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2010 Texas Rice Production Guidelines





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2010 Texas Rice Production Guidelines

Editor
M. O. Way, Professor of Entomology
Texas AgriLife Research and Extension Center at Beaumont

These guidelines are based on rice research conducted by research personnel of Texas AgriLife Research, Texas AgriLife Extension Service, and United States Department of Agriculture–Agricultural Research Service at the Texas AgriLife Research and Extension Center at Beaumont and the David R. Wintermann Rice Research Station at 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.

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TRRF Proposals Funded in 2009

Project Title: Generation Advance and Seed Increase of Selected Rice Genotypes at Puerto Rico Winter Nursery

Project Investigator: Rodante Tabien, Anna McClung

Amount: $43,897

Objective: To establish a winter nursery at Lajas, Puerto Rico, composed of 9,000 lines for generation advancement, selection, purification and/or seed increase

Project Title: Exploiting Generated Germplasm in the Development of High Yielding Conventional Rice Varieties for Texas

Project Investigator: Rodante Tabien

Amount: $112,240

Objective: The main objective of the project is to develop elite lines that are high yielding, with superior grain quality, herbicide tolerance and seedling cold tolerance. Specifically, it aims to generate crosses using elite lines developed by the program, selected germplasm, and advanced populations for selection, focusing on herbicide and seedling cold tolerance. Establish nurseries composed of segregating lines/populations, select desirable phenotypes and evaluate elite lines in various yield trials. Evaluate the degree of tolerance of selected lines to Liberty herbicide application and identify new donors for resistance to herbicide. Evaluate selected lines using DNA markers for amylose content, semi-dwarf gene aroma and blast resistance.

Project Title: Plant Physiology Research to Improve Texas Rice Main and Ratoon Crop Yields

Project Investigator: Lee Tarpley

Amount: $20,000

Objectives: 1) Evaluate the effects on main and ratoon crop rice yields of several specific plant growth regulator applications with effects on stem growth, prevention of environmental stress damage on seed set and fill, duration of grain filling, and within panicle inhibition. 2) Evaluate a reduced seeding rate for several inbred cultivars at Eagle Lake and Beaumont. 3) At Eagle Lake and Beaumont, evaluate the use of glycine betaine for enabling earlier drain of rice fields without loss in yield or quality. 4) Evaluate the effects of novel rice seed treatments on germination, emergence and stand in cool soils. 5) In cooperation with Dr. Way, evaluate tank mixes of gibberellic acid and pyrethroids to detect possible antagonism.

Project Title: Varietal Evaluations and Characterization and Nutrient Management Improvement for Texas Production Practices

Project Investigator: Lee Tarpley

Amount: $49,500

Objective: Conduct research at two locations upon a set of potential and current conventional varieties and hybrids for use in Texas rice production. Determine each entry's main and ratoon crop yield potential and milling response when 1) planted in early March at the location's optimal planting date for conventional varieties treated with or without fungicide when nitrogen is not limiting, and 2) for hybrids at two N rates without fungicide. Measure the contribution of specific management practices to ratoon crop yield using 'Cocodrie' as the test variety. Identify varieties with best yield and milling when planted before the optimum date on clay soil at Beaumont and sandy soil at Eagle Lake. Provide an economic ranking from each entry's average main, ratoon, and total crop net income. Provide some variety characteristics and growth stage data for use by researchers and producers.

Project Title: Water Management and Weed Science Research in Rice

Project Investigator: Garry McCauley, S.A. Senseman, J.M. Chandler

Amount: $50,000

Objectives: 1) Define the base fertilizer rates for the modern, high-yielding varieties and hybrids; 2) Determine the impact of Command on the yield and performance of the high-yielding varieties and hybrids under cool conditions; 3) Determine the impact of Newpath on the yield and performance of the high-yielding varieties and hybrids under cool conditions; 4) Evaluate the impact of rate and timing of selected ratoon crop herbicides on weed control and yield of hybrid and conventional rice; 5) Assess the tolerance of red rice biotypes to available broad spectrum herbicides; and 6) Update the weed science information presented in the Texas Rice Production Guidelines. Establish cooperative research with commercial industry to identify new potential weed control technology and production management. Deliver an accurate assessment of select herbicides to Texas rice producers for use in their management decisions.

Project Title: Entomology Research and Extension Program for 2009

Project Investigator: M.O. Way

Amount: $63,197

Objectives: To provide research and extension expertise to develop and implement integrated pest management (IPM) programs for the array of arthropods attacking rice. Specifically, the project will 1) continue developing economic injury levels for stem borers, 2) evaluate promising insecticides for stem borer control, 3) determine stem borer damage on ratoon rice, 4) evaluate dinotefuran for rice stink bug knock-down and residual activity, 5) evaluate tank mixes of gibberellic acid and pyrethroids to detect possible antagonism, 6) revise treatment thresholds for rice stink bug, 7) evaluate seed treatments for rice water weevil control, and 8) extend results of above research to clientele via field visits, *Texas Rice* articles, *Texas Rice Production Guidelines*, *Rice Farming* articles, *Rice Advocate* articles, *2009 Entomology Annual Report* and extension meetings. Extension information also will be placed on the Beaumont Center website.

Project Title: Personnel Support at David R. Wintermann Rice Research Station at Eagle Lake

Project Investigator: Jack Vawter

Amount: $30,000

Objective: To support one position involved in Farm Services activities at the David R. Wintermann Rice Research Station at Eagle Lake.

Contents

Land and Seedbed Preparation

G. N. McCauley

Leveling and drainage considerations

Fields for growing rice should be relatively level but gently sloping toward drainage ditches. Ideally, land leveling for a uniform grade of 0.2 percent slope or less but not zero grade 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 repeating germinations of grass, weeds 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 seedlings 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.

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 and adequate soil seed contact. This will ensure rapid germination and emergence of the rice seedlings.

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 seedlings. 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 custom cultivation can cost up to $12 per acre. Therefore, some farmers are adding as much as $60 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 may be drill or water seeded. For satisfactory stand establishment, you must use a minimum or no-till drill.

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. The fall system also is an excellent tool for the management of red rice. For more details on the spring stale seedbed technique, see the chapter on Red Rice Management. Equipment and labor costs may 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 establishment, cultural practices for reduced tillage are the same as for conventional tillage rice production.

Stand Establishment

F. Dou and L. Tarpley

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

Other factors that affect stand uniformity and density include quality of seedbed, % 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 Texas 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) for extended periods, germination will not occur or will be slow and uneven. These germination restrictions are why seedbed preparation and soil drainage affect stand levels and uniformity.

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

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

Varieties

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Long-grain varieties

Bowman

Bowman is an early maturing variety developed by the Delta Research and Extension Center in Mississippi. It has high yield potential with Dixiebelle type parboiling qualities. It has agronomic traits and milling qualities nearly like Cocodrie. It is susceptible to blast but has some tolerance to sheath blight.

Catahoula

Catahoula was developed by the Louisiana Agricultural Experiment Station from a cross of RU9502008-A, a sister line of Cocodrie and Drew. It is very early-maturing, with excellent yield potential and milling quality. It has susceptibility to sheath blight and straighthead but excellent resistance to the predominant races of blast. Agronomic traits of Catahoula are similar to Cocodrie and Cheniere.

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, but not superior, to Cocodrie in yield, ratoon and milling quality. It is 1 to 2 inches shorter and 4 to 5 days later than Cocodrie. It is more susceptible to blast than Cocodrie and is moderately susceptible to sheath blight.

CL111

Released by the Louisiana Agricultural Experiment Station, it is the earliest maturing, herbicide-tolerant (CLEARFIELD production system), non-hybrid variety with good yield potential for both main and ratoon crops.

CL131

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

CL151

CL151 is a very early-maturing semidwarf variety with excellent yield potential and good ratooning ability. It has strong tolerance to herbicides that are part of the CLEARFIELD production system. It has susceptibility to blast, sheath blight and straighthead. It was reported to have very good seedling vigor and consistently high head rice yields.

CL161

CL161 is an early, semidwarf, long-grain variety that looks much like Cypress. It has good yield potential and high tolerance to herbicides in the CLEARFIELD production system. 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 and is moderately resistant to straighthead.

CL142-AR

This is a traditional height, herbicide-tolerant (CLEARFIELD production system) variety with good vigor and tillering ability. Good yield potential with large kernel size makes it good for the parboiling market.

CL171-AR

CL171-AR is a long-grain variety similar to Wells. It offers good yield potential that is equal to or better than CL161 and it has a high tolerance to herbicides in the CLEARFIELD production system. CL171-AR has excellent seedling vigor and good standability. It is similar to CL161 in height and maturity. Disease resistance is better than CL131 and CL161, and the variety appears to have more tolerance to sheath blight.

CL181-AR

This is a semidwarf, herbicide-tolerant (CLEARFIELD production system) variety with good vigor, yield potential and milling quality.

CLEARFIELD XL729

It is a long-grain variety that offers the high hybrid yield potential combined with tolerance to herbicides in the CLEARFIELD production system. As with other hybrids, CLEARFIELD XL729 is disease tolerant. It is 4 to 5 days earlier than CL161 and has very good ratoon potential. CLEARFIELD XL729 is very easy to thresh and should be harvested as soon as grain moisture reaches acceptable levels (18 to 20 percent). Milling yield is standard. It is resistant to blast and is moderately susceptible to sheath blight.

CLEARFIELD XL745

This is a high yielding, long-grain hybrid tolerant of herbicides in the CLEARFIELD production system. It is 2 to 3 days earlier than CLEARFIELD XL729 and 1 day later than XL723 with a similar disease package. It is slightly taller than CLEARFIELD XL729 and yields about 4 percent more. It should be harvested at 18 to 20 percent moisture to maximize yield and milling quality.

Cocodrie

Cocodrie was developed by the 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. Although other cultivars may exceed it in ratoon crop yields and milling quality, Cocodrie continues to be a very stable and strong performing cultivar. This variety has improved resistance to blast similar to that of Jefferson, but is considered moderately susceptible to sheath blight.

Cybonnet

The University of Arkansas released Cybonnet in 2003. It was developed from a cross of Cypress/Newbonnet/Katy, and is similar to Cocodrie in yield. It is later and taller than Cocodrie: Cybonnet is early and 40 inches tall, while Cocodrie is very early and 38 inches tall. It has excellent milling quality like Cypress and broad-spectrum resistance to blast like Katy. It is moderately susceptible to sheath 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. It is taller than Cocodrie (41 inches versus 38 inches), and has consistently lower milling yields. It is susceptible to all races of blast and, like LaGrue, is moderately resistant to sheath blight.

Jefferson

Jefferson is a very early-maturing, semidwarf, long-grain variety developed at the Beaumont Center from the cross Vista/Lebonnet/Rosemont. Although main crop yields of Jefferson are not as high as Cocodrie, its ratoon crop yield is superior to most other cultivars. 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 and Rosemont. It is a long-grain variety that is similar in maturity and height to Cocodrie. Its main crop yield is lower than Cocodrie, but its ratoon crop potential averages 35 percent higher than Cocodrie. Presidio has excellent milling quality, similar to or better than Cocodrie. Presidio inherited broad spectrum blast resistance and moderate susceptibility to sheath blight from Jefferson at a level that is likely to make fungicides unnecessary in most circumstances.

Spring

Spring is a semidwarf, long-grain variety developed by the University of Arkansas. It is very early maturing, averaging 5 days earlier than Cocodrie. It has good seedling vigor and is taller than Cocodrie. Because of its early maturity, it should be closely managed to optimize yield and milling quality. It has broad spectrum resistance to blast. Although it is susceptible to sheath blight, it may escape sheath blight pressure because of its earliness.

Trenasse

Trenasse is a semidwarf, long-grain variety developed by the Louisiana Agricultural Experiment Station. It flowers 4 days earlier than Cocodrie, which is similar to Spring. It has main crop yield potential similar to or better than Cocodrie, while its milling quality is better. It is moderately resistant to blast like Cypress, and moderately susceptible to sheath blight like Cocodrie.

Wells

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

XL723

The conventional (non-herbicide tolerant) long-grain hybrid XL723 offers superior yield and disease resistance and above average straw strength. XL723 has a short season, making it an excellent choice after wheat or in ratoon situations. This variety also has good milling, is easy to thresh, and should be harvested as soon as grain moisture reaches acceptable levels (18 to 20 percent).

Medium-grain varieties

Bengal

Bengal is a mid-season, reduced height, medium-grain variety. It is about 10 inches shorter than Mars. Yields of Bengal are slightly less than Jupiter. 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, moderately susceptible to sheath blight, and very susceptible to straighthead.

CL261

This is the first CLEARFIELD production system medium grain release from the Louisiana Agricultural Experiment Station. It has good yield potential and good milling/cooking quality.

Jupiter

Jupiter is a medium-grain variety developed by the Louisiana Agricultural Experiment Station using the cultivars Bengal, Mercury and Rico-1. It has better main crop yield potential than Bengal, but milling yield is comparable. It is similar in height and maturity to Bengal. It is more susceptible to blast than Bengal, but has similar or better resistance to sheath blight and panicle blight disease.

Neptune

Neptune is a semidwarf, mid-season, medium-grain cultivar released in 2007 by the Louisiana Agricultural Experiment Station. It is derived from a cross involving Bengal, Mercury and Rico varieties. It has excellent yield potential and very good milling qualities. It has good seedling vigor and resistance to lodging. The grain of Neptune is similar to Bengal and bolder than Jupiter. It has better resistance to blast than Jupiter and is moderately susceptible to sheath blight and straighthead.

Specialty rices

Della

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

Dellrose

This cultivar was developed by the Louisiana Agricultural Experiment Station from a cross between Lemont and Della. 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 compared to Della. It is moderately resistant to blast and moderately susceptible to sheath blight.

Deltabelle

Deltabelle was developed at the Beaumont Center in partnership with the processing industry and is suited for the "quick cooking brown rice" market. Compared to Hidalgo rice, which is currently grown for this market, Deltabelle has significantly reduced lodging susceptibility (6 percent versus 20 percent) and will, therefore, reduce production risks.

Dixiebelle

Dixiebelle is an early maturing, semidwarf, long-grain variety developed at the Beaumont Center 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 of Dixiebelle averages about 10 percent lower than Cocodrie, whereas ratoon yield and milling quality are similar. Dixiebelle is very susceptible to blast and sheath blight.

Hidalgo

Hidalgo is a long-grain specialty cultivar that was developed at the Beaumont Center from a cross of Cypress, Pelde and Jefferson. It is a semidwarf cultivar similar in height, maturity and yield potential to Cocodrie. It has higher milling quality than Cocodrie and cooks soft like Toro. It is like Cypress in susceptibility to blast and is considered moderately resistant to sheath blight.

Jasmine 85

Jasmine 85 is an aromatic rice that has 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 when fertilized heavily. The milling yield of Jasmine 85 is lower than that of other southern U.S. long-grain varieties. Jasmine 85 is very resistant to blast and shows good tolerance to sheath blight.

Jazzman

Jazzman is an aromatic rice developed by the Louisiana Agricultural Experiment Station from a cross of Ahrent variety of Arkansas and Chinese aromatic line 96a-8. It was reported to have yields comparable to many U.S. popular varieties and had milling comparable to Cypress. It was also shown to have good seedling vigor and disease resistance. Jazzman has the plant height and maturity of Cypress. It has better resistance to sheath blight and blast than Cypress.

JES

JES is an aromatic, soft-cooking, long-grain (Jasmine style) rice that was developed through mutation breeding using Thai Jasmine rice. JES has better yield than Jasmine 85 (currently grown for this market), is 5 inches shorter, and a week earlier in maturity. It has strong resistance to blast and moderate resistance to sheath blight. JES may provide another opportunity for U.S. growers to compete with aromatic imports.

Neches

Neches is a long-grain, waxy rice developed at the Beaumont Center from a cross of waxy Lebonnet and Bellemont. Neches is very similar to Lemont in height and maturity. Asian markets want waxy rice as a specialty rice, and it is also used by the ingredients industry as a flour and starch. Its grain is completely opaque, and it is very sticky when cooked because of its waxy (glutinous) property. Neches' yield is similar to Lemont. It is moderately resistant to blast and very susceptible to sheath blight.

Rondo

Rondo was developed from a high yielding variety from China. It has excellent yield and disease resistance and can be used in the white milled rice market although its milling quality is lower than Cocodrie. However, like Sabine and Dixiebelle varieties, Rondo has relatively high grain amylose content, making it well suited for use by the parboiling and canning industries where milling yield is less important. It has very high levels of resistance to blast and sheath blight. High yields can be achieved with relatively low fertilizer inputs. Because Rondo is a medium-height variety, high fertilizer inputs commonly used for semidwarf varieties can result in lodging.

Sabine

Sabine was developed at the Beaumont Center from a cross of an experimental line from LSU and Dixiebelle. It has the same superior parboiling and canning quality that is found in Dixiebelle, and was developed primarily for these industries. Sabine is about 2 inches taller and has higher yield potential than Dixiebelle. The two are very similar in maturity, milling quality and susceptibility to blast and sheath blight.

Sierra

Sierra was developed at the Beaumont Center from a cross involving Dellmont, Basmati 370 and Newrex. It is a long-grain rice that possesses the fragrance and cooked kernel elongation characteristics of 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. 2009-2008 comparison – Texas field yields by variety (main crop).

	2009						2008					
Variety	Number of fields reported	Reported acreage	Yield (lb/acre)	Milling yield %H	Milling yield %T	Grade	Number of fields reported	Reported acreage	Yield (lb/acre)	Milling yield %H	Milling yield %T	Grade
Cocodrie	114	12184	6476	58.8	71.0	2.0	150	15986	6377	62.8	71.9	2.1
Presidio	107	10887	6374	56.8	70.0	1.7	44	4861	5010	59.1	70.4	2.0
XL723	114	9960	8156	59.6	71.5	2.0	21	2463	7389	61.2	72.5	2.0
CL151	111	8157	7312	56.5	69.9	2.3						
CLXL729	62	6519	7073	57.9	70.3	2.1	29	3321	6640	61.1	70.7	2.0
Other	20	4346	1026	42.8	65.8	2.0	4	741	5910	54.4	70.4	1.9
CLXL745	46	4345	6894	57.9	69.7	2.3	9	677	7078	59.9	67.3	2.0
Cheniere	47	4041	6879	61.1	71.8	1.8	7	729	7237	65.1	73.1	1.6
Neptune	13	1642	6593	62.0	72.3	2.0						
Milagro	23	1521	7033	46.5	67.7	2.1						
Texmati	7	1241	3400	43.4	67.9							
Catahoula	14	1236	7659	55.8	72.7	2.4						
CL111	11	583	7086									
CL161	4	496	4570	54.2	69.1	2.0	8	589	6414	66.6	71.9	2.1
Sierra	4	169	3723	50.1	71.8	2.0						
Jasmine	2	151	4028	51.0	66.0							
Trenasse	1	140	9081	59.0	70.0		5	494	5870	55.5	68.8	2.0
Dixiebelle	1	13	8790	61.0	70.0	2.0						
CLXL730							30	3210	6670	59.9	70.8	2.1
XP744							17	3094	7089	61.2	72.9	2.0
CL171							18	1891	6255	60.8	70.8	2.1
Wells							5	526	3882	54.1	72.0	2.0
Cybonnet							1	400	7085	68.0	74.0	2.0
Jasmine85							8	284	3858	48.3	66.3	2.7
Cypress							2	177	4481	67.0	72.0	2.0
XP729							1	68	6765	60.0	69.0	2.0
XL8							1	42	7155	63.0	70.0	2.0
Risotto							1	41	4463	29.0	70.0	2.0
Total	**701**	**67631**	**6531**	**56.7**	**70.2**	**2.0**	**361**	**39594**	**6328**	**61.2**	**71.5**	**2.0**

Data compiled by Texas AgriLife Research and Extension Center at Beaumont. Data compiled from Texas Rice Belt grower reports, rice dryers and marketing offices. All yields are adjusted to 12% moisture and weighted for field size and reported acres.

Table 2. 2009 Texas rice acreage by variety and county.

County	2008 acreage	2009 acreage	Acreage change	% MC ratooned	Variety acres by county: Long-grain: Cocodrie	CL151	Presidio	XL723	Cheniere	Milagro	CLXL745	XP729	XL729	Catahoula	CL171	CLXP746	CL161	Sierra	CLXL730	Medium: Neptune	Jupiter	Other
East Zone																						
Brazoria	14833	14833	0.00%																			
Chambers	13048	1262	-90.30%	100							1262											
Galveston	654	1527	133.50%																			
Hardin	950	460	-51.60%																			
Jefferson	15641	13749	-12.10%	7		10559	1842													1347		
Liberty	7579	7227	-4.60%	84		1077	424				5868					289						
Orange																						
East Total	**52705**	**40677**	**-22.80%**	**37**		**21278**	**3368**				**13038**					**528**				**2463**		
Northwest Zone																						
Austin	959	1036	8.00%		1036																	
Colorado	30776	31587	2.60%	56	5496	5717	5022	8149	2969	979	1958		190	316			348	190				190
Fort Bend	4358	5589	28.20%	22	2403	1537	458	1140						45								
Harris	395	395	0.00%																			
Lavaca	1255	1057	-15.80%	50	654				403													
Robertson	200																					
Waller	6508	6379	-2.00%	92	740	555	51	2035			383	1824	364		370				51			
Wharton	38699	43064	11.30%	81	5728	7192	7795	3747	6201	8699	1120											2541
Lamar	203	215	5.90%																			
Northwest Total	**83353**	**88927**	**6.70%**	**69**	**16117**	**15057**	**13376**	**15128**	**9609**	**9714**	**3474**	**1831**	**555**	**362**	**371**		**349**	**191**	**51**			**2740**
Southwest Zone																						
Calhoun	2803	2154	-23.20%		1331			823														
Jackson	9519	11350	19.20%	20	3314	647	1589	556	1339	692	465		636	647		477						987
Matagorda	17979	24594	36.80%	70	16134		4107		2730	1377											270	
Victoria	1081	1622	50.00%																			
Cameron	30																					
Southwest Total	**31412**	**39869**	**26.90%**	**54**	**21731**	**677**	**5957**	**1442**	**4255**	**2165**	**486**		**665**	**677**		**499**					**282**	**1032**
Northeast Zone																						
Bowie	569	517	-9.10%	0											517							
Hopkins																						
Red River		210						210														
Northeast Total	**569**	**517**	**-9.10%**	**0**				**149**							**368**							
State Total	**168039**	**169990**	**1.20%**	**58**	**41832**	**30984**	**23695**	**18919**	**15492**	**13341**	**12555**	**2071**	**1350**	**1145**	**1007**	**870**	**395**	**216**	**58**	**1530**	**307**	**4222**

Data compiled by Texas AgriLife Research and Extension Center at Beaumont. Data collected from dryers, sales offices, agribusiness, USDA/CFSA and county extension agents, as appropriate. Research funded by Texas AgriLife Research - Beaumont and TRRF.

