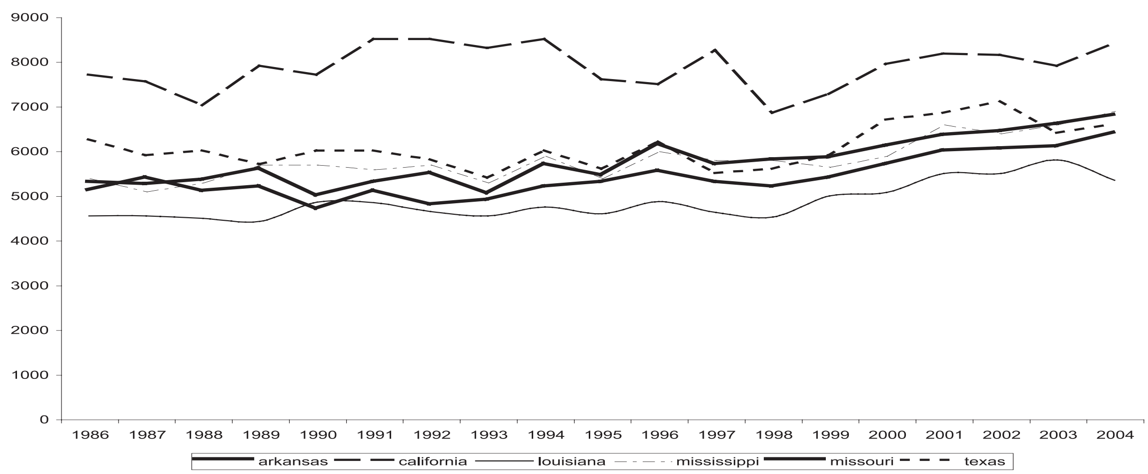


Figure 10. Average rice yields (lb/A), 1986-2004.

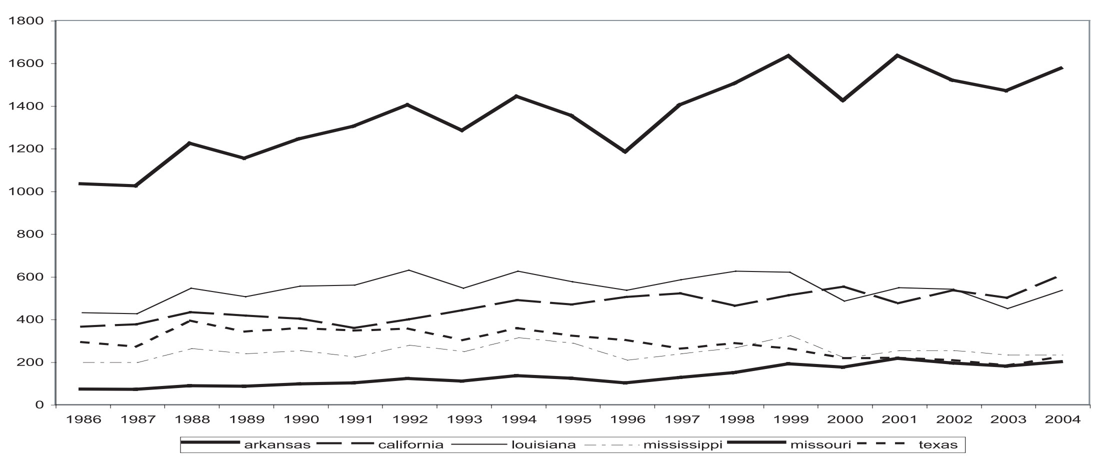


Figure 11. Total area (1,000 A) planted to rice, 1987-2004.