Table 3. Selected variety information update for 2010 Texas Rice Production Guidelines. The table below provides a comparison of various characteristics of several rice varieties based upon experimental plot data. All varieties are compared to Cocodrie for main crop yield, ratoon crop yield and milling yield.

Variety	Maturity	Height (inches)	Main crop yield	Ratoon crop yield	Milling yield
Cocodrie	Very early	38	—	—	—
Della (A)	Very early	52	Lower	Lower	Lower
Dellrose (A)	Very early	41	Lower	Lower	Similar
Hidalgo	Very early	39	Similar	Lower	Higher
Jefferson	Very early	37	Lower	Similar	Similar
Presidio	Very early	37	Lower	Higher	Higher
Spring	Very early	39	Lower	Higher	Lower
Trenasse	Very early	39	Higher	Similar	Higher
XL8	Very early	45	Higher	Higher	Lower
Banks	Early	44	Higher	Lower	Lower
Cheniere	Early	36	Similar	Similar	Similar
CL161	Early	38	Higher	Similar	Lower
Cybonnet	Early	40	Similar	Similar	Higher
Cypress	Early	41	Lower	Lower	Higher
Dixiebelle	Early	35	Lower	Similar	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
Jupiter (M)	Mid-season	36	Higher	Lower	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

F. Dou and L. Tarpley

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

However, planting after April 15 reduces ratoon crop potential. Also, planting is not recommended when the 4-inch daily minimum soil temperature falls below 65 degrees F. The 4-inch minimum soil temperature is an indicator of residual heat in the soil, which is very important for normal seed germination and seedling growth. The 4-inch soil temperatures are available on-line (*http://beaumont.tamu.edu/WeatherData/*) at the Texas AgriLife Research and Extension Center at Beaumont, (409) 752-2741, and the David R. Wintermann Rice Research Station 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 growing season.

Planting earlier than March 15 can result in good yields but higher production costs because: 1) reduced nitrogen utilization increases the amount of nitrogen required; 2) additional flushings increase the amount of water required; 3) weeds are harder to control, so more herbicide is needed; and 4) there is a longer time until permanent flood.

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

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

Low plant populations of common Texas cultivars (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.

Seeding Rates

G. N. McCauley, L. Tarpley and F. Dou

Uniform stands of healthy rice seedlings pave the way to a productive rice crop. Growers generally 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 you get the desired number of seed per square foot.

For example, Jefferson ought to be planted at a 15 percent higher rate than that used for Cypress and Cocodrie and 25 percent higher than 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. Table 5 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. This 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 4. Recommended seeding rates adjusted for seed size and tillering for March 20 to April 1 planting on good seed beds.

	Seeding rate (lb/A)		
Variety	**Drill seeded**	**Broadcast (dry)**	**Water planted**
Jefferson	90-100	110-120	120-130
Priscilla and 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, use an additional 20 pounds of seed per acre above the 70 to 90 pounds per acre of drilled seed.
- 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, you may need an additional 10 pounds of seed because earlier planting usually means cooler weather.
- You might not need to increase the seeding rate if soil and air temperatures are 70 degrees F. or above. However, growers who have had problems achieving recommended stands should use higher seeding rates.
- When drilling to moisture in stale seedbed conditions, you can generally reduce the seeding rate 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.
- You can reduce the need for higher seeding rates by using gibberellic acid as a seed treatment, which can increase seedling vigor.

Replanting is not recommended unless stands have fewer than 8 to 10 seedlings per square foot over most of the field for semidwarf varieties and 5 seedlings per square foot for hybrids. If there are fewer than 15 seedlings per square foot, you can improve plot yields 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)

Measuring seedling stand density

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 can be measured using a square or circular hoop of 1, 2, 3 or more square feet. The hoop is randomly tossed in the field, and the seedlings inside the hoop are counted. Seedling density is determined by counting and then dividing the number of seedlings inside the hoop by the area of the hoop. This process should be repeated at several locations in the field.

The hoop method should not be used in drill seeded rice. The size of the hoop and the row spacing can introduce significant error in accurately measuring seedling stand density. Stand density in drill-seeded rice should be determined by counting the number of seedlings in a given length of row. The seedling density can then be calculated using the seedling count, length of row and row spacing. Research has shown that optimum length of row is 3 feet and that the measurement should be repeated at 7 to 10 random locations in the field. Conversion from seedling count to seedlings per square foot can be made using Table 6.

Table 5. The effect of seed per pound (seed size) on the number of seed per square foot at various seeding rates. The number of live seedlings per square foot depends on the germination rate and planting conditions.[1]

		Seeding rate (lb/A)											
		30	40	50	60	70	80	90	100	110	120	130	140
Variety	Seed/lb[2]	Seed/square foot											
Bolivar	18,500	13	17	21	25	30	34	38	42	47	51	55	59
CL161	19,800	14	18	23	27	32	36	41	45	50	55	59	64
CL131	20,700	14	19	24	29	33	38	43	48	52	57	62	67
Cheniere	20,200	14	19	23	28	32	37	42	46	51	56	60	65
Cocodrie	18,800	13	18	22	26	31	35	40	44	48	53	57	62
Cypress	18,400	13	17	21	25	30	34	38	42	46	51	55	59
Dixiebelle	20,500	14	19	24	28	33	38	42	47	52	56	61	66
Jacinto	21,300	15	20	24	29	34	39	44	49	54	59	64	68
Jefferson	16,500	11	15	19	23	27	30	34	38	42	45	49	53
Saber	20,800	14	19	24	29	33	38	43	48	53	57	62	67
Sabine	17,600	12	16	20	24	28	32	36	40	44	48	53	57
Spring	20,700	14	19	24	29	33	38	43	48	52	57	62	67
Trenasse	17,700	12	16	20	24	28	33	37	41	45	49	53	57
Wells	18,200	13	17	21	25	29	33	38	42	46	50	54	58
CLXL729	19,700	14	18	23	27	32	36	41	45	50	54	59	63
CLXL745	19,690	14	18	23	27	32	36	41	45	50	54	59	63
XL723	19,731	14	18	23	27	32	36	41	45	50	54	59	63

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

Table 6. Converting seedling count per 3 feet of linear row to seedlings per square foot in drill-seeded rice.

Seedlings per 3 feet of row	Row spacing (inches)								
	6	6.5	7	7.5	8	8.5	9	9.5	10
	Seedlings per square foot								
1	0.67	0.62	0.57	0.53	0.50	0.47	0.44	0.42	0.40
2	1.33	1.23	1.14	1.07	1.00	0.94	0.89	0.84	0.80
3	2.00	1.85	1.71	1.60	1.50	1.41	1.33	1.26	1.20
4	2.67	2.46	2.29	2.13	2.00	1.88	1.78	1.68	1.60
5	3.33	3.08	2.86	2.67	2.50	2.35	2.22	2.11	2.00
6	4.00	3.69	3.43	3.20	3.00	2.82	2.67	2.53	2.40
7	4.67	4.31	4.00	3.73	3.50	3.29	3.11	2.95	2.80
8	5.33	4.92	4.57	4.27	4.00	3.76	3.56	3.37	3.20
9	6.00	5.54	5.14	4.80	4.50	4.24	4.00	3.79	3.60
10	6.67	6.15	5.71	5.33	5.00	4.71	4.44	4.21	4.00
11	7.33	6.77	6.29	5.87	5.50	5.18	4.89	4.63	4.40
12	8.00	7.38	6.86	6.40	6.00	5.65	5.33	5.05	4.80
13	8.67	8.00	7.43	6.93	6.50	6.12	5.78	5.47	5.20
14	9.33	8.62	8.00	7.47	7.00	6.59	6.22	5.89	5.60
15	10.00	9.23	8.57	8.00	7.50	7.06	6.67	6.32	6.00
16	10.67	9.85	9.14	8.53	8.00	7.53	7.11	6.74	6.40
17	11.33	10.46	9.71	9.07	8.50	8.00	7.56	7.16	6.80
18	12.00	11.08	10.29	9.60	9.00	8.47	8.00	7.58	7.20
19	12.67	11.69	10.86	10.13	9.50	8.94	8.44	8.00	7.60
20	13.33	12.31	11.43	10.67	10.00	9.41	8.89	8.42	8.00
21	14.00	12.92	12.00	11.20	10.50	9.88	9.33	8.84	8.40
22	14.67	13.54	12.57	11.73	11.00	10.35	9.78	9.26	8.80
23	15.33	14.15	13.14	12.27	11.50	10.82	10.22	9.68	9.20
24	16.00	14.77	13.71	12.80	12.00	11.29	10.67	10.11	9.60
25	16.67	15.38	14.29	13.33	12.50	11.76	11.11	10.53	10.00
26	17.33	16.00	14.86	13.87	13.00	12.24	11.56	10.95	10.40
27	18.00	16.62	15.43	14.40	13.50	12.71	12.00	11.37	10.80
28	18.67	17.23	16.00	14.93	14.00	13.18	12.44	11.79	11.20
29	19.33	17.85	16.57	15.47	14.50	13.65	12.89	12.21	11.60
30	20.00	18.46	17.14	16.00	15.00	14.12	13.33	12.63	12.00
31	20.67	19.08	17.71	16.53	15.50	14.59	13.78	13.05	12.40
32	21.33	19.69	18.29	17.07	16.00	15.06	14.22	13.47	12.80
33	22.00	20.31	18.86	17.60	16.50	15.53	14.67	13.89	13.20
34	22.67	20.92	19.43	18.13	17.00	16.00	15.11	14.32	13.60
35	23.33	21.54	20.00	18.67	17.50	16.47	15.56	14.74	14.00
36	24.00	22.15	20.57	19.20	18.00	16.94	16.00	15.16	14.40
37	24.67	22.77	21.14	19.73	18.50	17.41	16.44	15.58	14.80
38	25.33	23.38	21.71	20.27	19.00	17.88	16.89	16.00	15.20
39	26.00	24.00	22.29	20.80	19.50	18.35	17.33	16.42	15.60
40	26.67	24.62	22.86	21.33	20.00	18.82	17.78	16.84	16.00

Seeding Methods

G. N. McCauley

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

On fine clay soils, several seeding methods can be used, including dry- and water-seeding. A well prepared, weed-free seedbed is important when rice is dry seeded. When dry seeding with a drill on fine clay soils, flush the field immediately after planting to ensure uniform emergence. Seed can be broadcast on a rough, cloddy seedbed if followed immediately with a flush so soil clods disintegrate, seeds are covered and soil-seed contact is established. 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. Planting under these conditions requires a significantly higher seeding rate.

On sandy soils, plant seed in moist soil 1 to 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.

Planting in a reduced till/stale seedbed requires the use of minimum or no-till drill. Depth control is critical for even seed depth and uniform seedling stand density. Disk opener closure and good seed-soil contact is essential for maximum germination. Seeding rates may need to be increased if an emergence flush will be used and if a preemergence herbicide has been applied.

Early Flood Rice Culture

G. N. McCauley

Definitions

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

In the continuous flood system, dry or sprouted seed are dropped into a flooded field and that flood is maintained until near harvest.

In the pinpoint system, dry or 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.

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 two additional disadvantages:

- possibility of seedling damage from rice seed midge; and
- seedling drift, especially in large, open cuts, which can be caused by wind and certain aquatic beetles.

A good seedbed is critical for both of these water management techniques. 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 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 emerges through the water. 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 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 also can 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.

Planting

The flooded conditions mandate that the field be aerially seeded. Timing and management are critical. The field must be seeded as soon as possible after flood establishment and stabilization to minimize damage from rice seed midge. Also, the water oxygen content will decrease each day after flood establishment. The sprouted seed should be ready for planting as soon as the field is flooded. The seeding rate should be increased to 120 to 140 pounds per acre.

Blackbirds

M. O. Way

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

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

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

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

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

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

Bird control on emerging rice

To control blackbirds on emerging rice:

- Delay planting until large flocks of birds move north, and try not to plant when your field is the only one in the area with seeds and seedlings available for the birds.
- Increase the seeding rate if you usually experience bird problems at planting, and cover the seed to make it more difficult for the birds to find.

- Patrol the fields early and consistently using firearms and scare devices.* This is probably the most effective tactic. Laborers can be hired to perform this tedious but important job. If possible, make sure all margins of the field are accessible for patrol. Start patrolling immediately after planting to scare away "scout" birds. Birds are more difficult to move once they establish in a field. Most feeding occurs during the early morning and late afternoon. However, patrol the fields as long as birds are present.
- Use continuous flooding, which can deter blackbirds from feeding on seeds and seedlings. However, other birds, such as ducks, geese, ibises and dowitchers, feed on and/or trample submerged sprouts.
- If possible, destroy roosts and loafing sites on the margins of fields.

DRC 1339, a blackbird toxicant formulated as a bait, can be used to kill blackbirds threatening rice. It can be applied only by authorized governmental personnel. For more information, contact the Texas Wildlife Damage Management Service at (979) 845-6201 or (979) 234-6599.

Control on ripening rice

To control blackbirds on ripening rice:

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

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

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

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

Residue data were collected in Texas to help register the product, but field efficacy data are unavailable. For more details, call (409) 752-2741.

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

Seedling Disease Management

*X. G. Zhou, Y. Jo and D. E. Groth**

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 soil and any condition that delays seedling emergence favor the development of seed rots and seedling diseases. Severe seed rots and seedling diseases may result in the need to replant.

The organisms that cause seed rot and seedling blight include *Achlya* spp., *Cochliobolus miyabeanus, Fusarium* spp., *Pythium* spp., *Rhizoctonia solani, Sclerotium rolfsii,* and other pathogenic fungi. They survive in the soil or on seeds between crops. These fungi infect germinating seeds or young seedlings, resulting in seed rot and slow growth or even seedling death. Low temperatures slow the germination and growth of rice seedlings but do not affect the growth and infection of these pathogens. Therefore, damage by these fungi is more severe in rice planted in late February to mid-March when temperatures are still too low.

Seed treatments with fungicides have been shown to significantly increase stands in both drill and water-seeded rice, especially in early plantings. Fungicides should not be applied to sprouted, water-seeded rice since the chemicals can be washed off and contaminate water. Fungicides can be applied to soaked seed using specialized equipment and to water-seeded dry seed. Fungicides typically increase stands by 20 to 40 percent, which may not eliminate the need to replant. In addition to fungicide seed treatments, other practices that aid in obtaining a healthy and uniform stand include:

- Plant in a well prepared, uniform seedbed.
- Avoid planting too early.
- Plant shallow when planting rice early.
- Use healthy seed with high germination and good vigor.

The following fungicides (Table 7) are registered for use on rice seed. CruiserMaxx® is a recently registered seed treatment containing three fungicides and one insecticide targeting a broad spectrum of early-season diseases and selected harmful insects. 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.

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Table 7. Fungicides registered for use on rice seed.

Common name	Trade name	Rate/100 lb seed
azoxystrobin	Dynasty®	0.15-1.5 fl oz
carboxin + thiram	Vitavax® CT Vitavax® M	9-12 fl oz 9-12 fl oz
fludioxonil	Maxim® 4FS	0.08-0.16 fl oz
mancozeb	Dithane® DF Dithane® F 45 Dithane® M 45 Manzate® Flowable Manzate® Pro-Stick	2.1-4.3 oz 3.2-6.4 fl oz 2-4 oz 3.4-6.7 fl oz 2-4 oz
mefenoxam	Apron XL® LS Apron XL®	0.0425-0.085 fl oz 0.0425-0.085 fl oz
 mefenoxam + fludioxonil + azoxystrobin + thiamethoxam *	CruiserMaxx® contains: Apron XL® Maxim® 4FS Dynasty® Crusier 5FS®	 0.44 fl oz 0.05 fl oz 0.88 fl oz 3.3 fl oz
metalaxyl**	Dyna-Shield®	0.75 fl oz

* Thiamethoxam is an insecticide. See the Insect Management section for more details.

** Effective for controlling *Pythium* damping-off. Use in combination with another material to broaden spectrum of control.

Irrigation and Water Management

G. N. McCauley

Reducing irrigation costs

There are two general ways to reduce irrigation costs:

- reduce the amount of water used to produce the rice crop; and/or
- 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 AgriLife Extension Service); 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 pump 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 zero grade. “Land grading” is a better, more descriptive term because some grade, or slope, is desirable for surface drainage. Zero grade does not use less water than land with a slight uniform grade.

Shallow flood depth decreases the amount of water required and increases yield if 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, which can impede 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 can 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 cut 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. The rice should be planted immediately to minimize rice 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 rice 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 the propanil off the weeds, reduces absorption and control.

Flood establishment

The flood should be established as the seedlings reach the 4 to 5-leaf or second tiller stage (assuming continuous flood culture is not being used). Flood depth should be adjusted to allow ⅓ to ½ of the seedling above the water. To maintain the flood, apply additional water to replace that lost by evaporation, transpiration, seepage and runoff.

The flood may be drained mid-season only when the field has a history of straighthead. If application of a mid-season herbicide is necessary, lower the flood level to obtain better exposure of broadleaf weeds. To ensure availability of water during the reproductive stage, the rice must be reflooded 7 to 10 days before anticipated panicle differentiation or sooner.

Maintaining a 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.

Maintain the 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.

Fertility Management

F. Dou and L. Tarpley

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

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

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

Of the three primary nutrients (nitrogen, phosphorus and potassium, or N, P and K), nitrogen affects rice yield in Texas most. Because soil nitrogen availability changes rapidly and continuously, soil testing is not recommended for determining nitrogen rates for rice. The recommended nitrogen rates (Table 8) for each rice variety are determined by nitrogen fertilizer response in research tests.

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

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

Take one composite sample from each uniform area in the field. Sample separately any portion of the field that varies because of soil texture, organic matter and/or slope.

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

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

Take a minimum of 10 or 15 samples randomly selected from each uniform area. Take the cores or slices from the plow layer (5 to 6 inches). Thoroughly mix all the samples from each uniform field or area and remove a pint of it as a composite sample.

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

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

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

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

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

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

Soil Test Laboratory
Texas AgriLife Extension Service
Soil and Crop Sciences Department
The Texas A&M System
2474 TAMU
College Station, TX 77843-2474 • Phone: (979) 845-4816

A & L Plains Agricultural Labs, Inc.
302 34th Street (P. O. Box 1590)
Lubbock, TX 79408 • Phone: (806) 763-4278

Efficient fertilizer management

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

Nitrogen

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

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

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

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

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

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

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

Phosphorus

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

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

Potassium

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

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

Micronutrients

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

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

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

Symptoms of iron and zinc deficiencies in rice seedlings include:

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

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

Soil and plant additives

Soil additives, foliar-applied nutrient growth stimulators, and yield enhancers have not increased rice yields in research tests or demonstrations conducted throughout the Texas 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 main crop, assuming semidwarf varieties planted the first week of April.

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

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

Nitrogen rates

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

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

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

Table 9. Chlorophyll levels above which there is usually no yield benefit from applying additional nitrogen fertilizer.

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

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

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

Symptoms and characteristics of nitrogen deficiency include:

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

Phosphorus and potash rates

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

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

Fertilizer timing for main crop yield

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

Nitrogen applied at or near heading has not increased main crop yields when sufficient nitrogen is available, but it can maximize ratoon crop potential. (See the Ratoon Crop Production chapter 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 ⅓ of the nitrogen at each of the three application times.

May plantings (two applications)

Apply about ⅔ of the nitrogen and required phosphorus and potassium just before planting. Apply the remaining ⅓ at PD or earlier if needed to correct nitrogen deficiencies.

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

Use the two applications described under May planting above.

Other factors influencing nitrogen timing

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

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

Maximizing benefits of fertilizer application

Preplant or initial fertilizer application

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

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

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

Preflood application

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

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

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

PD application

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

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

Chlorophyll meter use

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

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

The procedure for using a Minolta model 502 chlorophyll meter to determine the average chlorophyll reading in a rice field is to walk into representative areas of the rice field and insert the edge of a most recently matured leaf, at a point ¾ of the way up the leaf, into the measuring head of the meter. When the measuring head is clamped on the leaf, the meter will provide an instant three digit chlorophyll value.

The meter will store and average up to 30 readings. Fields having chlorophyll readings above the critical levels given above are unlikely to benefit from nitrogen topdressings. Fields having lower chlorophyll values will benefit from topdressing nitrogen (Table 9).

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

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

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

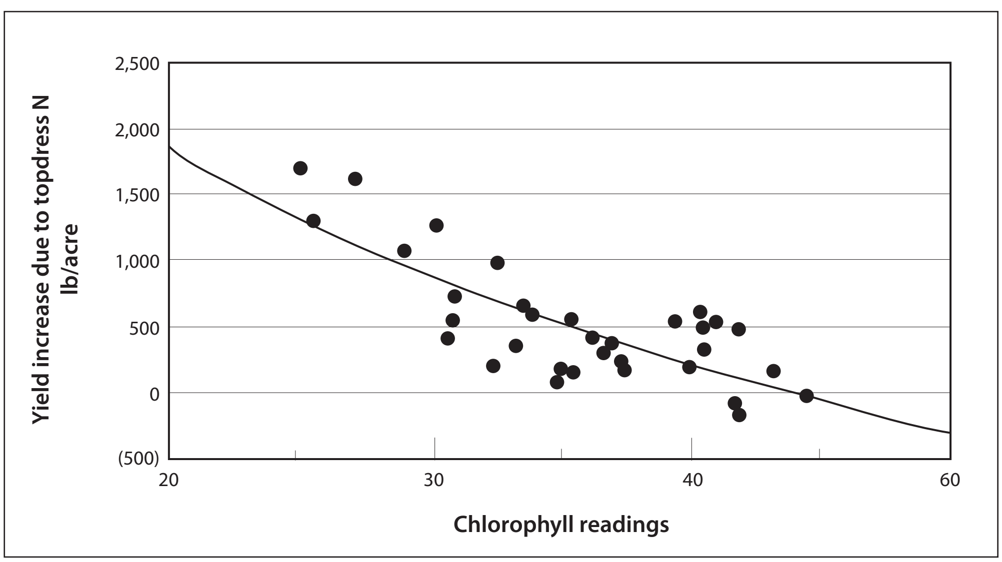

Figure 1. Relationship between yield increase and chlorophyll readings.

2008* Variety Evaluation for Main and Ratoon Crop Yield Potential

F. Dou and L. Tarpley

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

On clay soil at Beaumont (Fig. 2), most inbreds and hybrids with relatively high main crop (MC) yields had even higher MC and total yields when treated in one of two ways:

- Inbred cultivars —Fungicide (8 fl oz Quadris plus 6 fl oz Tilt at late boot)
  (Cultivars received MC nitrogen as three applications: 45 lb/acre preplant (PP), 90 lb/acre at permanent flood (PF), and 80 lb/acre at panicle initiation (PI). The ratoon crop received 135 lb/acre preflood).
  OR
- Hybrid cultivars—Additional preflood nitrogen (Cultivars received nitrogen in two applications: 120 or 150 lb/acre preflood and 30 lb/acre at boot. The ratoon crop received 135 lb/acre preflood. Cultivars had no fungicide treatment).

CLEARFIELD XL729 and CLEARFIELD XL745 at the higher nitrogen rate had the highest total crop yields. Bowman's MC and total crop yields were competitive with other inbreds. Applying fungicide to the inbreds usually slightly increased MC milling (Table 10). Catahoula, XL723 and Presidio were among the best millers.

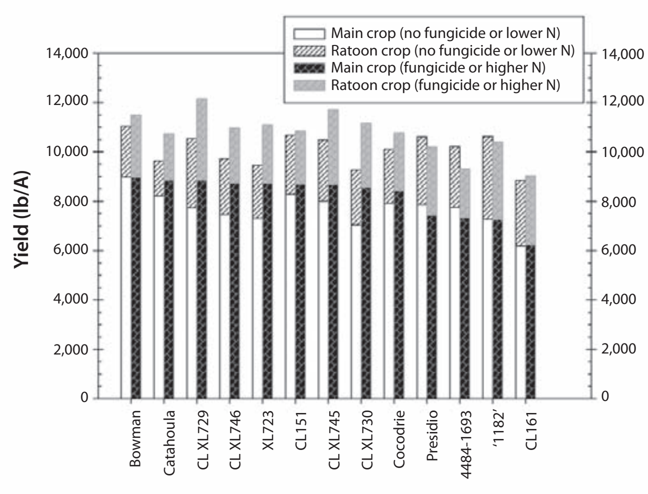

Figure 2. 2008 variety evaluation, April 15 planting, Beaumont, Tx.

Table 10. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted April 6 on clay soil at Beaumont, Texas, in 2006.

Cultivar–BMT	MC% whole	MC% total	RC% whole	RC% total
Bowman	58	68	–	–
Bowman (+F)	61	69	47	62
Catahoula	61	71	–	–
Catahoula (+F)	62	71	56	67
CL XL729	57	67	50	65
CL XL729 (HI N)	56	66	53	66
CL XL746	57	68	51	65
CL XL746 (HI N)	56	68	52	63
XL 723	61	70	53	65
XL 723 (HI N)	63	72	57	68
CL151	57	69	47	61
CL151 (+F)	58	69	–	–
CL XL745	59	69	47	64
CL XL745 (HI N)	60	70	51	64
CL XL730	57	69	47	62
CL XL730 (HI N)	58	69	45	60
Cocodrie	59	68	–	–
Cocodri (+F)	60	70	57	67
Presidio	63	70	–	–
Presidio (+F)	64	70	55	68
'4484–1693'	50	66	–	–
'4484–1693' (+F)	40	65	41	61
'1182'	60	69	–	–
'1182' (+F)	63	70	48	64
CL161	58	66	54	65
CL161 (+F)	59	66	–	1

On silt loam soil at Eagle lake (Fig. 3 and Table 11), applying fungicide to the inbreds (45 lb/acre PP, 80 lb/acre PF and 60 lb/acre PI, plus 135 lb/acre for the ratoon crop preflood) or a higher rate of nitrogen to the hybrids (90 or 120 lb/acre preflood and 30 lb/acre at boot, plus 135 lb/acre for the ratoon crop preflood, with no fungicide) did not have a consistent effect on yield or milling quality. Main crop hybrids had higher yields than the inbreds, and usually higher total yields as well. XL723 and CLEARFIELD XL745 had the highest total crop yields. Bowman had the highest MC yield among the inbreds, but ratoon yield data are not available for Bowman and several other cultivars. Rondo (4484-1693) lodged extensively at Eagle Lake under both nitrogen rates and with or without fungicide. The total crop yields of CL151 were fairly competitive with hybrid crop yields because of its large ratoon yield. Catahoula and Cocodrie were among the better millers.

Fig. 4 plus Table 12, and Fig. 5 plus Table 13, provide the results for earlier planting dates at Beaumont and Eagle Lake, respectively. Neither fungicide nor a higher N treatment was applied in these studies.

*2009 data unavailable at time of deadline for submission of revisions. These will be provided as an update to the Texas Rice Production Guidelines.

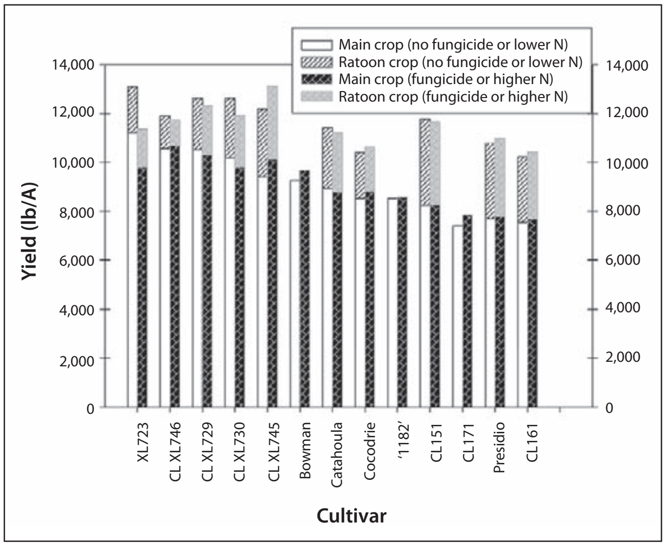

Figure 3. 2008 variety evaluation, April 3 planting, Eagle Lake, Tx.

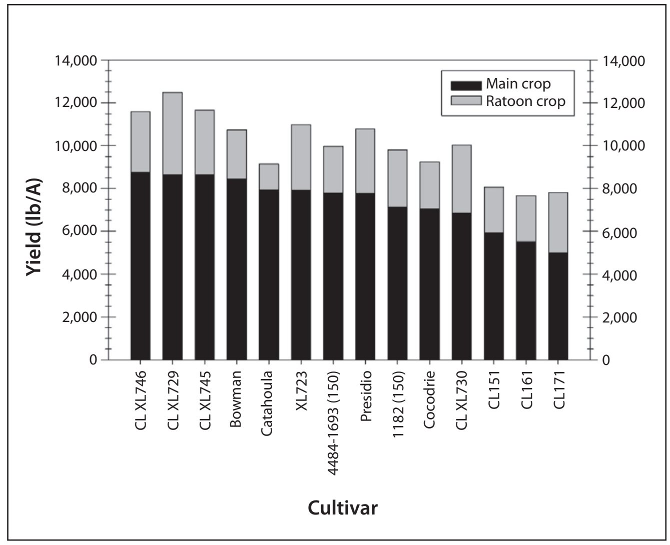

Figure 4. 2008 variety evaluation, early planting, Beaumont, Tx.

Table 11. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted March 27 on sandy soil at Eagle Lake, Texas, in 2006.

Cultivar–EL	MC% whole	MC% total	RC% whole	RC% total
XL723	55.8	69.1	63.2	72.9
XL723 (HI N)	55.8	69.1	62.2	72.9
CL XL746	57.2	70.8	58.7	73.0
CL XL746 (HI N)	56.7	70.4	59.3	72.8
CL XL729	54.4	69.3	64.2	73.1
CL XL729 (HI N)	54.5	69.2	60.3	72.7
CL XL730	55.0	70.0	61.8	72.9
CL XL730 (HI N)	54.9	69.9	59.6	72.7
CL XL745	55.9	71.0	58.1	73.3
CL XL745 (HI N)	55.9	70.4	58.0	72.8
Bowman	55.8	68.4	64.7	–
Bowman (+F)	56.4	69.3	65.3	–
Catahoula	62.7	71.8	64.7	73.6
Catahoula (+F)	62.5	72.3	65.3	74.1
Cocodrie	58.4	69.4	65.7	73.8
Cocodrie (+F)	61.3	70.4	63.2	73.5
'1182'	58.6	67.7	–	–
'1182' (+F)	57.4	67.4	–	–
CL151	57.4	69.8	60.4	72.4
CL151 (+F)	58.3	70.6	61.1	72.5
CL171	58.8	70.3	–	–
CL171 (+F)	59.6	70.3	–	–
Presidio	59.6	68.6	57.5	71.0
Presidio (+F)	59.2	68.2	59.9	71.4
CL161	57.1	68.3	65.2	73.5
CL161 (+F)	59.5	69.6	64.4	73.6

Table 12. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted March 6 on clay soil at Beaumont, Texas, in 2006.

Cultivar BMT	MC% whole	MC% total	RC% whole	RC% total
CL XL746	58	68	57	69
CL XL729	57	67	59	69
CL XL745	59	70	54	67
Bowman	56	67	48	65
Catahoula	54	69	53	68
XL723	58	69	59	70
'4484–1693' (150)	49	63	42	63
Presidio	62	70	56	69
'1182' (150)	56	70	55	67
Cocodrie	52	67	57	70
CL XL730	56	67	55	68
CL151	51	67	55	66
CL161	53	65	59	70
CL171	52	65	57	69

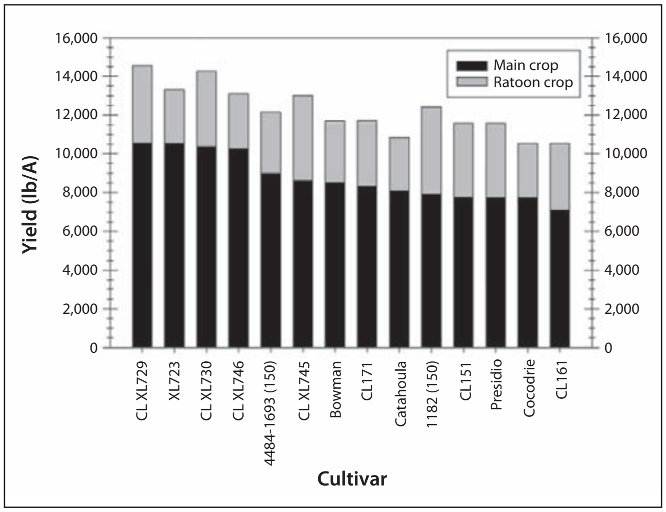

Figure 5. 2008 variety evaluation, March 20 planting, Eagle Lake, Tx.

Table 13. Main crop (MC) and ratoon crop (RC) yield and MC milling for varieties and hybrids planted March 7 on sandy soil at Eagle Lake, Texas, in 2006.

Cultivar–EL	MC% whole	MC% total	RC% whole	RC% total
CL XL729	55	79	62	71
XL723	55	70	61	72
CL XL730	54	71	63	72
CL XL746	54	70	61	72
4484–1693 (150)	46	67	53	69
CL XL745	53	71	60	72
Bowman	55	70	54	69
CL171	58	71	61	71
Catahoula	52	73	63	73
'1182' (150)	56	70	59	71
CL151	56	71	63	72
Presidio	54	70	61	71
Cocodrie	57	70	61	72
CL161	59	70	63	72

Weed Management

G. N. McCauley and S. A. Senseman

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 weed seed;
- 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 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 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. See Table 14 for weed response ratings for rice herbicides.

Preemergence herbicides

Bolero® 8E

1–2 pt product/acre
(2.0–4.0 lb a.i./acre)

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

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

Broadhead® 70DF

4.0–12.0 oz product/acre + surfactant

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

Command®

0.7–1.6 pt product/acre
(0.4–0.6 lb a.i./acre)

Strengths:

- Provides excellent control of grassy weeds
- Very economical

Weaknesses:

- Rate dependent on soil texture
- Application technique critical
- Does not control nutsedge or broadleaf and aquatic weeds

Facet® 75DF

0.33–0.67 lb product/acre
(0.25–0.50 lb a.i./acre)

Strengths:

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

Weaknesses:

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

Facet® 75DF + Bolero® 8EC

1–2 pt + 0.33–0.67 lb product/acre
(0.25–0.50 + 2.0–4.0 lb a.i./acre)

Strengths:

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

Weakness:

- Does not control broadleaf weeds

Permit®

0.67–1.34 oz product/acre + surfactant
(0.031–0.062 lb a.i./acre)

Strengths:

- Excellent control of sedges
- Safe on rice

Weaknesses:

- Does not control grassy weeds
- Narrow weed spectrum

Prowl® H20

1.5–2.0 pt product/acre
(0.75–1.0 lb a.i./acre)

Strengths:

- Good control of grassy weeds
- Residual control

Weaknesses:

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

Postemergence herbicides

Aim® EC

1.6–3.2 fl oz product/acre + surfactant
(0.025–0.05 lb a.i./acre)

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

Basagran®

1.5–2.0 pt product/acre
(0.75–1.0 lb a.i./acre)

Strengths:

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

Weaknesses:

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

Blazer®

1 pt product/acre + surfactant
(0.25 lb a.i./acre)

Strengths:

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

Weakness:

- Very narrow weed spectrum

Broadhead® 70DF

4.0–12.0 oz product/acre + surfactant

Strengths:

- Broad spectrum weed control
- Contact and residual control
- Season long control of susceptible weeds
- Water management not critical
- Safe on rice

Weaknesses:

- Rate dependent on soil texture
- Restricted from use on sand
- Sensitive to standing water after application

Clincher® SF

3.0–6.0 qt product/acre + 1 qt COC /acre

Strengths:

- Broad spectrum weed control
- Safe on rice

Weaknesses:

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

Duet®

6.6 – 8.3 lb product/acre + surfactant

Strengths:

- Broad spectrum weed control
- Safe on rice

Weaknesses:

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

Facet® 75DF

0.33–0.67 lb product/acre + COC
(0.25–0.50 lb a.i./acre)

Strengths:

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

Weakness:

- Narrow spectrum control

Grandstand R®

0.67–1.0 pt product/acre + surfactant
(0.25–0.38 lb a.i./acre)

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 Stam M4 or Stam 80 EDF

Weaknesses:

- Water management critical—delay flooding for 72 hours after application
- Does not control grasses
- May cause injury on young rice

Grasp®

2.0–2.3 fl oz product/acre + COC or MSO
(0.031–0.036 lb a.i./acre)

Strengths:

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

Weakness:

- Antagonism from Stam on alligatorweed

GraspXtra®

16.0–18.0 fl oz product/acre + COC or MSO
1.0 qt/acre

Strengths:

- Residual control for some weeds and barnyardgrass
- Broad spectrum control of broadleaf weeds, flatsedges and barnyardgrass
- Excellent control of alligatorweed

Weaknesses:

- Antagonism from Stam on alligatorweed
- Water management critical
- Minimum 10 gal/acre spray volume

Londax®

1.00–1.66 oz product/acre + surfactant
(0.6–1.0 oz a.i./acre)

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®

0.67–1.34 oz product/acre + surfactant
(0.031–0.062 lb a.i./acre)

Strengths:

- Excellent control of sedges
- Safe on rice

Weaknesses:

- Does not control grassy weeds
- Narrow weed spectrum

RebelEx®

16.0–18.0 fl oz product/acre + COC or MSO
1.0 qt/acre

Strengths:

- Residual control for some weeds and barnyardgrass
- Broad spectrum control of broadleaf weeds, flatsedges and barnyardgrass

Weaknesses:

- Antagonism from Stam on alligatorweed
- Moist soil critical
- Water management critical
- Minimum 10 gal/acre spray volume

Regiment®

0.40 – 0.57 oz product/acre + either an approved surfactant and 2% UAN or an approved surfactant that contains UAN
(11.25–15.0 gm a.i./acre)

Strengths:

- Broad spectrum control of broadleaf weeds and flatshedges
- Excellent control of large barnyardgrass
- Good control of alligatorweed

Weakness:

- No residual control

RiceBeaux®

3.0–5.3 qt product/acre + surfactant

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 and hemp sesbania

RicePro®

3.0–6.0 qt product/acre acre + COC 1.0 qt/acre

Strengths:

- Safe on rice
- Broad spectrum weed control

Weakness:

- Poor control of sprangletop and smartweed

RicePyr® LC

3.0–4.5 qt product/acre

Strength:

- Broad spectrum weed control

Weaknesses:

- Water management critical—delay flooding for 72 hours after application
- May cause injury to young rice

Ricestar HT®

13.0–17.0 fl oz product/acre
(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

Stam M4 OR 80 EDF

2.0–4.0 qt or 3.75–5.0 lb product/acre
(2.0–4.0 lb a.i./acre)

Strengths:

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

Weaknesses:

- No control of sprangletop or dayflower
- No residual control
- Performance dependent on environmental conditions
- Phytotoxic interaction with certain insecticides
- Always use surfactant or COC with Stam 80 EDF

Stam M4 + Aim® EC

2.0–4.0 qt + 1.6–3.2 fl oz product/acre
(2.0–4.0 lb + 0.025–0.05 lb a.i./acre)

Strength:

- Broad spectrum weed control

Weaknesses:

- No residual control
- Most effective on small weeds

Stam M4 + Basagran®

2.0–4.0 qt + 1.5–2.0 pt product/acre
(2.0–4.0 + 0.75–1.0 lb a.i./acre)

Strengths:

- Safe on rice
- Broad spectrum weed control

Weaknesses:

- No residual control
- Does not control sprangletop

Stam M4 + Bolero® 8E

2.0–4.0 qt + 1–2 pt product/acre
(2.0–4.0 + 2.0–4.0 lb a.i./acre)

Strengths:

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

Weakness:

- Poor control of broadleaf signalgrass, Texasweed and hemp sesbania

Stam M4 + Grandstand R®

1.0–4.0 qt + 0.5–0.67 pt product/acre
(1.0–4.0 + 0.19–0.25 lb a.i./acre)

Strength:

- Broad spectrum weed control

Weaknesses:

- Water management critical—delay flooding for 72 hours after application
- May cause injury on young rice

Stam M4 + Permit®

2.0–4.0 qt + 0.67–1.34 oz product/acre
(2.0–4.0 + 0.031–0.062 lb a.i./acre)

Strengths:

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

Weaknesses:

- No residual control
- Weak on sprangletop

Storm®

1.5 pt product/acre + surfactant

Strengths:

- Safe on rice

- Excellent control of yellow nutsedge, dayflower and hemp sesbania

Weaknesses:
- No residual control
- Does not control grassy weeds

Strada®

1.7–2.1 oz product/acre + surfactant (0.053–0.066 lb a.i./acre)

Strengths:
- Excellent control of sedges
- Good control of selected broadleaves
- Safe on rice
- Good tank mix partner in the CLEARFIELD* system

Weakness:
- Does not control grassy weeds

Post-flood herbicides

2,4-D Amine 4E

1.5–2.5 pt product/acre + surfactant (0.75–1.25 lb a.i./acre)

Strengths:
- Very economical
- Good control of broadleaf weeds

Weaknesses:
- Timing of application critical
- Apply between tillering and panicle initiation
- No residual control

Clincher® SF

13.5–15.0 fl oz product/acre + COC or MSO (0.25–0.28 lb a.i./acre)

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

Weakness:
- Does not control broadleaf weeds or sedges

Grasp®

2.3–2.8 fl oz product/acre + COC or MSO (0.036–0.044 lb a.i./acre)

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

Weakness:
- Does not control broadleaf signalgrass, sprangletop or fall panicum

GraspXtra®

16.0–18.0 fl oz product/acre + COC or MSO 1.0 qt/acre

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

Weaknesses:
- Antagonism from Stam on alligatorweed
- Minimum 10 gal/acre spray volume
- Do not apply after rice reaches ½ inch internode

Permit®

0.67–1.34 oz product/acre + surfactant (0.031–0.062 lb a.i./acre)

Strengths:
- Excellent control of sedges
- Safe on rice

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

Permit® - Seed head suppression

1.0–1.34 oz product/acre + surfactant (0.046–0.062 lb a.i./acre)

Strengths:
- Hemp sesbania and northen joint vetch
- Safe on rice

Weaknesses:
- Do not apply within 48 days of harvest
- Narrow weed spectrum

RebelEx®

18.0–20.0 fl oz product/acre + COC or MSO 1.0 qt/acre

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

Weaknesses:
- Antagonism from Stam on alligatorweed
- Moist soil critical
- Water management critical
- Minimum 10 gal/acre spray volume
- Do not apply within 60 days of harvest

Regiment®

0.40–0.57 oz product/acre + either an approved surfactant and 2% UAN or an approved surfactant that contains UAN (11.25–15.0 gm a.i./acre)

Strengths:
- Broad-spectrum control of broadleaf weeds and aquatic weeds
- Excellent control of large barnyardgrass