Table 26. 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	2.00	66.0000	132.00	________
Total Income				587.40	________
Direct expenses					
Adjuvants	acre	7.00	1.0000	7.00	________
Custom fertilize	acre	21.25	1.0000	21.25	________
Custom spray	acre	36.13	1.0000	36.13	________
Fertilizers	acre	88.24	1.0000	88.24	________
Fungicides	acre	26.34	1.0000	26.34	________
Herbicides	acre	60.67	1.0000	60.67	________
Insecticides	acre	14.38	1.0000	14.38	________
Irrigation supplies	acre	9.25	1.0000	9.25	________
Seed	acre	24.30	1.0000	24.30	________
Survey levees	hour	4.00	0.3500	4.00	________
Crop insurance—rice	hour	6.75	0.7100	6.75	________
Irrigation	gal	78.71	2.7795	78.71	________
Checkoff/commission	acre	10.56	1.0000	10.56	________
Drying—rice	acre	2.80	1.0000	83.45	________
Rice hauling	acre	83.45	1.0000	83.45	________
Storage—rice	acre	21.12	1.0000	21.12	________
Service fees	acre	20.00	1.0000	20.00	________
Vehicles	acre	12.00	1.0000	12.00	________
Operator labor	hour	10.75	1.3603	14.66	________
Rice water labor	hour	10.75	1.5700	16.87	________
Diesel fuel	gal	1.35	12.6673	17.09	________
Repair and maintenance	acre	32.73	1.0000	32.73	________
Interest on op. cap.	acre	29.34	1.0000	29.34	________
Total Direct Expenses				656.08	________
Returns above direct expenses				-68.68	________
Total Fixed Expenses				68.08	________
Total Specified Expenses				724.16	________
Returns Above Total Specified Expenses				-136.76	________
Residual Items					
Rice land charge	acre	75.00	1.0000	75.00	________
G&A overhead	acre	10.50	1.0000	10.50	________
Management charge	%	587.40	1.0000	29.37	
Residual Returns				–251.63	________

Note: Cost of production estimates are based on 18-20 levees per 100 acre. 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 27. 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—Ratoon crop loan	CWT	6.90	16.0000	110.40	
Rice—Ratoon crop prem.	CWT	2.00	16.0000	32.00	________
Total Income				142.40	________
Direct expenses					
Custom fertilizer	acre	5.25	1.0000	5.25	________
Custom spray	acre	5.75	1.0000	5.75	________
Fertilizers	acre	21.38	1.0000	21.38	________
Insecticides	acre	3.48	1.0000	3.48	________
Irrigation	acre	25.58	1.0000	25.58	________
Checkoff/commission	acre	2.56	1.0000	2.56	________
Drying—Rice	acre	21.21	1.0000	21.21	________
Rice hauling	acre	5.40	1.0000	5.40	________
Storage—Rice	acre	5.12	1.0000	5.12	________
Operator labor	hour	10.75	0.3500	3.77	________
Rice water labor	hour	10.75	0.7100	7.64	________
Diesel fuel	gal	1.35	2.7795	3.75	________
Repair and maintenance	acre	10.43	1.0000	10.43	________
Interest on op. cap.	acre	2.80	1.0000	2.80	________
Total Direct Expenses				124.12	________
Returns above direct expenses				18.28	________
Total Fixed Expenses				17.96	________
Total Specified Expenses				142.08	________
Returns Above Total Specified Expenses				0.32	________
Residual Items					
Management Charge	%	142.40	0.0500	7.12	________
Residual Returns				–6.80	________

Note: Cost of production estimates are based on 18-20 levees per 100 acre. 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.

2005 Agricultural Policy Outlook

J. L. Outlaw and D. P. Anderson

For a non-farm bill year, 2005 is expected to be an interesting year for agricultural policy in the United States. The current (2002) farm bill doesn't expire until the end of 2007, so what is going on? It is common knowledge that after the election the President and the Congress are going to turn their attention to controlling the growing federal budget deficit. The agricultural committee and appropriations staff have indicated in public statements that no program is likely to be spared. Even though commodity programs have universal producer support, they are likely to be cut.

The question then becomes, which of the three types of payments do producers want to cut? Rice producers, along with producers of other commodities, will likely have to wrestle with this question by late January. Most producers would not be expected to choose cutting direct payments – even though a significant portion of this money does not go to producers, but to landowners across the country. What about counter-cyclical payments? To cut these payments, all Congress has to do is cut target prices – maybe. It depends on what the Congressional Budget Office (CBO) projects market prices to be in their March 2005 baseline. If commodity prices are projected to be high, almost no CCP payments would be expected anyway, so very little money could be saved. Even if prices eventually were to turn out to be low, it wouldn't matter. Program cuts just have to achieve savings 'on paper" relative to the CBO baseline. The last option for cutting payments – cutting marketing loan gains and/or loan deficiency payments – isn't really an option at all. There is almost no way to achieve savings by cutting only loan rates because a loan rate cut would increase the likelihood of incurring CCP payments, due to the interrelatedness of these policy tools.