Weakness:
- No residual control

Table 14. 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
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
Permit	–	–	–	P	P	E	–	P	P	E	P	G	P	G	P	G	E	P	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[2]	P	P	P	P	P	P	P	P	F	F	F	F	P	E	E	E	G	E	G	F
Basagran[2]	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[3]	P	P	P	P	P	P	P	P	G	F	P	F	G	G	E	G	P	G	G	F
Grandstand R + Stam[3]	P	P	P	P	P	P	G	G	G	F	F	G	G	E	E	E	F	G	G	F
Grandstand R + Permit[3]	P	P	P	P	P	E	E	F	G	F	F	F	G	G	E	E	F	G	G	F
Grasp	G	P	P	P	P	F	E	G	F	G	E	E	P	G	F	G	G	P	G	G
GraspXtra	E	P	P	P	P	F	E	G	E	E	E	E	F	E	E	E	E	E	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
RebelEx	E	P	F	G	P	F	E	G	F	E	E	E	P	E	F	E	G	G	G	G
Regiment	E	P	P	P	P	P	G	P	F	G	G	F	P	G	F	G	G	G	F	G
RiceBeaux	E	E	E	G	P	P	G	E	G	G	G	G	F	G	P	G	P	G	G	P
RicePro	E	E	E	P	P	P	F	G	F	P	F	G	P	G	G	G	P	F	F	P
RicePyr LC	P	P	P	P	P	P	G	G	G	F	F	G	G	E	E	E	F	G	G	F
Ricestar HT	E	E	E	E	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Stam[2]	E	E	E	P	P	P	F	G	F	P	F	G	P	G	P	G	P	G	F	P
Stam + Aim	E	E	E	P	P	P	P	P	F	F	F	G	P	E	E	E	G	E	G	P
Stam + Basagran	E	E	E	P	P	G	G	G	G	E	E	G	G	G	P	G	G	G	F	P
Stam + Bolero	E	E	E	G	P	P	G	E	G	G	G	G	F	G	P	G	P	G	G	P
Stam + Permit	E	E	E	P	P	E	G	G	F	P	F	G	P	G	P	G	P	G	F	P
Stam + Strada	E	E	E	E	P	G	E	G	E	E	G	G	P	E	G	E	F	G	G	G
Strada	P	P	P	P	P	G	E	–	E	G	G	G	–	E	G	E	F	–	G	F
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[3]	P	P	P	P	P	P	G	G	E	E	E	E	F	F	E	E	F	E	E	G
Clincher	G	P	E	E	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Grasp	G	P	P	P	P	F	G	G	F	G	E	E	–	G	P	G	G	G	–	G
GraspXtra	E	P	P	P	P	F	E	G	E	E	E	E	–	E	E	E	E	E	F	E
Permit	P	P	P	P	P	E	G	P	P	P	P	P	P	P	P	G	P	P	P	P
RebelEx	E	F	G	G	P	F	E	G	F	E	E	E	–	E	P	E	G	G	F	G
Regiment	E	P	P	P	P	P	G	P	F	G	G	F	P	G	F	G	G	G	F	G
Clearfield* System																				
Beyond	–	–	–	–	E	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Newpath	E	E	E	F	E	G	E	G	G	F	F	P	P	P	G	P	G	P	F	P
Clearpath	E	E	E	F	E	G	E	G	G	F	F	G	P	G	G	F	G	F	F	P

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

[1] water-seeded rice, [2] early postemergence and [3] mid-season

CLEARFIELD* System

Beyond®

5.0 oz product/acre + COC (0.04 lb a.i./acre)

Strengths:

- Controls red rice escapes in CLEARFIELD*
- Limited carryover

Weaknesses:

- Restricted to imidazolinone-tolerant rice varieties or hybrids possessing the second generation tolerance trait
- Cannot be tank mixed with other herbicides
- Can be used only after two applications of Newpath at 4 oz product/acre (0.0625 lb a.i./acre)
- Timing critical
- ⅔ of red rice must be exposed at application

Clearpath®

0.5–0.72 lb product/acre + COC

Strengths:

- Excellent control of red rice, grassy weeds and nutsedge
- Adds broadleaf control to the CLEARFIELD* system
- Can be applied preplant, preemergence, or postemergence
- Residual control

Weaknesses:

- Application timing and water management critical
- CLEARFIELD* varieties must be grown
- Clearpath must be preceded or followed by Newpath
- Restricted to imidazolinone-tolerant rice varieties or hybrids possessing the second generation tolerance trait

Newpath®

4.0–6.0 oz product/acre + COC (minimum of 12.8 oz) for postemergence applications (0.0625 a.i./acre)

Strengths:

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

Weaknesses:

- Application timing and water management critical
- Seasonal application not to exceed 12 oz/acre
- Chemical rate, water volume and adjuvant rate are critical
- CLEARFIELD varieties must be grown
- Two applications required (only soybeans can be planted after 12 oz product/acre)
- Restricted to imidazolinone-tolerant rice varieties or hybrids possessing the second generation tolerance trait

Red Rice Management

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 is 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. 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 supression.

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.

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 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 after 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 use the fall or spring stale seedbed cultural management system as described in the Land and Seedbed Preparation chapter. Keep it idle or stale to allow germination and growth of red rice. If necessary, fields may 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 in moist soils. Normal production practices are then followed. 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.

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 post-emergence 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 Management

*X. G. Zhou, Y. Jo and D. E. Groth**

Rice diseases are a serious limiting factor in the production of rice in Texas. Texas provides a warm, humid climate favorable for the epidemic development of many diseases. It is estimated that diseases annually reduce rice yields an average of 12 percent across the Texas Rice Belt.

There are many diseases damaging to Texas rice production. They are caused by pathogenic fungi, bacteria, viruses and nematodes. They also can be caused by physiological and environmental disorders. Fungal diseases are the major diseases affecting Texas rice. These fungal diseases include sheath blight, blast, stem rot, narrow brown leaf spot, brown leaf spot, black sheath rot, false smut, and kernel smut. Bacterial panicle blight caused by *Burkholderia glumae* and *B. gladioli* is present in Texas. However, the extent of its occurrence and economic significance in Texas is unknown. Straighthead caused by a physiological disorder can result in a significant reduction in yield and quality of rice. Fortunately, Texas and other U.S. rice-producing states currently do not have any serious viral or nematode diseases.

Over the past decade many changes in rice production practices designed to obtain maximum yields have also created conditions favorable for diseases. Some of these practices include increased nitrogen fertilization, widespread use of varieties very susceptible to sheath blight, shortened rotations, and more dense plant canopies.

Several options for management of rice diseases are available. However, employing single disease management options are frequently not very effective or sustainable. Rice producers must try to manage disease losses through an integrated use of resistant varieties, sound cultural practices, and chemical controls.

Sheath blight

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

Typical symptoms are characterized by large oval lesions on leaf sheaths and irregular lesions on leaf blades.

The initial lesions on leaf sheaths are circular, oval or ellipsoid, and greenish-gray and usually develop a little above the waterline. The lesions enlarge and coalesce forming bigger lesions with irregular outlines and grayish-white centers surrounded by dark brown borders. As lesions coalesce on the sheaths, entire leaves eventually die. Lesions on the leaf blades are more irregular with dark green, brown or yellow-orange margins. The lesions usually coalesce on leaf blades producing a rattlesnake skin pattern. Sclerotia, the survival structures of the fungus, may form on the surfaces on some sheaths and leaf blades. The pea-sized sclerotia are white when first formed, and then turn brown or dark brown. Diseased plants reduce grain filling, especially in the lower portion of the panicles. Losses in yield also are associated with increased lodging or reduced ratoon crop production.

A change in cultural practices during the 1980s is the reason for sheath blight becoming an important disease. 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 towards shorter crop rotations has made the disease more troublesome by allowing the fungus to increase in quantity within fields. None of the leading high yielding varieties have acceptable levels of resistance to sheath blight. As a result, rice producers have increased their reliance on fungicides to manage sheath blight.

Cultural control

To effectively and economically reduce losses from sheath blight, use an integrated management approach. 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 sheath blight or limit its effects where the problem exists. Some recommended cultural practices include:

- Avoid excessive seeding rates, which result in a very dense canopy that creates a moist microclimate favorable to disease development;
- Avoid excessive rates of nitrogen fertilization, which increase the severity of the disease;
- Where possible, increase 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 an average incidence of sheath blight of 0.4, 2.7 and 5.4 percent, respectively, at panicle differentiation (PD). In addition, more sheath blight inoculum for future rice crops tends to be produced in drilled soybeans than in row-planted soybeans; and
- Control grass weeds that can serve as hosts of the sheath blight fungus. Barnyardgrass, crabgrass and broadleaf signalgrass are among the most common weed hosts of the pathogen.

Variety selection

Long grain rice varieties differ in their susceptibility to sheath blight. Among those considered very susceptible are CL131, CL161, CL171, Cocodrie, Trenasse and Cybonnet (Table 17).

Less susceptible are Cheniere, Jefferson, Wells, Spring, Saber, and most of the medium grain and hybrid varieties. Taller varieties tend to sustain less loss than semidwarf varieties.

Chemical control

Several fungicides are available for effective control of sheath blight (Table 16). In many situations, foliar fungicides may be economically justified for reducing losses from sheath blight if:

- 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 PD growth stage (Fig. 6). 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). Remember, under very favorable conditions any variety can benefit from a fungicide for sheath blight control.

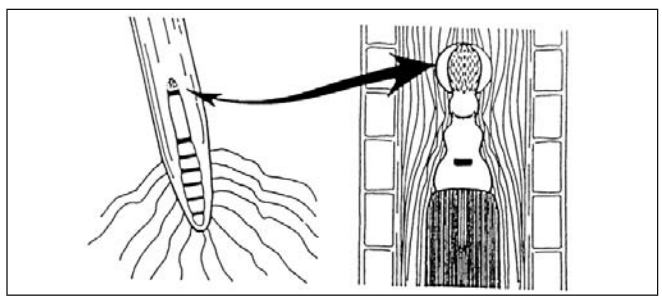

Figure 6. Panicle differentiation (PD).

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 (Fig. 7), periodically observing rice 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 sampling tool can be made from a ¾ inch PVC pipe fashioned into the shape of a “T,” with a 4 foot handle connected by a “T” joint to two, 14 inch lat-

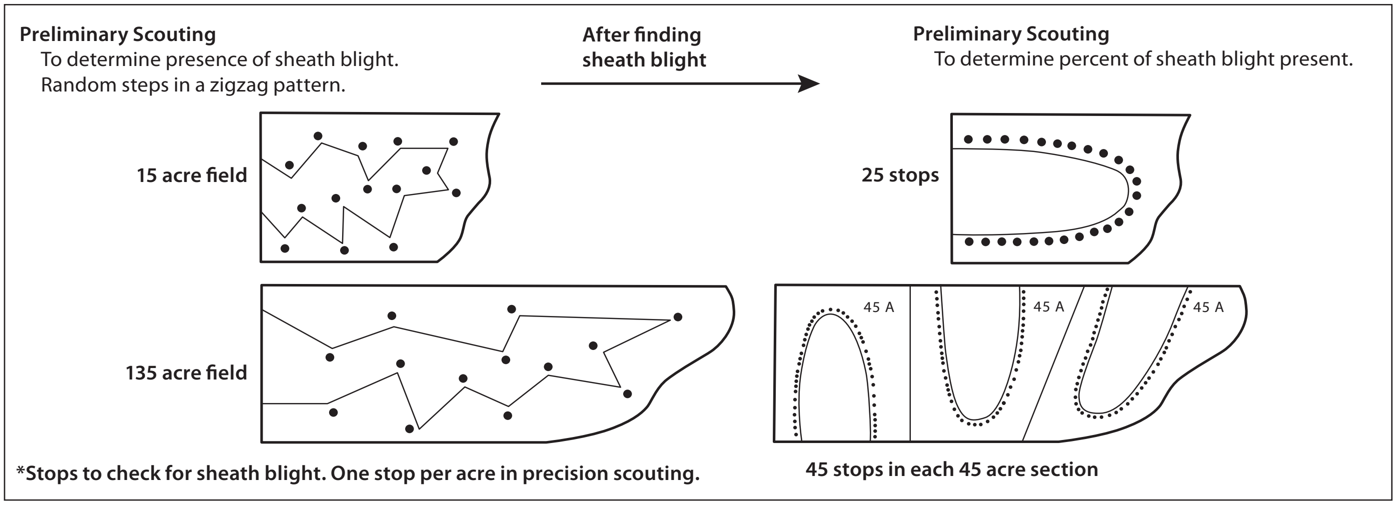

Figure 7. Suggested scouting procedure for sheath blight.

eral 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 inspect each section separately (Fig. 7). 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 (Table 15). With very susceptible and susceptible varieties, 35 percent positive stops indicate that a fungicide is necessary. A moderately susceptible variety requires 50 percent positive stops to justify a fungicide treatment. In the past, two fungicide applications were necessary to control sheath blight but with the advent of more effective fungicides and economic restraints, a single application is generally used. Fungicides are normally applied from 7 days after PD to 50 to 70 percent heading. Earlier applications tend to weather off too soon to obtain season long control and late applications can allow sheath blight to cause significant damage early in the season. As with blast, fungicides must be applied by the heading growth stage since control is greatly reduced with as little as a 5 day delay.

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.

Table 15. Threshold guidelines suggested for economical fungicide application for management of sheath blight.

Sheath blight susceptibility	Positive stops	Infected tillers
Very susceptible varieties: CL131, CL161, CL171, Cocodrie, Trenasse, Cybonnet, Cypress	35%	5%
Moderately susceptible to moderately resistant varieties: Jefferson, Wells, Spring, Saber, Cheniere, many medium grain varieties, hybrid varieties	50%	10%

Table 16. Fungicides for rice foliar disease control.

Material	Rate/A and timing
Gem® 500 SC	3.8-4.7 fl oz @ (PD+5 days) to 50% heading
Moncut® 70 DF	0.5-0.71 lb @ PD and 10-14 days later or 0.5-1.0 lb @ (PD+10 days) to heading
Propimax®	10.0 fl oz @PD to late boot
Quadris®	9.0-12.5 fl oz @ (PD+5 days) to 50% heading
Quilt®	21.0-34.5 fl oz @ (PD+5 days) to late boot
QuiltXcel® (contains 0.56 lb ai/gal more azoxystrobin than Quilt®)	15.75-27 fl oz applied as a preventative @ 90% panicle emergence, depending on disease
Stratego®	14.0-19.0 fl oz @ (PD+5 days) to late boot
Tilt®	6.0-10.0 fl oz @ PD to late boot
Bumper ® 41.8 EC	6.0-10.0 fl oz @ PD to late boot

[1]See product label for details on application rates and timing.
Some other 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® 6.4-9.8 fl oz/A at late boot and again at early heading when 50 to 70 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 more effective.

The thresholds suggested do not take into account the possibility of second cropping (ratoon cropping) the field being evaluated. They are based on only one harvest.

It is well documented that when sheath blight is controlled by fungicides in the main crop, a significant increase in yield also can occur in the ratoon 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 can develop rapidly and make the original threshold determination obsolete. Sheath blight should be monitored periodically during the development of the rice crop through heading. Evaluate alternatives at each step.

Rice blast

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

The blast fungus causes leaf symptoms (spots and lesions) on young plants, from the seedling to tillering stages, and panicle blast or rotten neck symptoms after heading. Leaf lesions are football or spindle-shaped and elongated with brown to purple-brown borders and grayish centers. Leaves and whole plants are often killed when the disease is severe, especially in upland or non-flooded situations.

The rotten neck phase of the disease is commonly observed 5 to 10 days after head emergence. With rotten neck, a brownish lesion at the node at the base of the panicle often prevents the grains from filling or weakens the neck of the panicle so that filled panicles easily break before harvest.

Selecting varieties resistant to blast is the most effective method for management of blast. However, the rice blast fungus is a highly variable pathogen and there are many pathogenic races. In recent years, the races IC-17 and IB-49 have been the most prevalent in Texas. The adoption of varieties with resistance to these races of blast has greatly reduced losses. For the past few years, the occurrence of the disease has been sporadic in Texas and the disease has not been observed in some Texas rice-producing areas.

Chemical control of blast usually is not recommended when resistant or moderately resistant varieties (Table 17) are planted. When moderately susceptible or susceptible varieties are grown in areas where blast has historically occurred, preventive applications of triazole and/or strobilurin (e.g., Gem®, Quadris®, Stratego® or Quilt®) 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 Gem®, Quadris®, Stratego® or Quilt® (Table 16) 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 panicle length emerged.

The late boot application is most important if there is a large number of leaf lesions caused by blast. The heading application is more important to protect panicles from spore showers. The heading growth stage is critical for blast control since a delay of as little as 5 days can greatly reduce fungicide efficacy. Blast is favored by excessive nitrogen fertility, thick stands, light sandy soils, and inadequate flooding.

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 seed-like structures called sclerotia, which can survive in the soil for up to 6 years, serving as the primary source for disease infection.

Stem rot is initiated when the sclerotia float to the water surface and infect the rice plant at the waterline. At first, small, rectangular, black lesions develop on the sheath. Later these lesions enlarge as the fungus penetrates inward toward the culm. In the later stages of crop maturity, large areas within infested fields may begin to lodge soon after drainage has begun. Within infected culms and sheaths, numerous tiny, black sclerotia can be seen.

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

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

Crop rotation, increased potassium levels, and lower nitrogen fertilization in fields with a history of stem rot are recommended management practices.

Narrow brown leaf spot

Narrow brown leaf spot (also called Cercospora leaf spot), caused by the fungus *Cercospora janseana,* causes more yield and grain loss than is often suspected. Yield losses of up to 40 percent have been reported in research studies. The disease can cause premature ripening, yield reduction, and reduced milling quality. The severity of the disease has increased over years and the disease is considered one of the important rice diseases in Texas.

The fungus attacks the leaves, sheaths, internodes, panicle branches, 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 results in a large, brown blotch or "net blotch" caused by the browning of the leaf veins.

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.

Some varieties show less susceptibility than others; planting varieties resistant to narrow brown leaf spot (Table 17) is a good option for managing the disease. However, resistance may be not durable since new pathogen races can develop quickly.

Fungicides are available for control of this disease. When narrow brown leaf spot is severe enough to justify chemical control, Tilt®, PropiMax®, Bumper®, Stratego® or Quilt® fungicides containing propiconazole active ingredient should be applied in the mid to late boot stage.

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 many years.

Table 17. Disease reaction of rice varieties in Texas

Rice variety	Blast	Sheath blight	Kernel smut	Bacterial panicle blight	Brown leaf spot	Narrow brown leaf spot	Straighthead
Banks	MR	MR	—	MR	MR	R	MS
Bengal	S	MS	MS	VS	MR	MS	VS
Catahoula	R*	S*	—	MS*	—	—	S*
CL131	MS*	VS*	—	VS*	MR*	VS*	S*
CL151	S*	S*	—	S*	—	—	VS*
CL161	S	VS	S	S	MS	MS	MR
CL171-AR	MR	VS	S	S	MR	MS	MS
CLEARFIELD XL729	R	MR	MS	MR	MS	R	MR
CLEARFIELD XL730	R	MS	MS	MR	MR	R	MR
CLEARFIELD XP745	MR	MR	MS	MR	MS	R	—
Cheniere	S	MS	S	MS	MR	S	MR
Cocodrie	S	VS	S	S	MR	MS	S
Cybonnet	MR	VS	S	MS	R	MR	MS
Cypress	S	MS	S	VS	MR	MS	MS
Della	S	VS	—	—	S	MR	MS
Dellrose	S	MS	—	—	S	MR	MS
Dixiebelle	S	VS	—	—	R	MS	MR
Francis	S	MR	S	VS	MS	MR	MR
Hidalgo	S	MR	—	—	—	—	—
Jasmine 85	R	R	MS	—	S	R	VS
Jazzman	—	—	—	—	MR**	VS**	—
Jefferson	MR	MR	S	—	MR	MR	MR
Jupiter	MS	MR	MS	R	MR	R	—
Medark	MR	MS	—	MS	MR	R	—
Neches	MR	VS	—	—	—	—	—
Neptune	MR*	MS*	—	R*	—	—	MR*
Pirogue	MS	MR	MS	MR	MR	MR	MR
Presidio	MR	MS	S	—	MR	MS	MR
Saber	R	MR	S	—	R	MS	R
Sierra	MR	VS	—	—	—	—	—
Spring	S	MS	MS	MS	MR	MS	MS
Sabine	S	MS	S	—	—	—	—
Trenasse	MS	VS	S	VS	S	MS	MR
Wells	S	MS	MR	VS	MR	R	MS
XL723	MR	MR	MS	MR	MS	R	MR
XL744	MR	MR	MS	MR	MS	R	—

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 may show extensive disease development under favorable conditions.
Varieties rated R or MR show significantly less damage under similar conditions.
*Based on disease reaction ratings made in Louisiana.
**Based on 1-year (2009) evaluation made in Texas.

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.

Infected 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 non-grass crops, will help reduce the carryover of fungal inoculum. Thorough disking and maintaining a clean, fallow field from the summer before to planting will allow plant residue to decompose and eliminate weed hosts upon which the pathogen survives.

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 they are never successfully pollinated.

Research at Texas AgriLife 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 bacterial panicle blight.

Recent research conducted in Louisiana shows that bacterial panicle blight is caused by the bacteria *Burkholderia glumae* and *B. gladioli*. Infected 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.

Three important characteristics of bacterial panicle blight separate it from other panicle disorders:

- Bacterial panicle blight often does not appear to prevent successful pollination;
- Infected florets initially have discoloration ranging from light green to light brown on the basal portion with a reddish-brown margin separating this area from the rest of the floret that becomes straw-colored later; and
- The rachis or branches of the panicle remain green for awhile right to the base of each floret, even after the glumes desiccate and turn tan.

Some varieties are more susceptible to bacterial panicle blight than others (Table 17). Varieties with California germplasm, such as Cypress, Maybelle and Cocodrie, seem to be more prone to serious damage by bacterial panicle blight.

Since bacterial panicle blight is seed-borne, the best way to manage the disease is the use of pathogen-free seeds. Timely planting, proper varietal choice, and avoiding excessive seeding and nitrogen rates is also helpful in reducing the damage caused by the disease. Currently, no fungicides are recommended for management of this disease in the U.S.

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. Under favorable weather conditions, these fungi also cause black kernels, resulting from a mass of dark pathogen spores covering the kernels. This often results in poorly developed grains and low milling quality. Some fungicides applied in the mid to late boot stage help suppress ear blight.