Just for the sake of being complete, we will mention one other method being discussed (albeit not very much) that could be used to cut commodity spending – payment limits. There simply is no way to determine whether a new Congress and/or the President would see payment limit reductions as a politically appealing way to cut spending. Most producers outside the Midwest don't.

As of the end of October, the most talked about method is an across the board reduction in payments (meaning equal percentage cuts across commodities). As indicated previously, this isn't as easy as it sounds.

Rice Development Advisory

(http://Beaumont.tamu.edu/RiceDevA)

L. T. Wilson, Y. Yang, P. Lu, J. Wang,
J. Vawter and J. W. Stansel

DOS-based DD50 (1986-2003)

In 1976, Dr. Jim Stansel developed the concept, methodology and original data for forecasting rice development based on useable heat units. In 1986, Jack Vawter (TAMUS-Eagle Lake) wrote a DOS-based computer program ("DD50") based on Dr. Stansel's concept and methodology.

The DD50 program used current daily maximum and minimum air temperature and historic temperature data to calculate useable heat units for each day. Historic air temperature data were used to predict temperatures for dates when current temperature data are not available. 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 (Jack Vawter, James Woodard, Kuo-Lane Chen, W.H. Alford, and Jim Stansel).

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

The DOS-based DD50 had a number of limitations: (1) access to weather data for only two weather stations (Eagle Lake, and Beaumont), (2) need to manually input up-to-date weather data, (3) limited user interface, (4) accessible only by a small group of users, and (5) 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. 12). It forecasts rice growth stages for multiple varieties, different planting dates (Fig. 13) 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. 14).

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. RiceDevA 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% and 90% seedling emergence date. Additional information used by RiceDevA (but not by DD50) includes weather station data and year or historic average for the station. It can not predict rice crop yields and cannot account for changes in crop development due to other environmental factors and management practices.

Interface window

The top part of RiceDevA's window displays links to the Texas A&M University Beaumont Research & Extension Center Web site (Home, Research, Teaching, Extension, Outreach, Services, Personnel, and eLibrary) (Fig. 12). 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 Rice Development Advisory by clicking a link on the left side menu and making appropriate selections.

New Account Creation. To create a new account, click the "New Account" link, fill in the appropriate information, and click the "Submit" button. Once your account is created, you are automatically logged in, and you will be presented with more options on 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% emergence date and 90% emergence date. Weather data include weather station and year or historic average for the station. A user can create a field profile by clicking 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 an account with RiceDevA can save the profile and view/edit/delete existing profiles. A field profile is owned by a specific user and is accessible only by that specific user.

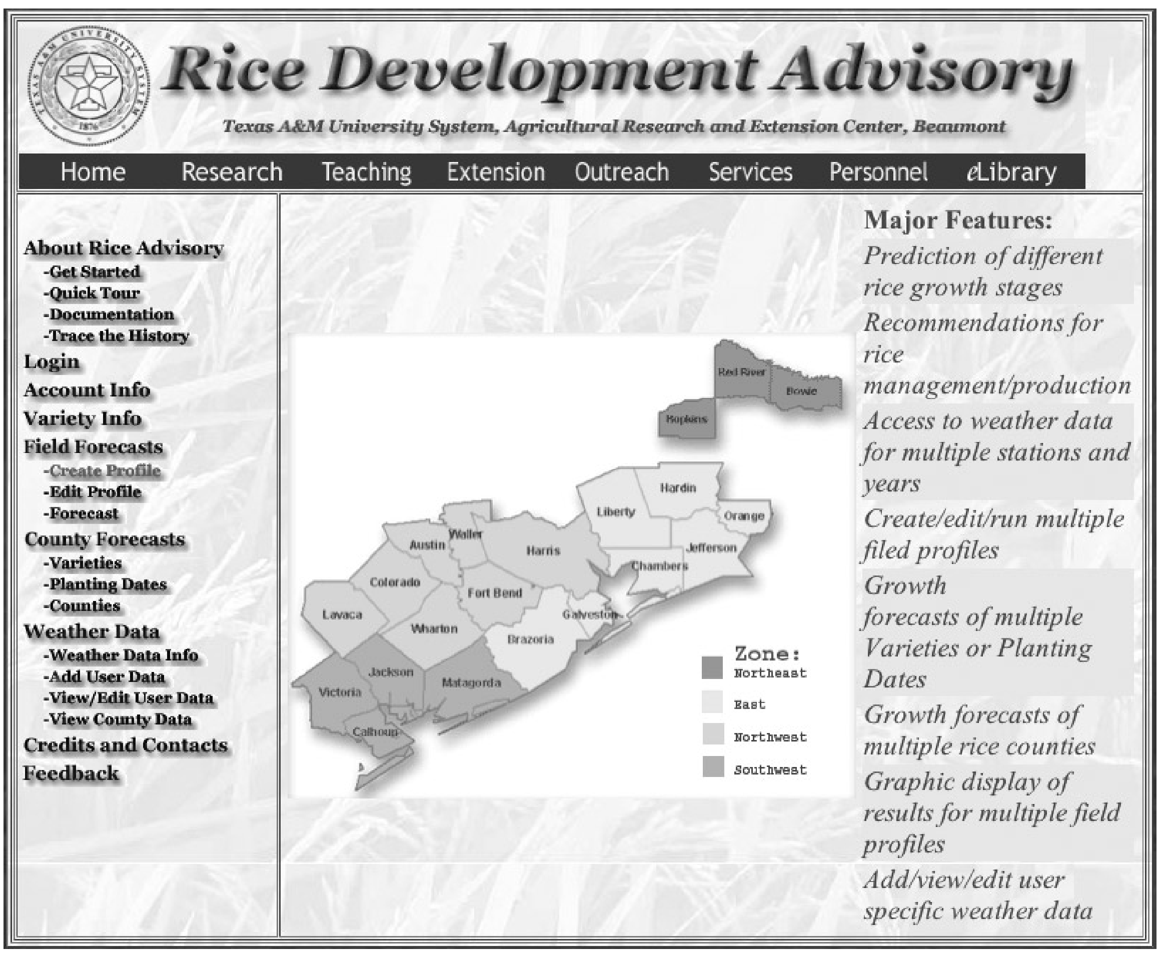
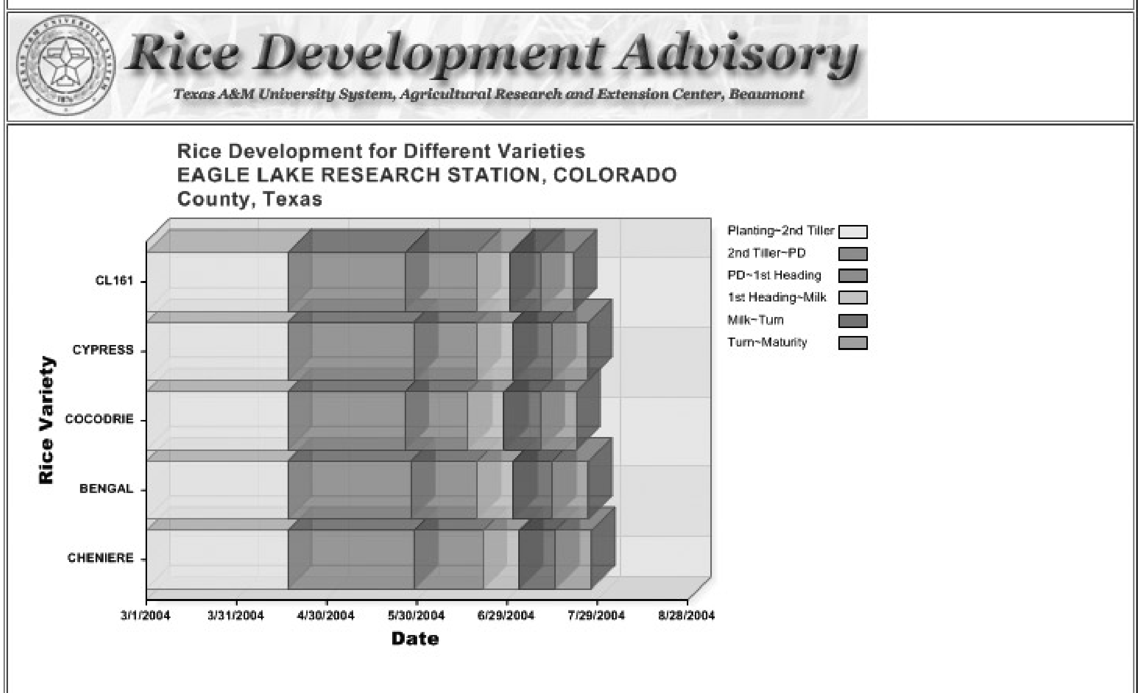


Figure 12.