False smut

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

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

False smut has historically been a minor disease in Texas, but the recent increase in Arkansas, from a few counties in 1997 to all rice growing counties today, 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, because the disease is more severe under high nitrogen fertility; and
- Limited data suggest that Tilt® applied at late boot gives some control of the disease. This application is probably not economical unless mills start to dock growers for contaminated rice.

Kernel smut

Kernel smut is a serious disease caused by the fungus *Tilletia barclayana (Neovossia horrida)*. The fungus infects and replaces the endosperm of the rice grain completely or partially with a mass of black smut spores. Usually only a few grains per panicle are infected.

Although yield losses are insignificant, monetary losses can be very high if the rice cannot 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. Some varieties (Table 17) 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.

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

Crop rotation, use of high quality planting seed and balanced fertility are recommended controls. Foliar fungicides are not economical for control of either leaf smut or brown spot. Some varieties are less susceptible to brown spot than others (Table 17).

Straighthead

Straighthead is a physiological disorder that causes seeds to blank and heads to remain upright at maturity. Straighthead generally occurs in spots scattered throughout a field.

It is most easily recognized near harvest when normal plants have down-turned 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 non-decaying vegetation has been plowed under soon before planting.

Control of straighthead is mainly achieved by planting resistant varieties (Table 17). When planting a susceptible variety in 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, as leaf blast can intensify in fields that are temporarily drained mid season.

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Insect Management

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

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

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

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

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

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

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

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

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

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

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

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

- preparing a good seedbed
- planting high quality seed at the proper depth, time and rate
- eliminating early weed competition
- employing proper irrigation procedures

Insecticide-herbicide interactions

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

Insecticide regulatory actions

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

Karate®Z

For the 1998 growing season, lambda-cyhalothrin (Karate®) was registered by the EPA to control rice water weevils, fall armyworms, chinch bugs, rice stink bugs, grasshoppers, leafhoppers, selected aphid species and stalk borers. For the 2004 growing season, Karate® was replaced by Karate® Z, which is more concentrated (2.08 versus 1.0 pound of active ingredient per gallon), less susceptible to breakdown by sunlight, safer for handlers and more rainfast than Karate®.

Texas data show Karate® Z to be as effective as, if not more effective than, Karate®. For more information, see Tables 21-24, 31 and 33.

Mustang MAX™

In the winter of 2003, the EPA approved the use of Mustang MAX™ against rice water weevils, fall armyworms, chinch bugs, rice stink bugs, grasshoppers, leafhoppers and selected aphid species. Mustang MAX™ was approved later for stalk borer control.

For more information see Tables 21-24, 31 and 33.

Dimilin® 2L

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

The active ingredient in Dimilin® 2L is diflubenzuron, which sterilizes the eggs developing in female adult rice water weevils and prevents larval emergence from eggs. Thus, Dimilin® 2L must be applied shortly after application of the permanent flood when adult rice water weevils invade rice fields. For more information, see Table 21.

Prolex™

In the spring of 2004, the EPA approved the use of Prolex™ against the rice water weevil, fall armyworm, chinch bug, rice stink bug, grasshoppers, leafhoppers and selected aphid species. The active ingredient in Prolex™ is gamma-cyhalothrin. Prolex™ was approved later for stalk borer control. For more information, see Tables 21-24, 31 and 33.

Trebon™ 3G

In 2009, EPA approved the use of Trebon™ 3G against the rice water weevil. The active ingredient in Trebon™ 3G is etofenprox. Trebon™ 3G is a good option for farmers who grow rice close to crayfish or fish ponds because it is less toxic to these organisms than most other labeled rice water weevil insecticides. In addition, the granular formulation minimizes drift to non-target areas. For more information see Table 21.

Tenchu® 20SG

In the spring of 2008, Tenchu® 20SG (active ingredient dinotefuran) received a Crisis Exemption and in 2009 received a Section 18 Emergency Exemption registration for rice stink bug. We hope to receive another Section 18 registration for the 2010 growing season. Dinotefuran is systemic and Texas data show residual control of 7 to 11 days. The rate of application is 7.5 to 10.5 ounces per acre, which is equal to 0.09375 to 0.131 pound active ingredient per acre. Do not make more than two applications per season; the pre-harvest interval is 7 days.

CruiserMaxx™

In the winter of 2009, EPA approved the use of CruiserMaxx™ against the rice water weevil, chinch bug, aphids, thrips, leafhoppers and grape colaspis (which is not a problem in Texas rice but is in Arkansas and Missouri rice). CruiserMaxx™ does not control stalk borers. The insecticidal active ingredient in CruiserMaxx™ is thiamethoxam, which is systemic; however, this seed treatment also contains three fungicides that control an array of seedling diseases. Because CruiserMaxx™ is a seed treatment, drift is minimal compared to liquid formulations. For more information, see Tables 21 and 22 and the Seedling Disease Management chapter in this bulletin.

Dermacor® X-100

For the 2008 and 2009 growing seasons, Dermacor® X-100 (active ingredient rynaxypyr/chlorantraniliprole) was approved for use in Texas under Section 18 Emergency Exemptions. EPA approved the use of this seed treatment for the 2010 growing season. The target pest for Dermacor® X-100 is the rice water weevil. Texas data from several years show Dermacor® X-100 provides excellent control of rice water weevil, as well as stalk borers (sugarcane borer and Mexican rice borer), when applied to seed at the recommended treatment rates relative to seeding rate (Table 18). In short, Texas data show combinations of seeding and Dermacor® X-100 treatment rates less than 0.06 pound a.i. per acre can compromise control. Data from Texas also suggest Dermacor® X-100 possesses fly larvae (e.g., South American rice miner) activity. In addition, data from other sources indicate good activity against fall armyworm, but minimal activity against chinch bug or other insects with piercing-sucking mouthparts.

The current label prohibits use of Dermacor® X-100 in a water-seeded culture. Because this is a seed treatment, drift of Dermacor® X-100 is minimal compared to liquid formulations.

Table 18. Dermacor® X-100 seed treatment rates – grower guide.

Dermacor® X-100 (fl oz per cwt seed)	Seeding rate (lb per acre) Low	High	lb a.i. per acre range
1.50	100	120	0.06 – 0.07
1.75	90	100	0.06 – 0.07
2.00	80	100	0.07 – 0.08
2.50	60	80	0.06 – 0.08
5.00	30	40	0.06 – 0.08
6.00	n/a	30	0.07

Rice water weevil
(Lissorhoptrus oryzophilus)

Identification and damage recognition

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

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

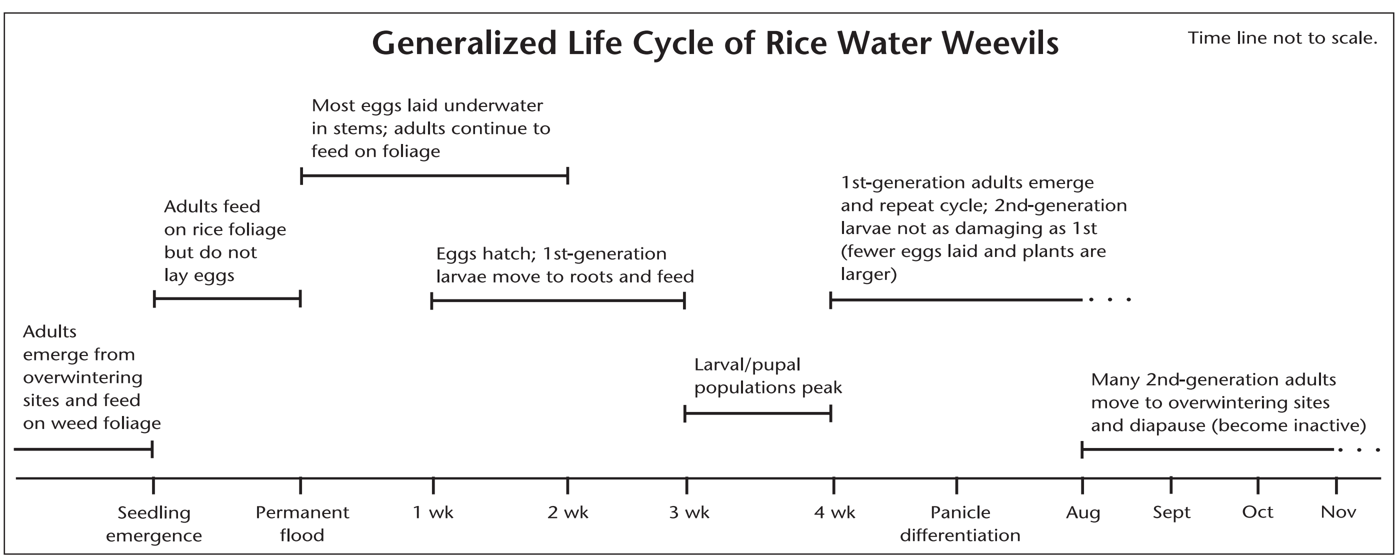

Figure 8. Rice water weevil occurrence during rice production in Texas.

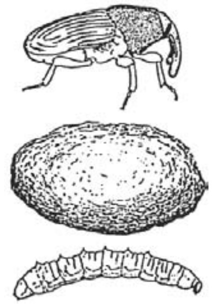

Figure 9. Rice water weevil life stages: adult, ⅛ inch long (top); pupal cell, ⅓ inch long; and larva, ⅓ inch long (bottom).

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

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

The root damage caused by root maggots reduces yield. Damage caused during the main crop can lower the ratoon crop's yield. Research indicates that rice water weevil feeding does not affect milling quality.

Sampling for larvae

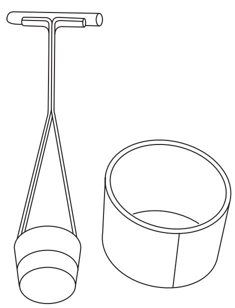

Figure 10. Core sampler and screen bucket.

The rice water weevil core sampler and screen bucket (Fig. 10) 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.

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

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

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

Table 19. Economic injury levels (number of larvae/pupae per core) for rice water weevil.

Estimated main crop yield (lb per acre)	Rough rice price ($ per cwt)	Cost of control ($ per acre)				
		10	15	20	25	30
5,000	6	4.0	6.1	8.1	10.1	12.1
	12	2.0	3.0	4.0	5.0	6.1
	18	1.3	2.0	2.7	3.4	4.0
	24	1.0	1.5	2.0	2.5	3.0
6,000	6	3.0	4.5	6.1	7.6	9.1
	12	1.5	2.3	3.0	3.8	4.5
	18	1.0	1.5	2.0	2.5	3.0
	24	0.8	1.1	1.5	1.9	2.3
7,000	6	2.4	3.6	4.8	6.1	7.3
	12	1.2	1.8	2.4	3.0	3.6
	18	0.8	1.2	1.6	2.0	2.4
	24	0.6	0.9	1.2	1.5	1.8
8,500	6	2.1	3.2	4.3	5.3	6.4
	12	1.1	1.6	2.1	2.7	3.2
	18	0.7	1.1	1.4	1.8	2.1
	24	0.5	0.8	1.1	1.3	1.6

Research in Texas conducted over a 6-year period from 2002 to 2007 with the variety Cocodrie revealed that one larva per core (4-inch diameter by 4-inch deep soil core containing at least one rice plant) reduces yield about 1 percent. For instance, if you expect to produce 7500 pounds per acre and you have an average of one larva per core, you can expect to lose 75 pounds per acre; if you have 10 larvae per core, you can expect to lose 750 pounds per acre. Table 19 shows the economic injury levels (number of larvae/pupae per core) for varying rice prices and costs of control.

Table 20. Relative susceptibility of selected rice varieties to rice water weevil.

Variety	Very susceptible	Susceptible	Moderately resistant
Bengal	✓		
Cheniere	✓		
CL121	✓		
Cocodrie	✓		
Cypress	✓		
Francis	✓		
Saber	✓		
Bolivar		✓	
CL131		✓	
CL161		✓	
Clearfield XL730		✓	
Dixiebelle		✓	
Gulfmont		✓	
Jupiter		✓	
Pirogue		✓	
Presidio		✓	
Trenasse		✓	
Wells		✓	
XL723		✓	
Clearfield XL8			✓
Jefferson			✓
Lemont			✓
Priscilla			✓

Higher yields and rough rice prices mean lower economic injury levels, while higher control costs mean higher economic injury levels. Although these economic injury levels are based on larval densities 3 weeks after flood and current recommended insecticide applications target adults, the relatively low larval densities throughout the table show the importance of controlling rice water weevil.

Sampling for adult feeding activity

Sampling for adult feeding activity was recommended when Furadan® 3G was available. Now that Furadan® 3G cannot be applied on rice, adult sampling is not recommended. Insecticides currently registered for rice water weevil are applied at planting 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 reliable.

Rice water weevil control alternatives

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

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

In general, you can reduce rice water weevil populations and damage by delaying application of the permanent flood. Research shows that applying the flood 4 weeks or longer after emergence can dramatically reduce rice water weevil populations and damage com-

Table 21. Insecticides for rice water weevil control.

Active ingredient/product	Rate per acre: Active ingredient	Rate per acre: Product	Timing of applications
chlorantraniliprole Dermacor® X-100	See Table 18 grower guide		Apply to dry seed.
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.
etofenprox Trebon™ 3G	0.178-0.268 lb	6-9 lb	3 days before to 7 days after permanent flood.
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. 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.
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.
thiamethoxam Cruiser™ 5FS mefenoxam Apron™ XL fludioxonil Maxim® 4FS azoxystrobin Dynasty™ CruiserMaxx™	Depends on seeding rate	3.3 fl oz/cwt 0.44 fl oz/cwt 0.05 fl oz/cwt 0.88 fl oz/cwt	Apply to dry seed.
zeta-cypermethrin Mustang MAX™	0.02–0.025 lb	3.2–4.0 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.

For additional information on these products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

pared to applying the flood 2 weeks after emergence. Data from 2000-2009 show that rice water weevils develop varying population densities on different rice varieties. Also, varieties respond differently to rice water weevil damage. Table 20 lists selected varieties in order of their relative susceptibility to rice water weevil.

Chinch bug
(Blissus leucopterus leucopterus)

Identification, biology and damage

Chinch bugs overwinter as adults. They are black, about ⅛ to ⅙ inch long, and elongate—about three times longer than wide. When viewed from above, the adult appears to have a white "x" on its back. Females are larger than males.

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

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

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

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

Inspect 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.

Texas data show that as few as an average of one chinch bug per two seedlings can cause significant mortality in rice, as well as reduction in height and delay in maturity of the surviving plants. If populations on seedling rice approach an average of one adult per two plants, quick control is suggested. Timely flushing/flooding of fields can help control chinch bugs. Research has shown chinch bug damage is exacerbated by other plant stresses, such as herbicide injury.

Fall armyworm
(Spodoptera frugiperda)

Identification, biology and damage

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

Caterpillars hatch from egg masses deposited by female moths in the field, or they move into rice from

Table 22. Insecticides for chinch bug 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 adult populations approach an average of one per two seedlings.
Sevin® 80WSP	1.0–1.5 lb	1¼–1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼–1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
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.
thiamethoxam			
Cruiser™ 5FS	Depends on seeding rate	3.3 fl oz/cwt	Apply to dry seed.
mefenoxam			
Apron™ XL		0.44 fl oz/cwt	
fludioxonil			
Maxim™ 4FS		0.05 fl oz/cwt	
azoxystrobin			
Dynasty™		0.88 fl oz/cwt	
CruiserMaxx™			
zeta-cypermethrin			
Mustang MAX™	0.0165–0.025 lb	2.64–4.0 fl oz	Apply when adult populations approach an average of one per two seedlings.

For additional information on these products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

Table 23. 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	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
zeta-cypermethrin			
Mustang MAX™	0.02–0.025 lb	3.2–4.0 fl oz	

For additional information on the above products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

adjoining areas. Caterpillars or larvae are light tan to greenish or brownish and are about 1½ inches long when fully grown. They have three yellowish-white, hairlike stripes on the back, a conspicuous inverted "Y" on the head and prominent black tubercles on the body from which hairs arise.

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

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

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

Sampling methods and economic threshold levels

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

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

Grasshoppers

Identification, biology and damage

Several grasshopper species attack rice. The most common and abundant is the meadow grasshopper, Conocephalus fasciatus. This green insect, ⅞ to 1⅛ inches long, feeds on rice leaves and flowers.

Table 24. Insecticides for grasshopper 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	Generally, grasshoppers do not cause economic damage. Apply when defoliation or stem and panicle damage is excessive.
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
methyl parathion	0.5 lb	1 pt (for 4 lb/gal	
Penncap-M®	0.5–0.75 lb	product), 2–3 pt	
zeta-cypermethrin			
Mustang MAX™	0.020–0.025 lb	3.2–4.0 fl oz	

For additional information on the above products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

A more serious pest can be the differential grasshopper, *Melanopsis differentialis*. It is larger (1¼ to 1½ inches long), light brown to yellowish with two black bands on the inside of each jumping leg.

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

Sampling methods and economic threshold levels

In Arkansas, control is recommended when seven to ten 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.

Rice stink bug
(Oebalus pugnax)

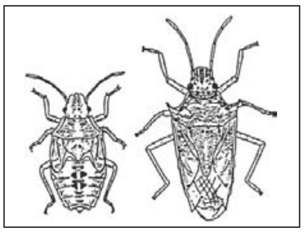

Figure 11. Rice stink bug, nymph and adult.

Identification, biology and damage recognition

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

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

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

Rice stink bug feeding reduces the quality and perhaps quantity of yield. Grains attacked 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. A high percentage of peck also has been correlated with reduced head yield and an increased percentage of broken kernels in milled rice.

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

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

Sampling techniques and economic thresholds

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

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

A recommended technique for sampling rice stink bug populations is to use a 15-inch diameter insect sweep net. When 50 percent of the panicles have emerged (headed), sample the fields once or twice a week until harvest. Sample when the foliage is not wet from dew.

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

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

Formerly, an insecticide application was justified when infestation levels reached or exceeded five or more stink bugs (adults) per 10 sweeps during heading and milk after 75 percent panicle emergence. Thereafter, insecticide applications were applied when 10 or more adults per 10 sweeps were collected.

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

Directions for using variable economic thresholds

1. Monitor the fields with a standard 15-inch diameter, heavy duty sweep net. Take 10 sweep samples in at least 10 randomly selected sites within the field, and calculate the average number of adult rice stink bugs per 10-sweep sample. Sample at least once each week beginning at heading.

2. Determine the stage of average plant development within the field (heading, milk or soft dough) and find the appropriate section of Table 25 (A, B or C). The milk stage occurs about 15 days after heading.
3. Estimate the expected yield (4,500, 6,000 or 7,500 pounds per acre) and find the appropriate columns in Table 25.
4. Find the column within the appropriate yield level that represents marketing conditions:
   - Rice moving into the government loan program (low price situation)
   - Rough rice selling for $9.00 per cwt (moderate price situation) or
   - Rough rice selling for $11.00 per cwt (high price situation)
5. Estimate the cost of an insecticide application ($5.20, $8.35 or $11.50 per acre), and find the row in Table 25 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).

Table 25. Economic thresholds for the adult rice stink bug (RSB) based on Dynamic Programming Analysis for 1989. The numbers in the table indicate the average level of adult RSB per 10 sweep sample at which treatment is economically warranted. A value of 15+ indicates that the threshold exceeds 15 adult RSB.

(A) Adult RSB thresholds at heading

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

(B) Adult RSB thresholds at milk

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

(C) Adult RSB thresholds at soft dough

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

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

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

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

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

Visual sampling

An alternative to sweep net sampling is the use of a 5-foot long sweep stick to determine visually the rice stink bug population level. This method of sampling requires less work and is as reliable as the traditional sweep net method.

Sweep the stick 180 degrees from one side to the other, lightly disturbing the tops of the panicles. While doing this, count the number of adult rice stink bugs observed on the rice or in flight from the area disturbed by the entire length of the stick. Repeat this process for a total of ten sweep stick sweeps per field and calculate the average number of adult rice stink bugs per sweep stick sweep.

The relationship between sweep stick and sweep net counts is given by this formula:

$$SN=(SS + 0.156) \div 0.675$$

where SN = number of adult rice stink bugs caught after ten sweeps with a 15-inch diameter sweep net, SS = number of adult rice stink bugs observed after one sweep of the sweep stick. Using this formula enables you to transform the sweep stick counts into number of insects caught with the sweep net. You can use the resulting number with the variable economic thresholds in Table 25.
When visually sampling for rice stink bugs using the sweep stick, follow the same general recommendations given for sweep net sampling.

Sequential sampling

Sequential sampling is used to classify an insect population as exceeding or not exceeding the economic threshold. If the threshold is exceeded, a management action is needed. With sequential sampling, fewer sample units than conventional sampling usually are required to reach a decision. This saves time. Tables 26 to 29 present sequential sampling plans for the rice stink bug for sweep net and visual sampling. These plans have been created for commonly used economic thresholds in the Texas Rice Belt: five adult rice stink bugs per 10 sweep net sweeps or 3.2 adult rice stink bugs per sweep stick sweep for heading and milk; and 10 adult rice stink bugs per 10 sweep net sweeps or 6.6 adult rice stink bugs per sweep stick sweep for soft dough.

Directions for using the sequential sampling tables

1. Choose the table corresponding to the sampling method to be used and the economic threshold relevant to the stage of the crop.
2. Choose the level of risk. A 20 percent risk level means that out of 10 samples, there is a probability of reaching a wrong decision two times. A lower risk will require taking more sample units.
3. After four sample units have been taken, determine the cumulative number of adult rice stink bugs caught or observed and locate the column that

Table 26. Sequential sampling table for sampling rice stink bugs using the sweep net method (Economic threshold = 5 adult rice stink bugs/10 sweeps, heading and milk stages).

	Cumulative number of adult rice stink bugs					
	10% risk			20% risk		
Sample unit number	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed
4	14 or fewer	15–33	34 or more	16 or fewer	17–26	27 or more
5	18 or fewer	19–38	39 or more	20 or fewer	21–32	33 or more
6	22 or fewer	23–43	44 or more	25 or fewer	26–37	38 or more
7	27 or fewer	28–48	49 or more	30 or fewer	31–42	43 or more
8	31 or fewer	32–54	55 or more	34 or fewer	35–48	49 or more
9	36 or fewer	37–59	60 or more	39 or fewer	40–53	54 or more
10	40 or fewer	–	65 or more	43 or fewer	–	59 or more

corresponds to this number (a sample unit is 10 sweep net sweeps or one sweep stick sweep). If the cumulative number is in the "stop sampling" column, then additional sampling is not required and a decision is reached. If the cumulative number is in the "continue sampling" column, then you need additional sampling.