Menu descriptions

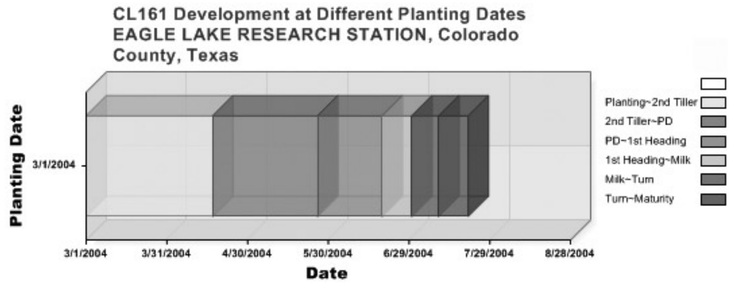
Menus to access RiceDevA features are displayed on the left side of the RiceDevA window (Fig. 12). The *Account Info* menu displays information about a user who has registered with RiceDevA (user name, user ID, email, etc.) The *New Account* menu allows a user to create a new account. A registered user (by creating a new account) will have access to advanced features of the RiceDevA. The *Variety Info* menu displays information about all varieties that are 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 currently in the database 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* 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 County Data* submenu allows any users to view weather data for 21 rice producing counties in Texas.



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 13.



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 14.

Historical Texas Rice Production Statistics

J. W. Stansel and R. Tate

Table 28. 11-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	866	38%	6,394	11,383,905
Avg. 1993–2003	**254,791**	**5,842**	**1,166**	**40%**	**6,210**	**15,543,234**
2004	216,810	6,231	1,105	35%	6,616	14,344,150**

*USDA–FSA certified planted acres
**TAMUS–Beaumont Crop survey data
***U.S. Rice Producers Association—check-off collections

Table 29. 11-year Texas rice planted acres comparison.

County	Rice planted acres*										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Austin	3,172	2,366	2,479	2,878	2,673	2,702	2,435	2,601	1,694	1,684	2,313
Bowie	1,459	1,600	1,600	1,136	1,329	1,538	1,030	1,435	1,287	1,332	1,510
Brazoria	32,701	29,975	16,818	21,888	18,718	19,241	17,163	15,279	14,969	10,395	15,748
Calhoun	5,682	4,875	4,760	2,502	3,851	3,164	1,568	1,468	1,498	1,897	2,488
Chambers	29,932	28,217	20,906	20,411	21,672	17,197	11,432	13,438	12,692	10,937	16,024
Colorado	41,783	37,551	36,200	36,091	35,698	33,522	31,136	32,110	30,726	28,572	33,273
Fort Bend	11,499	11,207	9,418	10,680	10,179	9,006	8,894	8,652	8,615	6,071	7,933
Galveston	3,780	2,993	2,144	2,110	1,993	1,590	1,360	768	1,166	781	847
Hardin	752	463	714	900	1,185	1,052	1,093	801	633	738	762
Harris	9,363	8,095	6,654	6,484	6,187	4,875	2,957	1,975	2,083	1,664	1,522
Hopkins	600	750	700	1,563	1,563	1,141	1,562	1,473	1,034	713	0
Jackson	30,920	27,561	25,235	20,521	20,128	18,355	16,208	14,953	13,214	13,057	14,734
Jefferson	33,849	32,324	26,102	24,947	24,422	22,655	18,519	18,575	18,389	15,037	19,954
Lavaca	4,040	3,572	3,703	2,682	2,452	2,006	2,523	1,746	1,690	1,582	2,189
Liberty	23,854	19,386	11,071	14,074	18,706	14,328	8,740	12,705	9,073	7,949	10,475
Matagorda	35,409	30,246	26,692	26,814	30,518	28,598	23,036	24,958	24,516	18,878	23,672
Orange	1,520	1,301	732	750	2,248	362	531	354	414	0	90
Red River	1,000	1,050	47	951	941	1,100	709	965	1,017	587	639
Victoria	4,190	3,824	2,775	2,941	3,302	2,401	1,937	1,977	1,748	1,247	1,356
Waller	7,343	6,785	5,677	6,741	6,694	6,142	6,206	6,951	6,917	7,168	7,868
Wharton	63,433	61,118	58,930	50,737	57,530	55,253	52,205	50,520	49,139	41,664	53,413
Total	**346,280**	**315,259**	**263,357**	**257,799**	**271,989**	**246,227**	**211,241**	**213,703**	**202,514**	**171,952**	**216,810**

*USDA–FSA certified plant acres

Table 30. Texas crop rice development statistics (date at 50% by development stages).

50% planted				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
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**	**3–Apr**	**31–Mar**	**4–Apr**

50% headed				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
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	**9–Jul**	**30–Jun**	**1–Jul**	**2–Jul**

50% main crop harvested				
Year	**East zone**	**Northeast zone**	**Southwest zone**	**State average**
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	**17–Aug**	**7–Aug**	**7–Aug**	**12–Aug**

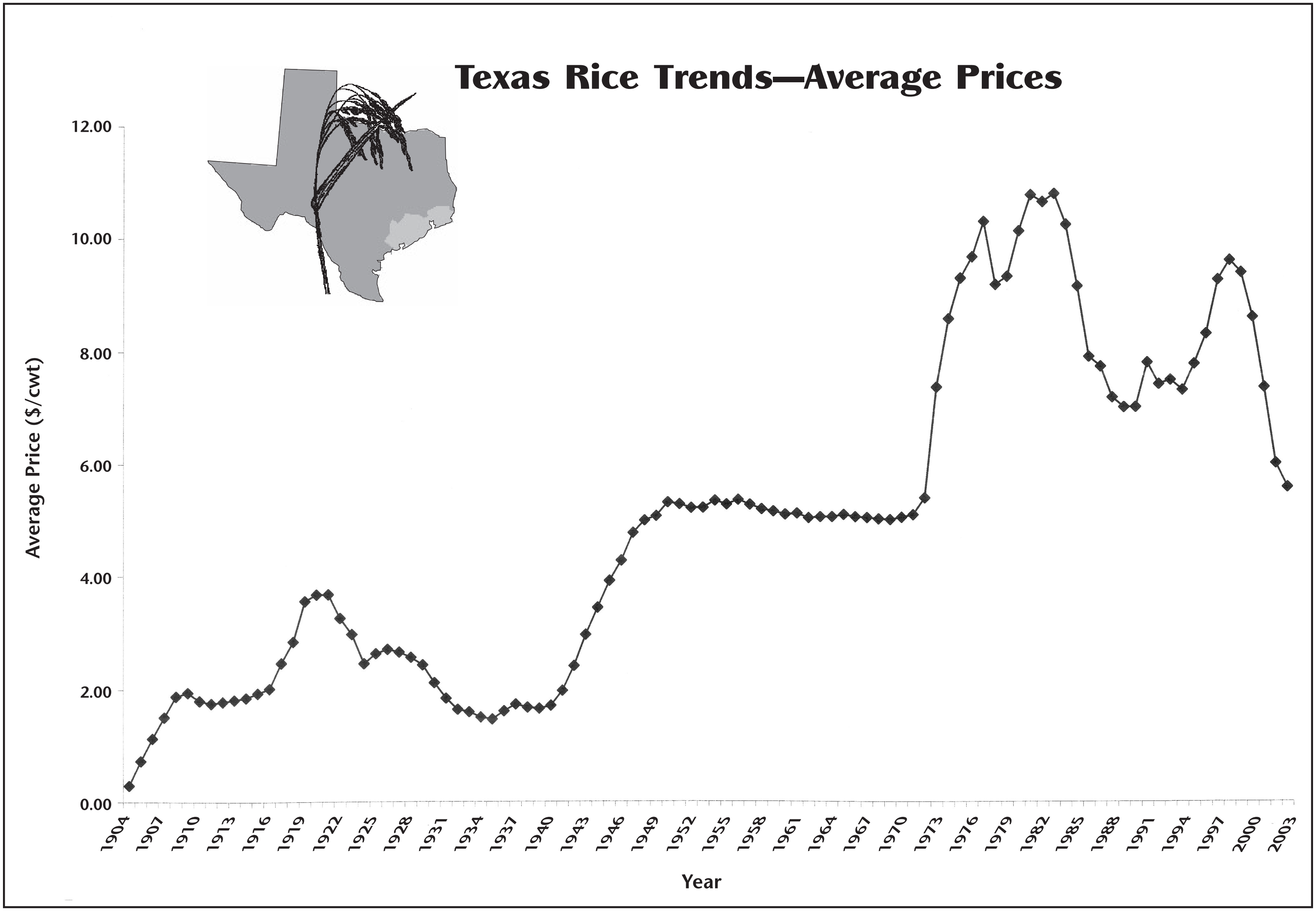


Figure 15. Texas Rice — Average Price Trends (1904-2004).