4. Repeat the process until the cumulative number obtained falls in the "stop sampling" column. If no decision is reached by the tenth sample unit, sample again in a day or two.

Revised Treatment Thresholds

Experiments conducted in Texas in 2005 and 2006 were designed to determine if treatment thresholds for rice stink bug need revision. The old treatment thresholds were published almost 20 years ago and were based on obsolete varieties and cultural practices and outdated market conditions. The recent experiments used Cocodrie grown according to current recommended production practices using field cages infested with rice stink bugs during different stages of grain maturation. The results of these experiments differ markedly from those of the old

Table 27. Sequential sampling table for sampling rice stink bugs using the sweep net method (Economic threshold = 10 adult rice stink bugs/10 sweeps, soft dough stage).

	Cumulative number of adult rice stink bugs					
	10% risk			20% risk		
Sample unit number	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed
4	29 or fewer	30–60	61 or more	33 or fewer	34–50	51 or more
5	38 or fewer	39–70	71 or more	42 or fewer	43–61	62 or more
6	47 or fewer	48–80	81 or more	51 or fewer	52–71	72 or more
7	56 or fewer	57–91	92 or more	61 or fewer	62–82	83 or more
8	65 or fewer	66–101	102 or more	70 or fewer	71–93	94 or more
9	74 or fewer	75–112	113 or more	79 or fewer	80–103	104 or more
10	83 or fewer	–	124 or more	89 or fewer	–	115 or more

Table 28. Sequential sampling table for sampling rice stink bugs using the visual method (Economic threshold = 3.2 adult rice stink bugs/sweep stick sweep, heading and milk stages).

	Cumulative number of adult rice stink bugs					
	10% risk			20% risk		
Sample unit number	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed
4	8 or fewer	9–21	22 or more	10 or fewer	11–17	18 or more
5	11 or fewer	12–24	25 or more	13 or fewer	14–21	22 or more
6	14 or fewer	15–28	29 or more	16 or fewer	17–24	25 or more
7	17 or fewer	18–31	32 or more	19 or fewer	20–27	28 or more
8	20 or fewer	21–35	36 or more	22 or fewer	23–31	32 or more
9	22 or fewer	23–38	39 or more	25 or fewer	26–34	35 or more
10	25 or fewer	–	43 or more	28 or fewer	–	39 or more

Table 29. Sequential sampling table for sampling rice stink bugs using the visual method (Economic threshold = 6.6 adult rice stink bugs/sweep stick sweep, soft dough stage).

	Cumulative number of adult rice stink bugs					
	10% risk			20% risk		
Sample unit number	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed	Stop sampling, control action not needed	Continue sampling	Stop sampling, control action needed
4	19 or fewer	20–38	39 or more	22 or fewer	23–33	34 or more
5	25 or fewer	26–45	46 or more	28 or fewer	29–40	41 or more
6	31 or fewer	32–52	53 or more	34 or fewer	35–47	48 or more
7	37 or fewer	38–59	60 or more	40 or fewer	41–54	55 or more
8	43 or fewer	44–66	67 or more	46 or fewer	47–61	62 or more
9	49 or fewer	50–73	74 or more	52 or fewer	53–68	69 or more
10	55 or fewer	–	81 or more	59 or fewer	–	76 or more

experiments, but recent results seem to corroborate field observations by farmers and crop consultants. However, both old and revised treatment thresholds are included in this chapter.

Basically, results of the recent experiments suggest rice stink bug does not reduce grain or head rice yield, given population densities investigated. Thus, the primary damage caused by rice stink bug is peck. Results also show that late instar nymphs can cause significant peck but not as much as adults. All stages of grain maturation (heading, milk, soft dough and hard dough) are susceptible to rice stink bug damage, but the earlier rice stink bugs enter a field, the more likely it is that more peck will develop. Thus, in general, controlling infestations during heading and milk is very crucial to managing peck. Early infestations initiate the peck-producing process sooner, which allows more time for peck to develop. Also, early populations of rice stink bug, if left uncontrolled, have more time to feed on more grains, which can lead to more peck. In addition, higher yields mean more grain is available for rice stink bug feeding, which implies that rice stink bug damage actually can be diluted by increasing yield (evidence does not show that high-yielding fields attract more rice stink bugs). Certain conditions and assumptions are crucial to these revised treatment thresholds:

1. The goal is to prevent peck damage from exceeding 2 percent (Grades 1 and 2 are not penalized). There are severe penalties for more than 2 percent peck.
2. Rice stink bugs do not affect grain yield or head rice yield.
3. If left uncontrolled, rice stink bug populations will remain at the same level throughout the entire grain maturation period.
4. More grains in a field (i.e., higher yields) dilute rice stink bug damage. Higher yielding fields do not attract more rice stink bugs or cause a change in the feeding behavior of rice stink bugs.
5. Sweep net efficiency is 15 percent. For instance, if 10 rice stink bugs are collected in 10 sweeps, then about 67 rice stink bugs are actually in the area sampled.

Table 30 shows the revised treatment thresholds based on sweep net sampling. When using the sweep net, take 10 consecutive sweeps (one sweep per one step), which is a sample unit. Make sure each sweep covers a 180 degree arc. The top of the net should be level with the tops of the panicles. Take at least four, 10-sweep sample units per field and don't sample near field margins. Your sample units should be distributed over the field. Sample fields at least at the beginning of each grain maturation stage (heading, milk, soft dough and hard dough). To use Table 30, average your sweep net counts for a field. Counts include adult and large nymphs (4th and 5th instars). If your average count per 10 sweeps exceeds the appropriate value in the table, spray. For instance, if you expect a yield of 7,500 pounds per acre and rice is heading, spray your field when your average count is 13 or more rice stink bug adults and large nymphs per 10 sweeps. Keep in mind that these treatment thresholds should be used as a guide to managing rice stink bugs. As more data are generated, these treatment thresholds may change.

Table 30. Revised treatment thresholds for rice stink bug (RSB).

	Average number of RSBs[1]/10 sweeps			
Projected yield (lb/acre)	**Heading**	**Milk**	**Soft dough**	**Hard dough**
4500	8	10	17	47
6000	10	14	22	63
7500	13	17	28	79
9000	16	21	34	94

[1]Includes adults and older nymphs (4th and 5th instars).

Insecticidal management

Research is on-going to determine possible resistance to pyrethroids. 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 rice stink bugs.

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

Treatment decisions may be complicated by uneven stands. Rice stink bugs prefer developing grain. In fields where much of the rice has matured, more rice 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 rice stink bug populations in the field. Unless spot treatments are feasible, decisions are best made using average 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.

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

Table 31. Insecticides for rice stink bug 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 from heading to near harvest when adult rice stink bug populations reach threshold levels.
Sevin® 80WSP	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® 80S	1.0–1.5 lb	1¼ – 1⅞ lb	
Sevin® XLR	1.0–1.5 lb	1–1½ qt	
Sevin® 4F	1.0–1.5 lb	1–1½ qt	
gamma-cyhalothrin			
Prolex™	0.0125–0.02 lb	1.28–2.05 fl oz	
lambda-cyhalothrin			
Karate® Z	0.025–0.04 lb	1.6–2.56 fl oz	
methyl parathion	0.25–0.5 lb	½ – 1 pt (for 4 lb/gal product)	
Penncap-M®	0.25–0.5 lb	1–2 pt	
zeta-cypermethrin			
Mustang MAX™	0.0165–0.025 lb	2.64–4.0 fl oz	

For additional information on these products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

Stalk borers

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

Recent studies using pheromone traps detected Mexican rice borers in all rice-producing counties south and west of Houston. In 2004 Mexican rice borers were detected in Chambers and Liberty Counties. In 2005 Mexican rice borers were detected in Jefferson County, so this insect is moving roughly 15 miles eastward per year toward Louisiana. In Calhoun, Colorado, Jackson, Matagorda and Wharton counties, the Mexican rice borer and sugarcane borer are becoming increasingly damaging pests. In the fall of 2008, Mexican rice borer moths were detected for the first time in Louisiana.

All three species lay eggs on rice foliage. Upon hatching, the larvae move to the protected areas between the leaf sheaths and culms. Eventually, the larvae bore into the culms and feed inside, which causes whiteheads and deadhearts.

Occasionally, larvae will feed on developing panicles within boots, causing partial blanking of panicles. Pupation occurs within damaged culms followed by emergence of adult moths.

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

Data collected from 2000 to 2009 at Ganado, Texas, show that stalk borers (sugarcane borer and Mexican rice borer) cause varying damage to rice, depending on variety. Table 32 lists selected varieties and their relative susceptibility to stalk borers.

Economic thresholds are not yet available for stalk borers, but preliminary work is in progress. However, rice grown in southern counties of the Texas Rice Belt has experienced serious stalk borer problems in recent years. Farmers in these counties who plant a stalk borer susceptible variety may want to consider preventive treatments of labeled insecticides as listed and described in Table 33. Mexican rice borers often attack the internodes below the panicles, which are very vulnerable due to the small diameter of these internodes.

Table 32. Relative susceptibility of selected rice varieties to stalk borers (sugarcane borer and Mexican rice borer).

Variety	Very susceptible	Susceptible	Moderately resistant
CL121	✓		
Cocodrie	✓		
Francis	✓		
Lemont	✓		
Priscilla	✓		
Saber	✓		
Bolivar		✓	
Cheniere		✓	
CL161		✓	
Clearfield XL729		✓	
Clearfield XL730		✓	
Cypress		✓	
Jacinto		✓	
Jefferson		✓	
Madison		✓	
Presidio		✓	
Trenasse		✓	
Wells		✓	
Clearfield XL8			✓
XL723			✓

Table 33. Insecticides for stalk borer control.

Active ingredient/product	Rate per acre: Active ingredient	Rate per acre: Product	Timing of applications
chlorantraniliprole			
Dermacor® X-100	See Table 18 grower guide		Apply to dry seed.
gamma-cyhalothrin			
Prolex™	0.015–0.02 lb	1.54–2.05 fl oz	In areas with historically high populations of stalk borers and damage, apply at 1- to 2-inch panicle followed by a second application at late boot/early heading. Two applications are more effective than one.
lamba-cyhalothrin			
Karate® Z	0.03–0.04 lb	1.92–2.56 fl oz	
zeta-cypermethrin			
Mustang MAX™	0.020–0.025 lb	3.2–4.0 fl oz	

For additional information on these products, read the labels or contact Texas AgriLife Research at (409) 752-2741.

Leafhoppers

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

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

Karate®Z (lambda-cyhalothrin), Mustang MAX™ (zetacypermethrin) and Prolex™ also are registered at 0.025 to 0.04, 0.02 to 0.025 and 0.0125 to 0.02 pound of active ingredient per acre, respectively. CruiserMaxx™ at the rate labeled for rice water weevil in Table 21 is reported to have activity against leafhoppers.

Rice seed midges

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

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

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

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

Aphids

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

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

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

Specifically, the following aphids have attacked Texas rice:

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

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

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

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

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

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

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

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

Karate®Z, Mustang MAX™, Prolex™ and CruiserMaxx™ are labeled for certain aphid species at the same rates as those applied for rice water weevil control. (See Table 21, "Insecticides for Rice Water Weevil Control.")

Four practices discourage aphid populations and damage:

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

South American rice miner
(Hydrellia wirthi)

During the past 5 years, we have seen the South American rice miner and associated injury in Texas and Louisiana rice. The adult of this insect is a small, gray fly that lays eggs singly on rice foliage. The eggs hatch, and larvae rasp and feed on developing foliage before the leaves unfurl. The larvae feed within leaves, resulting in mines and lesions.

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

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

Generally, injury occurs when rice is tillering. However, in Louisiana in 2004, a rice field planted late 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)

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

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

The egg masses are cylindrical, pink or red and are typically observed above the waterline on rice plants, weeds or human-made structures. To date, snail damage to rice in Texas has not been documented, possibly because of the practice of delayed flooding in Texas. Look for this potential pest and report any sightings to Mo Way at (409) 752-2741, ext. 2231.

Panicle rice mite

The panicle rice mite, *Steneotarsonemus spinki,* is a potential arthropod pest of rice in Texas. This mite is native to Asia, but was introduced into Latin America and the Caribbean and was found in the southern U.S. in the 1960s. In 2007, it was found primarily attacking rice in greenhouses in Texas, Louisiana and Arkansas. So, the pest status of this mite on rice in the U.S. is largely unknown. The panicle rice mite has sucking type mouthparts and can be found feeding on the inside of leaf sheaths surrounding culms. Mites can be observed with a 16X hand lens. Severe symptoms of damage are similar to bacterial panicle blight. USDA/APHIS/PPQ is concerned about this mite and is in the process of formulating regulatory policies to combat the panicle rice mite.

Other arthropod pests

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

Coleoptera

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

Lepidoptera

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

Diptera

Rice leaf miner, *Hydrellia griseola*

Hemiptera

Paromius longulus
Leptocorixa tipuloides
Sharpshooter, *Draeculacephala portola*

Thysanoptera

Thrips, species undetermined

Acari

Spider mite, *Schizotetranychus oryza*

Mosquitoes

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

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

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

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

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

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

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

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

Stored grain pests

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

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

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

Management: Good management of stored grain insects requires:

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

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

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

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

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

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

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

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

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

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

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Draining for Harvest

G. N. McCauley

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

Draining

To conserve water, discontinue irrigation 7 to 10 days before the anticipated drain date. Enough moisture must remain in the soil to ensure that the lower grains on the panicle fill properly before harvest, but the soil must be dry enough to support combines without severely rutting the field if a ratoon crop is anticipated. Table 34 or the Rice Development Advisory at *http://beaumont.tamu.edu/RiceDevA/RiceDevA.aspx* can be used as a guide for draining fields for harvest.

Research from Eagle Lake 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 main crop heading) for highest yields and quality. It appears that a short dry period after the main crop is harvested does not adversely affect ratoon crop yields on fine, sandy loam soils.

Table 34. 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 ⅔ or ¾ of panicles are yellow and turned downward

On fine (clay and clay loam) soils such as Beaumont clay, drain 15 days before harvest (20 days after main crop heading) for highest yields and quality. These fine soil types can be flooded immediately after main 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.

Harvesting

G. N. McCauley

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

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

Timing of harvest

If the rice crop is harvested too early or too late, the quality of the rice may suffer, cutting profits considerably. Rice is a crop that fruits and matures over a long period, and the grain moisture content varies greatly. For maximum quality, rice should be 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 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 one 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.

Most semidwarf cultivars 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 may increase harvest efficiency by desiccating green foliage and weeds.

Caution: Harvest aids may result in severe fissuring if the field is not harvested within 3 days of application. Also, desiccation of the main crop may reduce tillering and therefore yields of the ratoon crop.

It is important to adjust a 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 occur 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

Preharvest loss. Select a typical unharvested area of the field well in from the edges. Place a frame 12 inches square in the standing crop. Count all the rice grains lying on the ground within the frame. Make several random samples and determine the average. The loss can be estimated using Table 5 in the Seeding Rates chapter. Select the variety in the left column, go across the columns until the grain (seed) per square feet is located and the seeding rate at the top of the column becomes the grain loss per acre. For example, the average grain count was 13 for a field of Cocodrie. Table 5 reveals that the shattering loss is 30 pounds per acre.

Machine losses. Machine loss will be somewhat dependent on the age of the combine. This is due partly to age and partly to improved design. Do not use a 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, disengage header reel and threshing mechanism, 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.

- Total machine loss—Place the 1 square foot measuring frame on the ground in the residue trail. Separate the filled rice grains from the chaff and count grains. Subtract the number of grains from the preharvest loss from the average count here, then divide by the header width. The loss can be estimated using Table 5 in the Seeding Rates chapter. Select the variety in the left column, go across the columns until the grain (seed) per square foot is located and the seeding rate at the top of the column becomes the grain loss per acre. If the loss is acceptable, generally less than 5 percent of the average yield, then the machine check is complete. If the loss is unacceptable then proceed to the next three steps to isolate the exact source of the machine loss.
- Header losses—Place the 1 square foot measuring frame on the ground in front of the combine within the harvested area. Count the number of rice grains found in the frame. Check several other sample areas and average the grain counts. Finally, subtract the number of grains found in the preharvest loss check. The loss can be estimated using Table 5 in the Seeding Rates chapter. Select the variety in the left column, go across the columns until the grain (seed) per square foot is located and the seeding rate at the top of the column becomes the grain loss per acre. For example, the average grain count was 39 for a field of Cocodrie. Subtracting the preharvest loss leaves 26 grains for the header loss. Table 5 reveals that the header loss is 60 pounds per acre.
- Threshing unit loss—Check the ground in a few places directly behind the combine in the trail of

Table 35. Machine loss chart for small grain.

		Approximate number of kernels per square foot to equal 1 bushel per acre								
		Cutting width (ft)								
Crop	Separator width (in)	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

residue, using the 1 square foot frame. Count all the rice grains remaining on partially threshed heads. Do not include kernels lying loose on the ground. The loss can be estimated using Table 5 in the Seeding Rates chapter. Select the variety in the left column, go across the columns until the grain (seed) per square foot is located and the seeding rate at the top of the column becomes the grain loss per acre. For example, the average grain count was 440 for a field of Cocodrie. Divide the average grain count by the header width. Thus the threshing system loss was 22 grains for a 20 foot header. Table 5 reveals that the header loss is 50 pounds per acre. Typical threshing unit loss ranges from ½ to 1 percent of the average yield. Acceptable losses are largely a matter of operator preference.

- Straw walker and shoe losses—Place the 1 square foot measuring frame on the ground directly behind the combine in the residue trail. 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. The loss can be estimated using Table 5 in the Seeding Rates chapter. Select the variety in the left column, go across the columns until the grain (seed) per square foot is located and the seeding rate at the top of the column becomes the grain loss per acre. For example, the average grain count was 600 for a field of Cocodrie. Subtract the preharvest loss and header loss giving a final count of 561 grains. Divide the average grain count by the header width. Thus the threshing system loss was 28 grains for a 20 foot header. Table 5 reveals that the header loss is about 65 pounds per acre. Typical straw walker and shoe losses should be less than 1 percent of the average yield.

Ratoon (Second) Crop Production

G. N. McCauley, J. Tarpley and F. Dou

Several factors are critical to successful ratoon crop production. The earlier the ratoon crop matures, the higher its potential yield. 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 ⅓ to ½ 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 half immediately after harvest and the remainder 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 broadleaf weeds, particularly dayflower, is of the most concern in ratoon crop rice. Several herbicides are currently labeled for use in ratoon crop rice. These include 2, 4-D, Grandstand R®, and Basagran®. Check the label for rates, timing and weeds controlled.

Gibberellic Acid Treatment To Improve Ratoon Stand

L. Tarpley and A.R. Mohammed

Ratoon crop yield increases commonly occur in response to a gibberellic acid (GA) treatment of 4 grams (0.009 pounds) active ingredient per acre applied to the main crop between several days past peak flowering up to the soft dough stage. The yield increase appears to be a result of enhanced early growth of the ratoon tillers. Main crop yield is not affected by the treatment. Main crop and ratoon crop milling quality do not appear to be affected by the treatment. The GA application, however, slightly delays main crop development. This needs to be taken into account when planning harvests of main crop fields.

Ratoon yield was increased in 14 of 17 studies conducted on a range of cultivars and hybrids. The overall average increase from the 17 studies was 236 pounds per acre. The very early maturing hybrids, such as XL723, appear to be especially responsive to the GA treatment with an average ratoon yield increase of 622 pounds per acre.

The GA application at the soft dough stage has the potential additional advantage that it can be tank mixed with insecticide applications applied during grain filling. This would save on application costs and provide an economical way of increasing yields. Preliminary studies conducted in cooperation with M.O. Way and L. Espino (Texas AgriLife Research and Extension Center at Beaumont) showed no loss in efficacy of either compound when GA and a pyrethroid were coapplied at this growth stage. Although there is no known negative effect from later GA applications up to main crop harvest, the benefit gained from enhancing early growth of the ratoon tillers would often be diminished.

GA applied during active stem elongation can enhance stem elongation, thus increasing plant height and the potential for lodging. Avoid early applications of the GA to tall cultivars. Application during peak flowering can sometimes decrease main crop yield, according to research at Louisiana State University, therefore the GA should be applied after peak flowering. The GA 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, L. Tarpley, G. N. McCauley, M. O. Way, F. Dou and X.G. Zhou

Table 36 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 TexasAgriLife Research. 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 36. 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 management	
Stale seedbed:	
Fall	Land preparation late summer and fall, Broad-spectrum burndown herbicide or tank mix through winter to preplant, Follow conventional tillage system
Spring	Land preparation late summer and early spring, Allow seedbed to firm, Broad-spectrum burndown herbicide or tank mix preplant, Residual herbicides preplant or preemergence – herbicide selection should be based on history and/or scouting, Follow conventional tillage system
Conventional tillage:	
Early postemergence	Apply contact herbicide to control any emerged weeds based on scouting, Apply residual herbicide to prevent regrowth based on scouting and history, Apply contact herbicide to control any emerged weeds based on scouting
Late postemergence	Apply residual herbicide to prevent regrowth based on scouting and history
Post flood/salvage applications	Yield loss has occurred if weeds persist at this time – carefully evaluate economics prior to application, Salvage grass control should be achieved when water is static after flooding, Salvage broadleaf control can generally continue to near panicle initiation depending on herbicide selection
Disease management	
Seed treatments	Planting
Scout fields for sheath blight	Start at PD
Fungicide application	PD+5 days until late boot
Insect management	
Seed treatments	Planting
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
Plant growth regulation	
Seed treatments	Planting
Gibberellic acid for seedling vigor	2nd to 4th leaf
Gibberellic acid for ratoon vigor	MC late flowering to mid-dough

Rice Production Economics

L. L. Falconer

Texas' planted rice acreage has averaged nearly 170,000 in the past 5 years, with a low range of 146,000 to 150,000 planted in 2006 and 2007 (Fig. 12). Planted acreage recovered to near 170,000 acres in both 2008 and 2009 in response to higher rice prices, despite higher fuel and fertilizer prices (Fig. 13). Although input prices have declined substantially in the past year, cost of production is still historically high. If long-grain rice prices remain in the $11 per cwt area, acreage will likely remain stable for 2010. However, if substantial rains do not occur in the upper Colorado River basin before planting in 2010, it is possible that acreage could decrease to the 140,000 acre range due to lack of surface water.

Cost of production estimates for the 2010 crop

The planning budgets shown in the following tables were developed with input from producers, custom service and product suppliers, Texas AgriLife Extension Service specialists, and Texas AgriLife Extension Service agents. These budgets are based on projections for input and output prices for the 2010 crop year. These budgets are intended to represent the cost structure for a hypothetical 450-acre rice operation on land that requires 18 to 20 levees per 100 acres. The budget scenario represents a high yield, high input conventional tillage production system with moderate to heavy pest pressure. Main and ratoon crop budgets have been separated, and all general and administrative costs, crop insurance, land and vehicle charges are assigned to the main crop.

Annual usage rates for tractors are projected at 600 hours, with capital recovery factors calculated over an 8 year useful life. Annual usage rate for the combine was estimated at 200 hours with the 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 cost for owned durable items. No adjustment was made in aerial application costs for irregularly shaped fields. The interest rate charged on the projected operating loan for this budget is 5.5 percent.

The budgeted fertility program for the main crop includes a base fertilizer application, one preflood application, and one top-dress application. The total main crop fertilizer application is 183 units of N, 59 units of P, 39 units of K, and 4.3 units of S. The budgeted main crop herbicide program includes an initial ground applied treatment of clomazone; an aerial application of a general tank mix over the total planted acreage to control sedges, grasses and broadleaf weeds; along with a follow-up aerial application over ½ the planted acres to control escaped weeds. The budgeted disease and insect mangement program for the main crop includes one fungicide application to control foliar diseases, a pyrethroid application to control rice water weevils, and two pyrethroid 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,

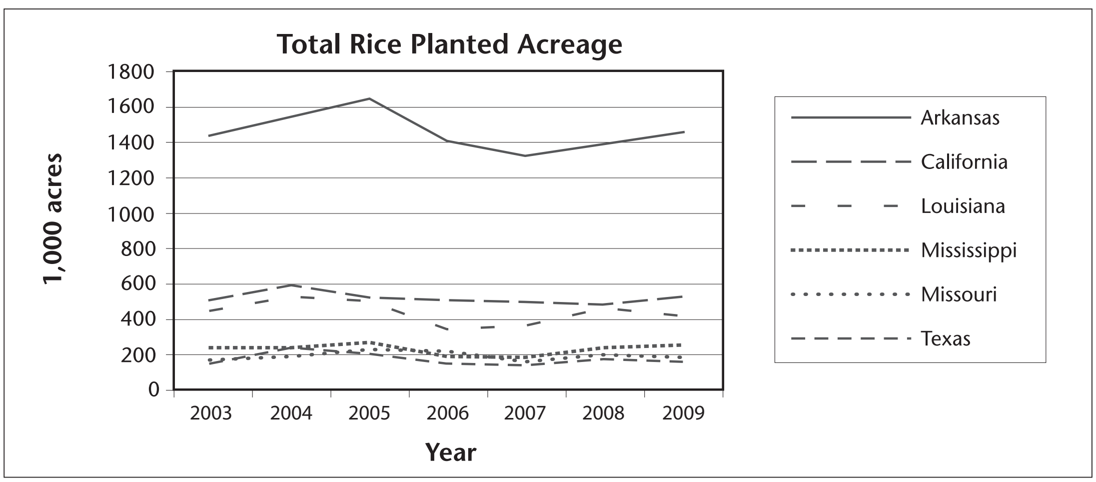


Figure 12. Total rice planted acreage.

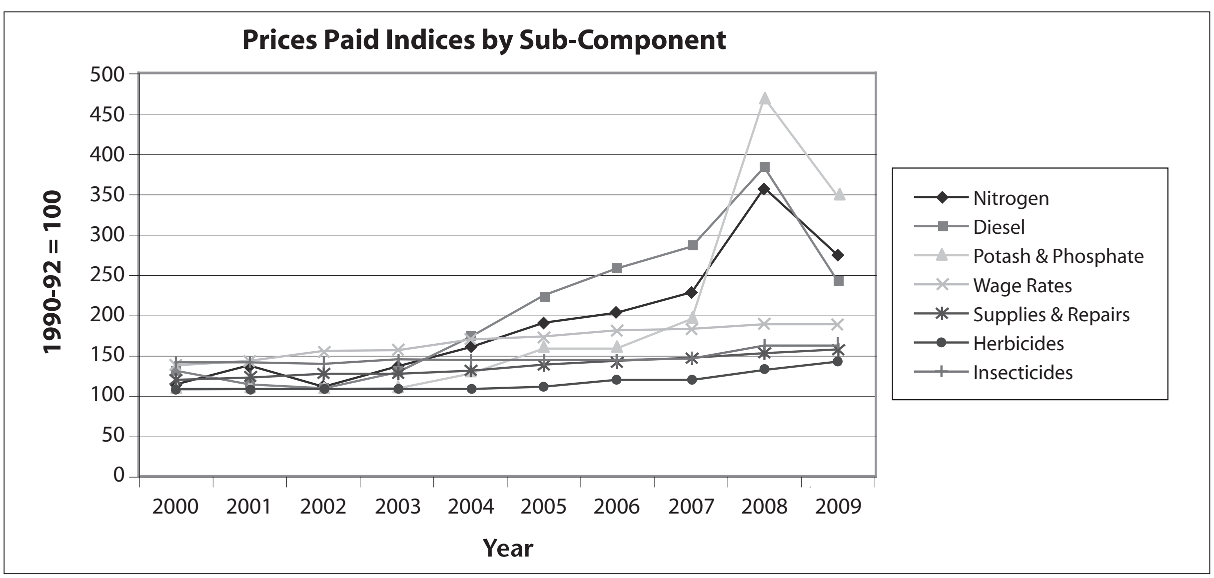


Figure 13. Prices paid indices by subcomponent.

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 2010.

The budgeted fertility program for the ratoon crop consists of one top-dress application of urea. The total ratoon crop fertilizer application is 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 2010.

No counter-cyclical, ACRE or direct payments from USDA are included in these budgets. The break-even price needed to cover the budget's direct expenses for the main crop is projected to be $11.06 per cwt, based on a main crop yield of 70 cwt per acre on a dry basis. The break-even price level needed to cover the budget's total specified expenses for the main crop is $12.24 per cwt. The break-even price level needed to cover the budget's

Table 37. Summary of estimated costs and returns per acre; rice west of Houston–main crop; 450-acre farm; District 11, 2010.

Item	Unit	Price (dollars)	Quantity	Amount (dollars)	Your Farm
Income Main					
Rice—crop loan	CWT	6.90	70.0000	483.00	
Rice—crop prem.	CWT	6.00	70.0000	420.00	____________
Total income				**903.00**	____________
Direct expenses					
Adjuvants	acre	7.00	1.0000	7.00	____________
Custom fertilizer application	acre	26.52	1.0000	26.52	
Custom spray	acre	40.56	1.0000	40.56	____________
Fertilizers	acre	118.06	1.0000	118.06	____________
Fungicides	acre	32.50	1.0000	32.50	
Herbicides	acre	74.41	1.0000	74.41	
Insecticides	acre	16.56	1.0000	16.56	____________
Irrigation supplies	acre	10.35	1.0000	10.35	____________
Seed	acre	31.50	1.0000	31.50	
Survey levees	acre	5.00	1.0000	5.00	
Crop insurance—Rice	acre	6.56	1.0000	6.56	
Irrigation	acre	101.46	1.0000	101.46	
Checkoff/commission	acre	11.20	1.0000	11.20	____________
Drying—Rice	acre	100.57	1.0000	100.57	____________
Rice hauling	acre	28.97	1.0000	28.97	____________
Storage—Rice	acre	22.40	1.0000	22.40	____________
Vehicles	acre	16.17	1.0000	16.17	
Operator labor	hour	13.75	1.3603	18.74	____________
Rice water labor	hour	13.75	1.5700	21.61	____________
Diesel fuel	gal	2.05	12.6673	25.97	____________
Repair and maintenance	acre	31.84	1.0000	31.84	____________
Interest on operating capital	acre	26.84	1.0000	26.84	____________
Total direct expenses				**774.79**	____________
Returns above direct expenses				128.21	____________
Total fixed expenses				**82.16**	____________
Total specified expenses				**856.95**	____________
Returns above total specified expenses				46.05	____________
Residual items					
Rice land rent	acre	75.00	1.0000	75.00	
G&A overhead	acre	10.50	1.0000	10.50	
Management charge	%	903.00	0.0500	45.15	____________
Residual returns				–84.60	____________

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

direct expenses for the ratoon crop is $9.47 per cwt. The break-even price level needed to cover the budget's total specified expenses for the ratoon crop is $10.59 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. It is based on the economic and technological relationships between inputs and outputs. The scenario shown in Tables 37 and 38 represents 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 county Extension office or go to the Extension budget Web site maintained by the Texas A&M University Department of Agricultural Economics at *http://agecoext.tamu.edu/resources/crop-livestock-budgets.html*.

Table 38. Summary of estimated costs and returns per acre; rice west of Houston–ratoon crop; 450-acre farm; District 11, 2010.

Item	Unit	Price (dollars)	Quantity	Amount (dollars)	Your farm
Income Ratoon					
Rice—crop loan	CWT	6.90	16.0000	110.40	___________
Rice—crop premium	CWT	6.00	16.0000	96.00	___________
Total income				**206.40**	___________
Direct expenses					
Custom fertilizer application	acre	8.98	1.0000	8.98	___________
Custom spray	acre	7.68	1.0000	7.68	___________
Fertilizers	acre	25.95	1.0000	25.95	___________
Insecticides	acre	4.42	1.0000	4.42	___________
Irrigation	acre	33.10	1.0000	33.10	___________
Checkoff/commission	acre	2.56	1.0000	2.56	___________
Drying—Rice	acre	24.10	1.0000	24.10	___________
Rice hauling	acre	6.94	1.0000	6.94	___________
Storage—Rice	acre	5.12	1.0000	5.12	___________
Operator labor	hour	13.75	0.3500	4.82	___________
Rice water labor	hour	13.75	0.7100	9.78	___________
Diesel fuel	gal	2.05	2.7795	5.70	___________
Repair and maintenance	acre	9.76	1.0000	9.76	___________
Interest on operating capital	acre	2.67	1.0000	2.67	___________
Total direct expenses				**151.58**	___________
Returns above direct expenses				54.82	___________
Total fixed expenses				17.89	___________
Total specified expenses				169.47	___________
Returns above total specified expenses				36.93	___________
Residual items					
Management charge	%	206.40	0.0500	10.32	
Residual returns				26.61	___________

Note: Cost of production estimates are based on 18 to 20 levees per 100 acres. All general and administrative costs including accounting, legal, general liability insurance and miscellaneous expenses are charged to 1st crop. All crop insurance and land charges are assigned to 1st crop. Vehicle charges assigned to 1st crop.

Web-Based Information Delivery

L. T. Wilson, Y. Yang, J. Wang and F. H. Arthur

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

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

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

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

Rice Development Advisory

DOS-based DD50 (1986-2003)

In 1976, Dr. Jim Stansel developed the concept, methodology and original data for forecasting rice development based on usable heat units. In 1986, Jack Vawter (David R. Wintermann Rice Research Station at Eagle Lake) wrote a DOS-based computer program ("DD50") based on Stansel's concept and methodology.

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

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

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

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

A new Web-based program called Rice Development Advisory (RiceDevA) was released in April 2004.

RiceDevA is a complete rewrite and replacement of the DOS-based DD50 program. It provides an improved user interface and advanced options for creating, running and displaying multiple-field growth forecasts for different rice varieties, planting/emergence dates and counties.

Major features

RiceDevA can provide growth forecasts and advisories for 21 rice counties in Texas (Fig. 14). It forecasts rice growth stages for multiple varieties, different planting dates (Fig. 15) 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. 16).

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

Crop forecasting

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

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

Interface window

The top part of RiceDevA's window displays links to the Web site of the Texas AgriLife Research and Extension Center at Beaumont (Home, Research, Teaching,

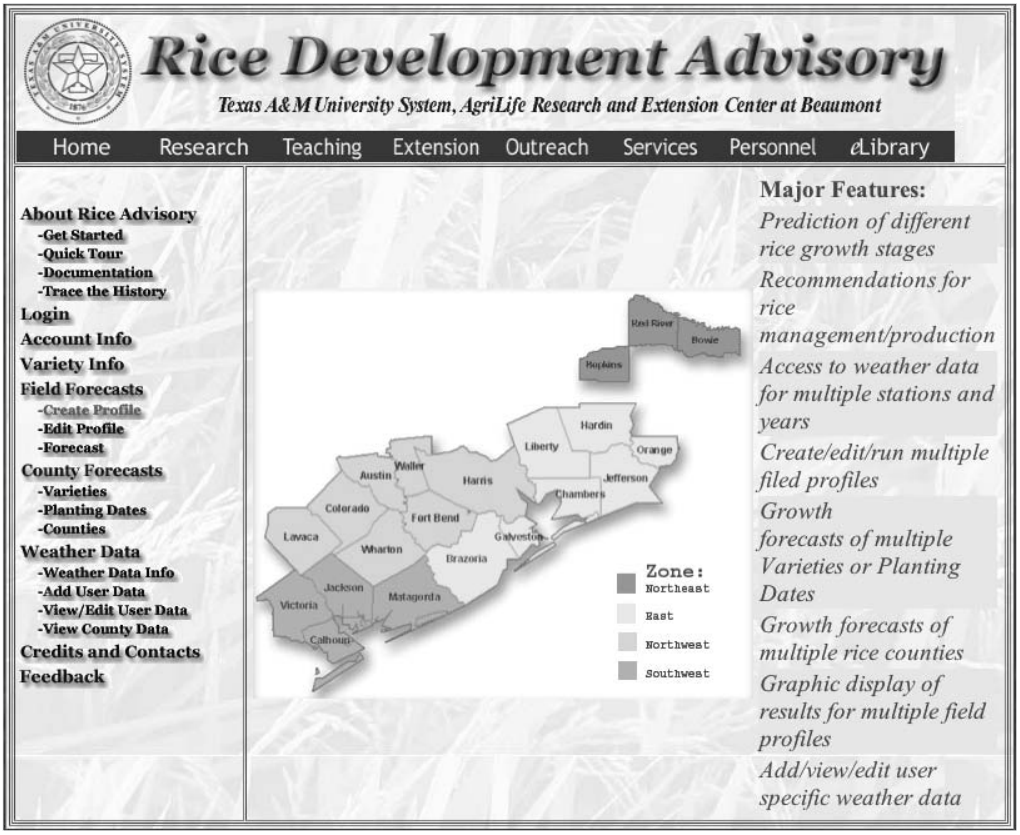
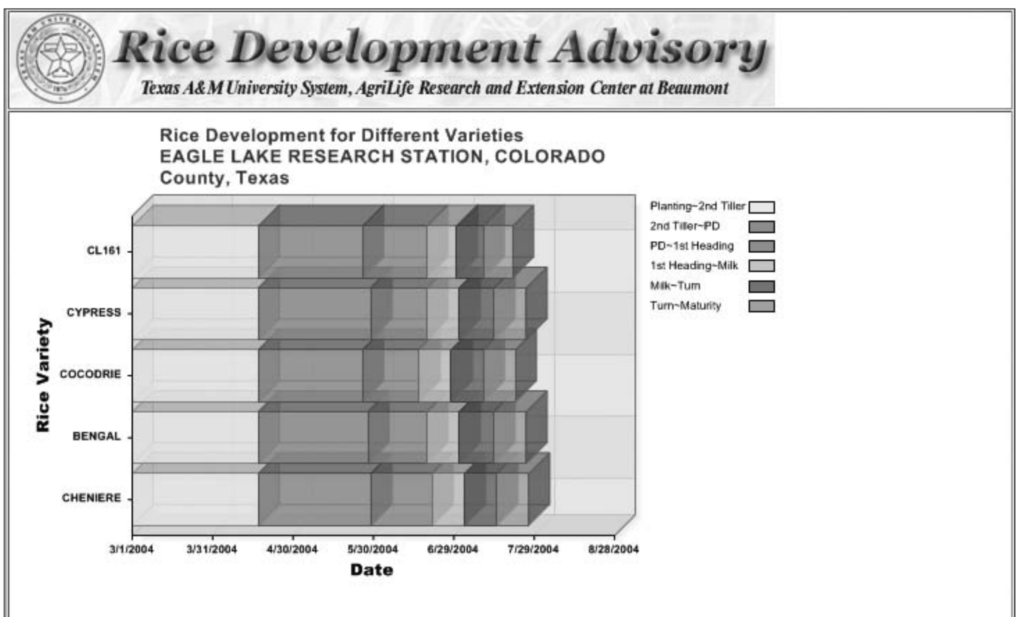


Figure 14. The RiceDevA Web site can provide growth forecasts and advisories for 21 rice counties in Texas.



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

Extension, Outreach, Services, Personnel and eLibrary) (Fig. 14). The left side of the window displays links to the major features of the Rice Development Advisory (About Rice Advisory, Login, New Account, Account Info, Variety Info, Field Forecasts, County Forecasts and Weather Data). The remaining part of the window allows users to input, edit and view data or display results.

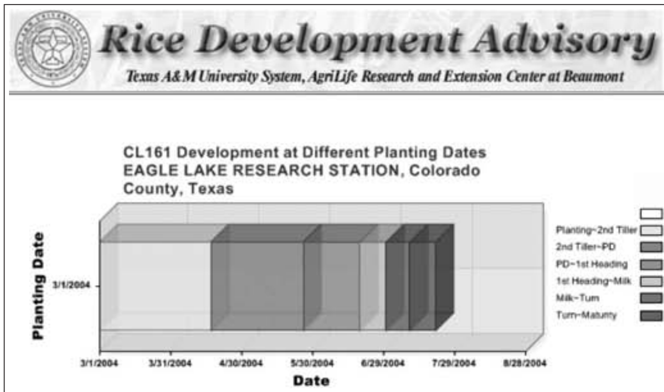
Feature access

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

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

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

A user can create a field profile by clicking on the Create Profile button under the Field Forecasts menu on the left side and making the appropriate selections for production and weather data. Only users who have accounts with



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 Karate Z, Mustang Max or Prolex from 7 days before to 5 days after flood and Dimilin 2L 2 to 5 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 16. The RiceDevA allows users to run multiple-field profiles at the same time and display and print results for multiple field profiles.

RiceDevA can save a profile or view, edit or delete existing profiles. A field profile is owned by a specific user and is accessible only by that user.

Menu descriptions

Menus to access RiceDevA features are displayed on the left side of the RiceDevA window (Fig. 14).

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

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

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

Post-Harvest Grain Management

Aeration and grain management

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The minimum airflow rate for grain aeration is 0.05 to 0.2 cubic foot per minute per bushel (CFM/Bu). Grain with low initial moisture content requires a lower airflow rate. For larger fans, this will speed up the cooling process as more air is moved through the grain.

Warm air rising in the center of the bin cools when it reaches the cold grain near the surface. This results in an increase in moisture content near the surface, which can lead to rapid spoilage.

A common symptom of moisture migration is crusting on the surface of stored grain. Significant migration can occur in cereal grains at moisture contents as low as 12 percent wet weight basis (w.b.), if the grain is placed into storage at a high temperature and not cooled.

Grain in storage is subject to moisture migration caused by differences in grain temperature. This is particularly true for grain stored in metal bins. In late fall and early winter, stored grain tends to be warmer than the outside air. Warm air rises slowly out of the center grain. When this air contacts the cold grain on the top of the bin, it cools, increases in relative humidity and causes the top grain to gain moisture.

Sometimes the temperature differences are enough to cause condensation on the top grain. Air and grain that are close to cold walls or floors also cool. The air increases in humidity, sometimes causing the grain closest to the cold metal to gain enough moisture to cause spoilage.

Moisture migration is slowed by aeration, regularly forcing outside air through the grain to reduce the temperature difference between the grain and the outside. The grain temperature should be within 10 degrees F of the average outside air temperature.

During the fall, aeration is used to cool the grain and maintain moisture uniformity. In the winter, aeration is needed just to maintain moisture uniformity.

Keep the grain temperature as low as possible during the spring to reduce insect damage. Insects become active when grain temperature rises above about 65 degrees F, and infestation and damage are likely when the grain temperatures are between 75 and 90 degrees F, which is the optimum range for growth and development of stored-grain insects.

To summarize, good storage practices can prevent losses in grain quality by:

- Keeping the moisture content of grain below about 12.5 percent, which corresponds to about 65 percent relative humidity
- Keeping the grain temperature within 10 degrees F of the average monthly air temperature and below 60 degrees F as long as possible during the year
- Designing and operating an aeration system to maintain uniform grain moisture and temperature
- Storing only well-cleaned grain. Fungi (mold) growth is minimal below 65 percent relative humidity and bacteria growth is minimal at even higher relative humidity.
- Reducing the occurrence of rapid shifts in temperature, thereby controlling grain fissuring
- Monitoring and reacting appropriately to any changes that may occur

Safe, long-term storage moisture for grain is based on how dry it is. Although grain can be stored above about 12 percent moisture content, the risk of noticeable mold growth increases as moisture, storage time and grain temperature rise. During storage, inspect the grain weekly. Test the discharge air for off-odors, any increases in temperature within the grain, and increases in moisture, which generally indicate a problem.

Web-based post-harvest grain management tool RiceSSWeb

The Post-Harvest Grain Management program (*http://beaumont.tamu.edu/RiceSSWeb*) is a web-based grain management tool (Fig. 17). It allows users to create different scenarios of bin and fan configurations and different initial conditions of pest infestations. It also allows users to simulate changes in grain temperature and moisture content and the resulting pest density and grain damage.