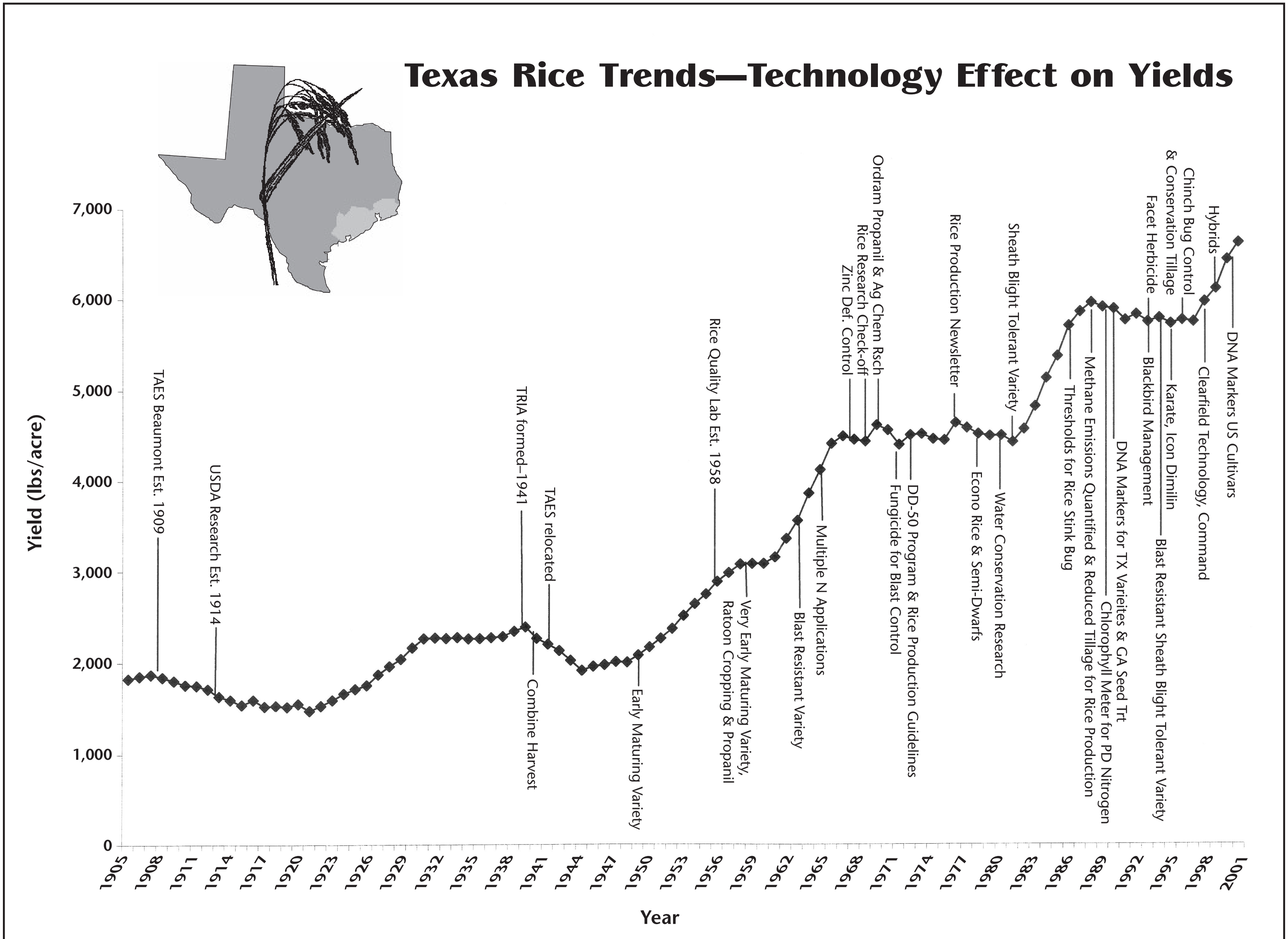


Figure 16. Texas Rice — Technology Trends effect on yields (1904-2004).

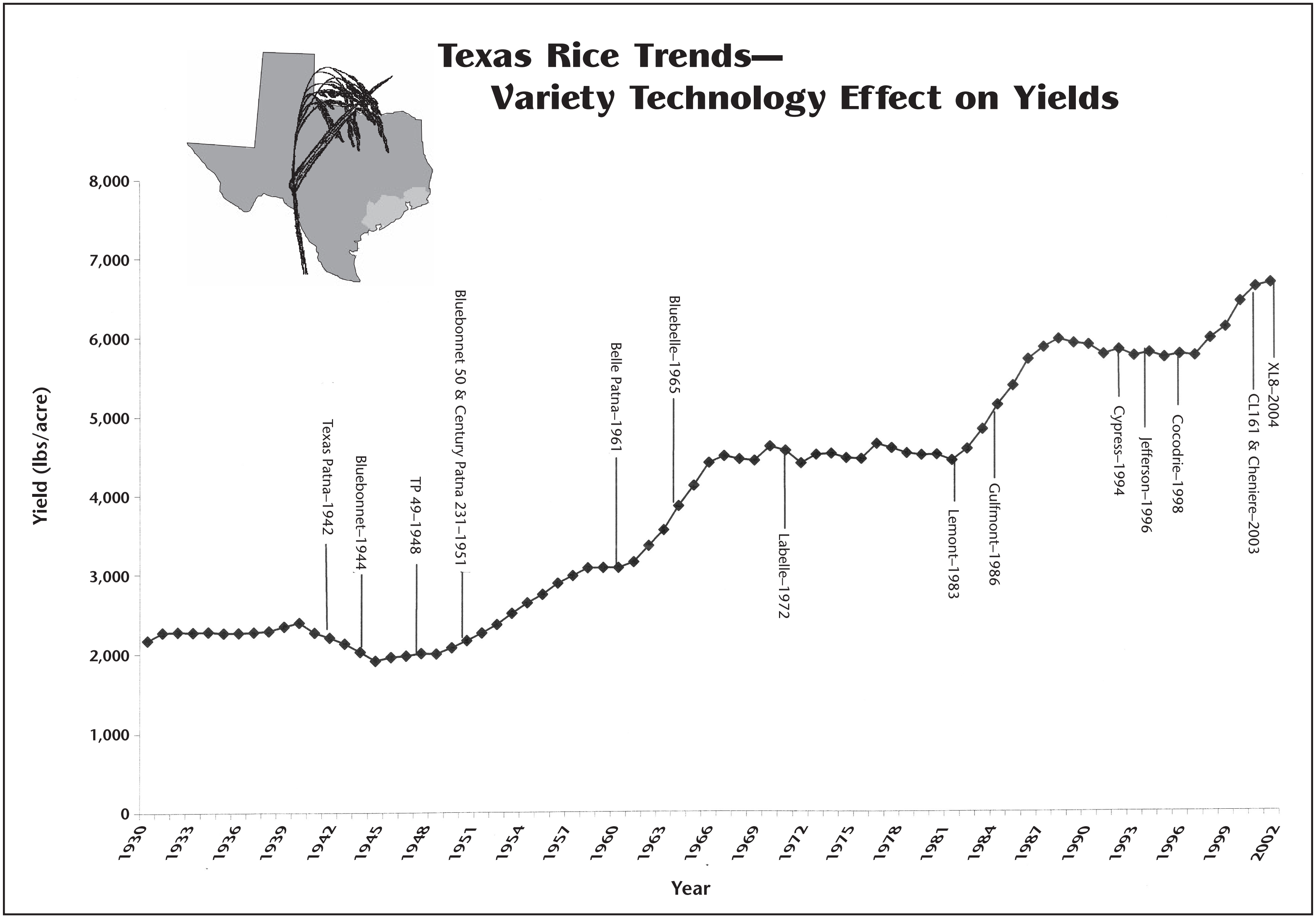


Figure 17. Texas Rice — Variety Technology Trends effect on yields (1930-2004).

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