The tool was developed jointly by scientists from Texas A&M University, the University of Arkansas, the Agricultural Research Service (Manhattan) of the U.S. Department of Agriculture, and the University of Missouri.

The web-based program is directly linked to a weather database that contains data for the southern rice-growing region (Arkansas, Louisiana, Mississippi, Missouri and Texas). The weather database is updated automatically with data from several sources, mainly weather data from the National Oceanic and Atmospheric Administration (NOAA).

Major features. The RiceSSWeb has the following major features:

- Prediction of grain temperature and moisture dynamics
- Prediction of rice weevil and grain borer dynamics
- Sensitivity analysis of different bin configurations
- Sensitivity analysis of different pest configurations
- Ability to create, edit and run multiple bin profiles
- Graphic display of results for aeration/pest dynamics
- Access to weather data for multiple stations and years
- Ability to add, view and edit user specific weather data

Interface windows. The Web interface window (Fig. 17) has three major parts. The left side of the window displays links to the major features of the Post-Harvest Grain Management program *(About This Program, Login, New Account, Create Profile Profile, Results and Analysis, and Weather Data).*

Four additional features *(Account Info, Bin Info, View/Edit Profile and Run Profile)* are available for users who have logged in. The top banner of the window displays links to information that is relevant to the Post-Harvest Grain Management program *(Decision Tools, Research Team, Display Unit, Calculators Etc., Knowledge Base, and Resources).* The remaining part of the window allows users to input, edit and view data and display results.

Feature access. A user can access features of the Post-Harvest Grain Management program by clicking on a link on the left side menu and making appropriate selections.

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

Bin Profile Creation. A bin profile is a collection of bin and pest configuration and weather data needed to forecast dynamics of grain temperature and moisture, and pests (Figs. 18-20). Bin configuration includes bin diameter, grain depth, initial grain temperature and moisture. Pest configuration includes pest species and initial pest density. Weather data include weather station and year or historic average for the station.

A user can create a bin profile by clicking on the Create Profile submenu under Bin Profiles on the left sidebar and making the appropriate selection for the bin, pest and weather data.

Only users who have accounts with the program can save the profile and view, edit or delete existing profiles. A bin profile is owned by a specific user and is accessible only by that user. Also, only registered users can add, edit or view their own weather data.

Menu descriptions. Menus to access RiceSSWeb features are displayed on the left side window (Fig. 18).

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

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

The *Bin Info* menu allows a user to add a new bin or view and edit existing bins.

The *Create Profile* menu allows users to create a new bin profile; the *Edit/Run Profile* menu allows a registered

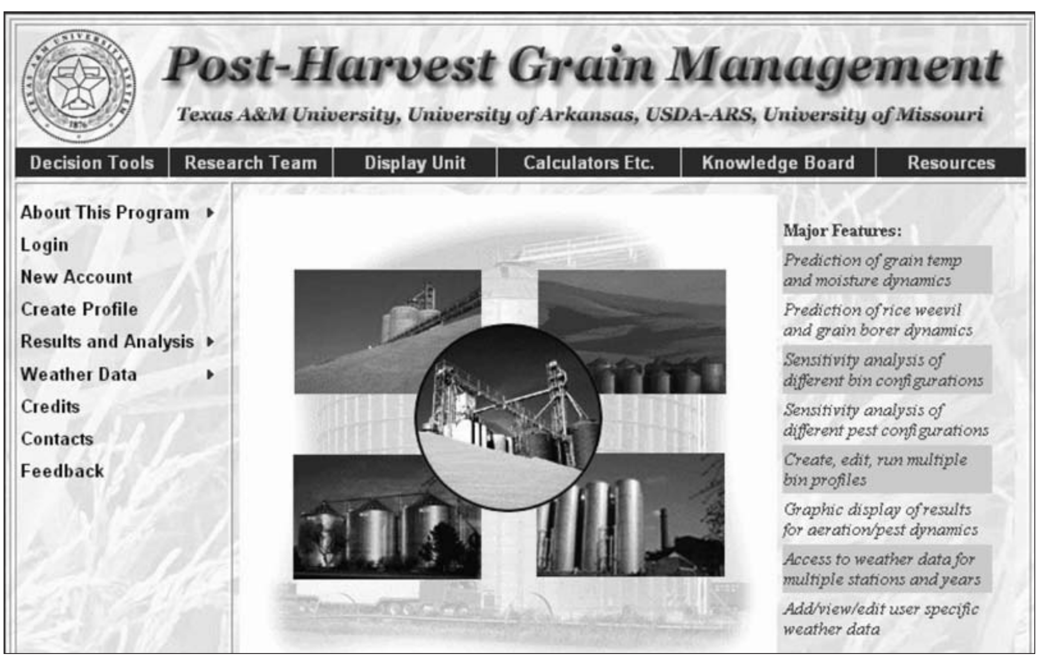


Figure 17. RiceSSWeb main page.

user to edit his or her existing bin profile(s); and the *Run Profile* menu allows a registered user to forecast dynamics of bin temperature, moisture, pests, and pest damage for single or multiple profiles.

The *Results and Analysis* menu has three submenus: *Aeration Dynamics, Pest Dynamics* and *Sensitivity Analysis*. The *Aeration Dynamics* submenu displays the dynamics over time for grain temperature, grain moisture, relativity humidity and fan power consumption. It also displays data animation for grain temperature and moisture (Fig. 21).

The *Pest Dynamics* submenu displays dynamics and damage of rice weevil and/or grain borer over time (Fig. 22). The *Sensitivity Analysis* submenu displays results at different levels of values for a selected set of bin and pest attributes and graphically examine the differences in grain temperature and moisture, power consumption, pest density or pest damage (Figs. 23 and 24).

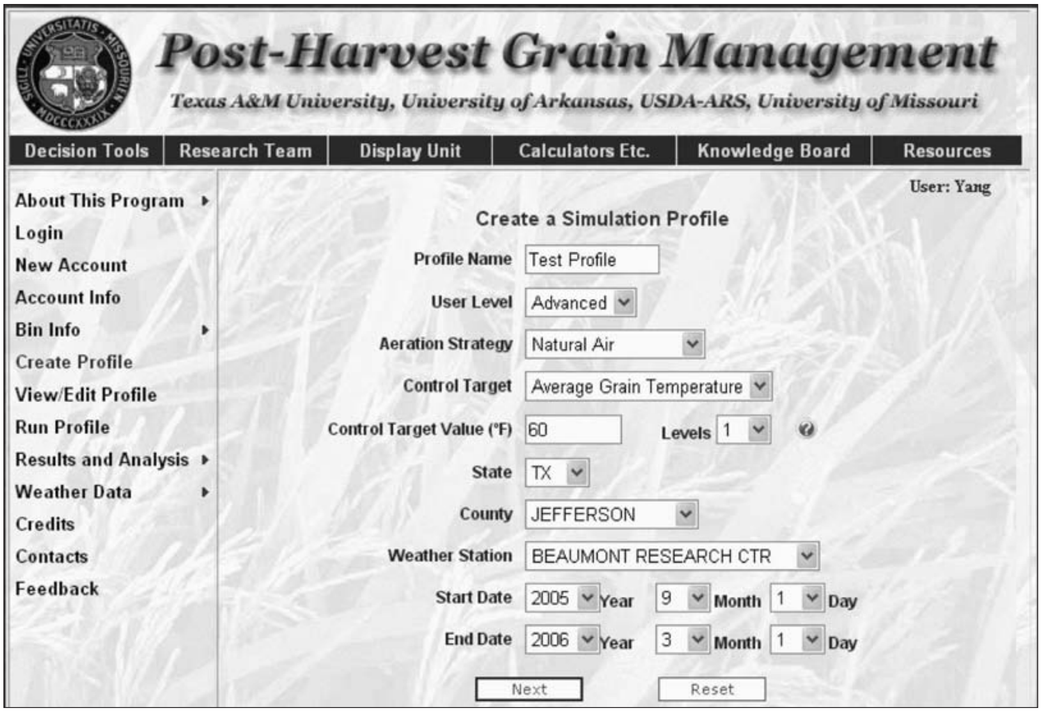


Figure 18. Create Profile – general and weather data.

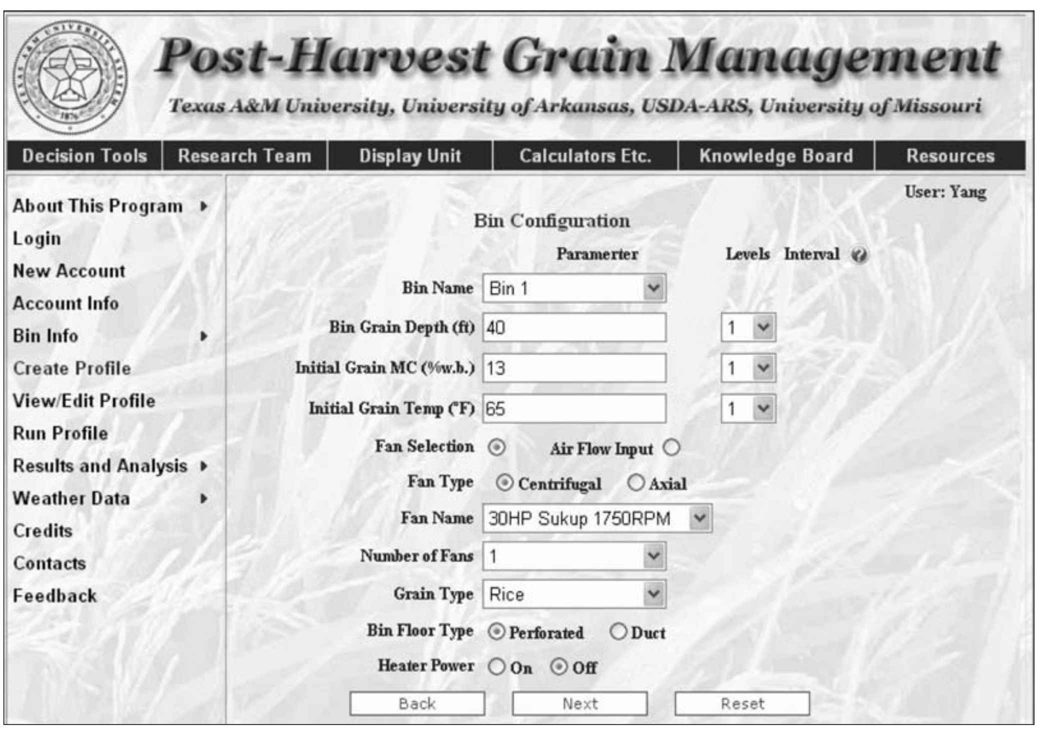


Figure 19. Create Profile – bin configuration.

The *Weather Data* menu gives users background information about weather data and options for adding user weather data and viewing county weather data. The Information submenu provides background information about weather data sources and usage.

The *Add User Data* submenu allows a registered user to add user-specific weather data for new or existing user stations. The *View User Data* submenu allows a registered user to view his/her weather data; and the *View/Download County Data* submenu allows any users to view available weather in the database.

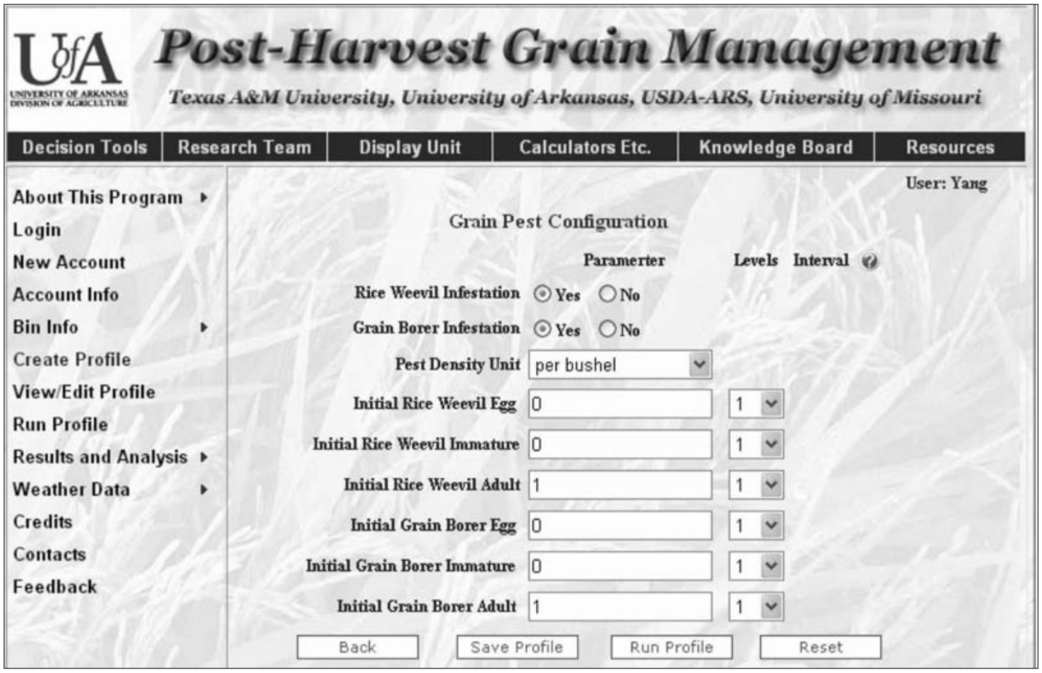


Figure 20. Create Profile – pest configuration.

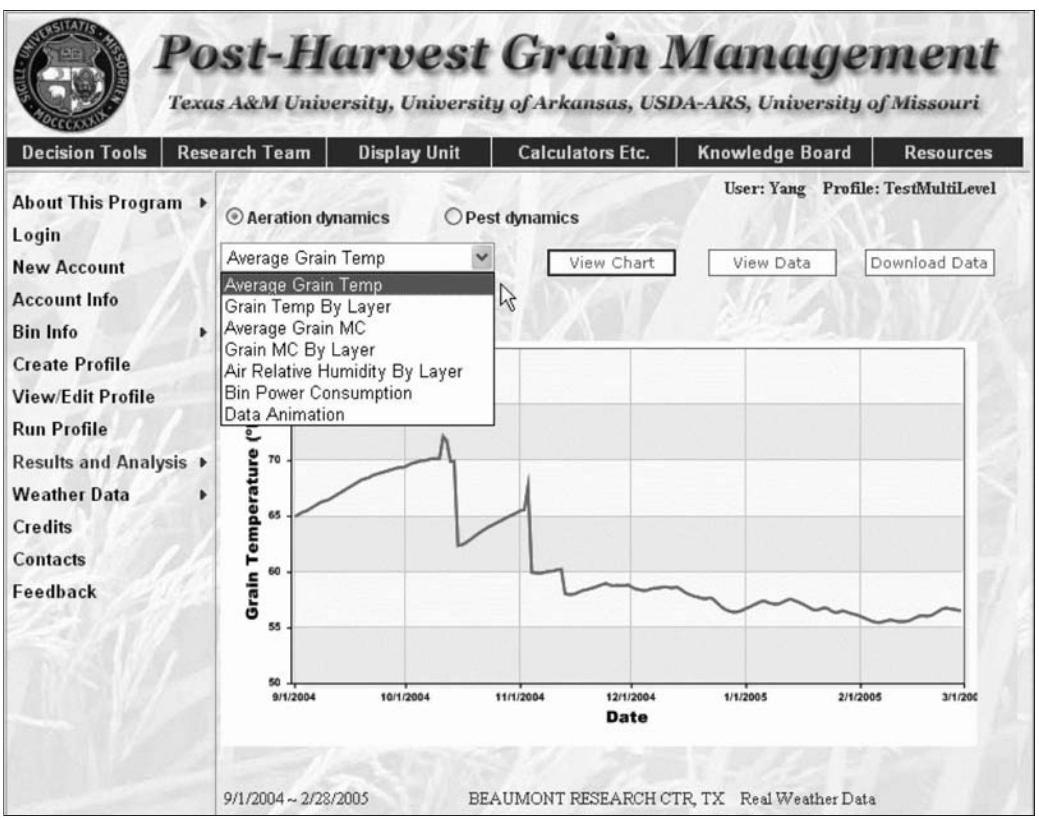


Figure 21. Simulation results for aeration.

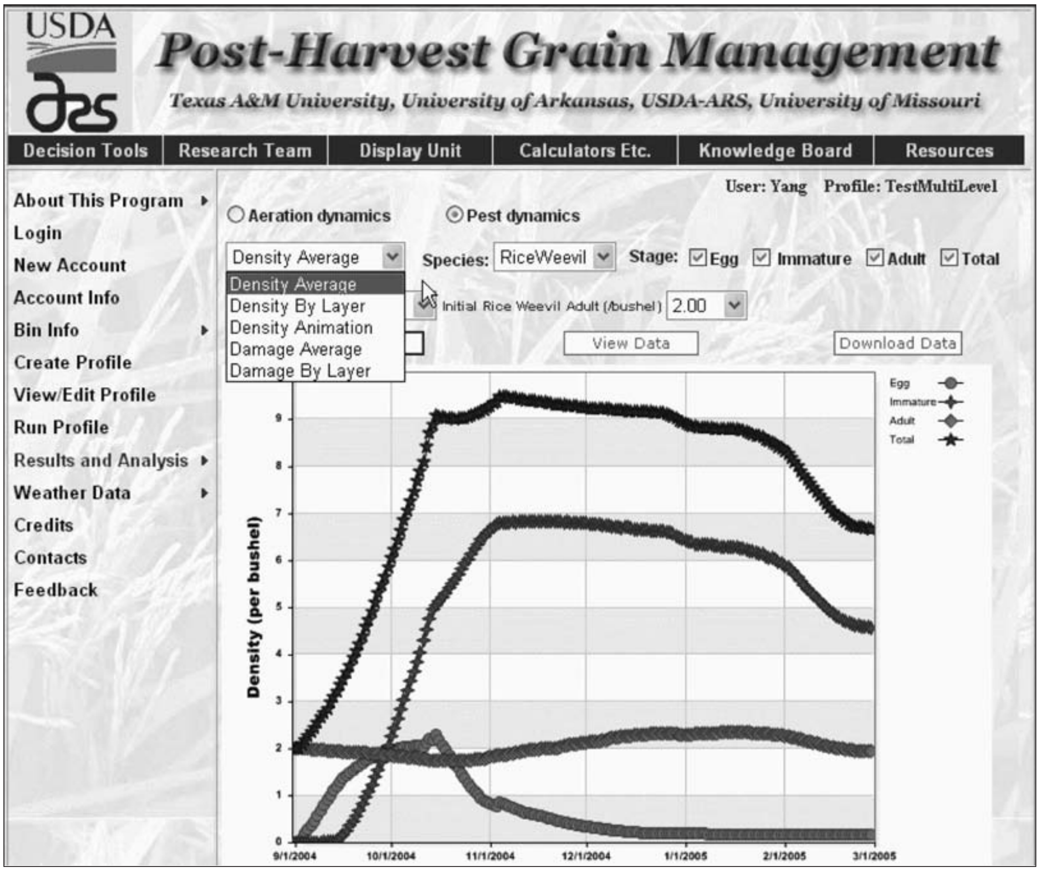


Figure 22. Simulation results for pest population and grain damage.

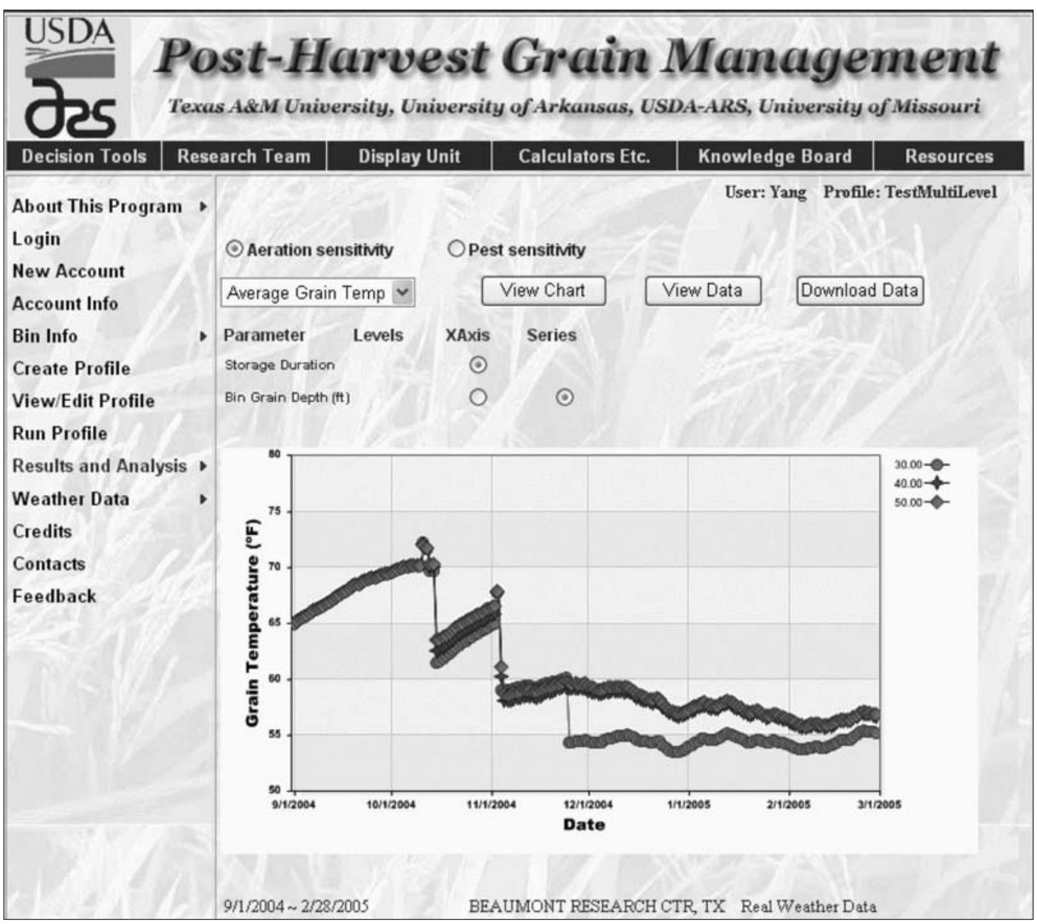


Figure 23. Bin temperature vs. bin grain depth.

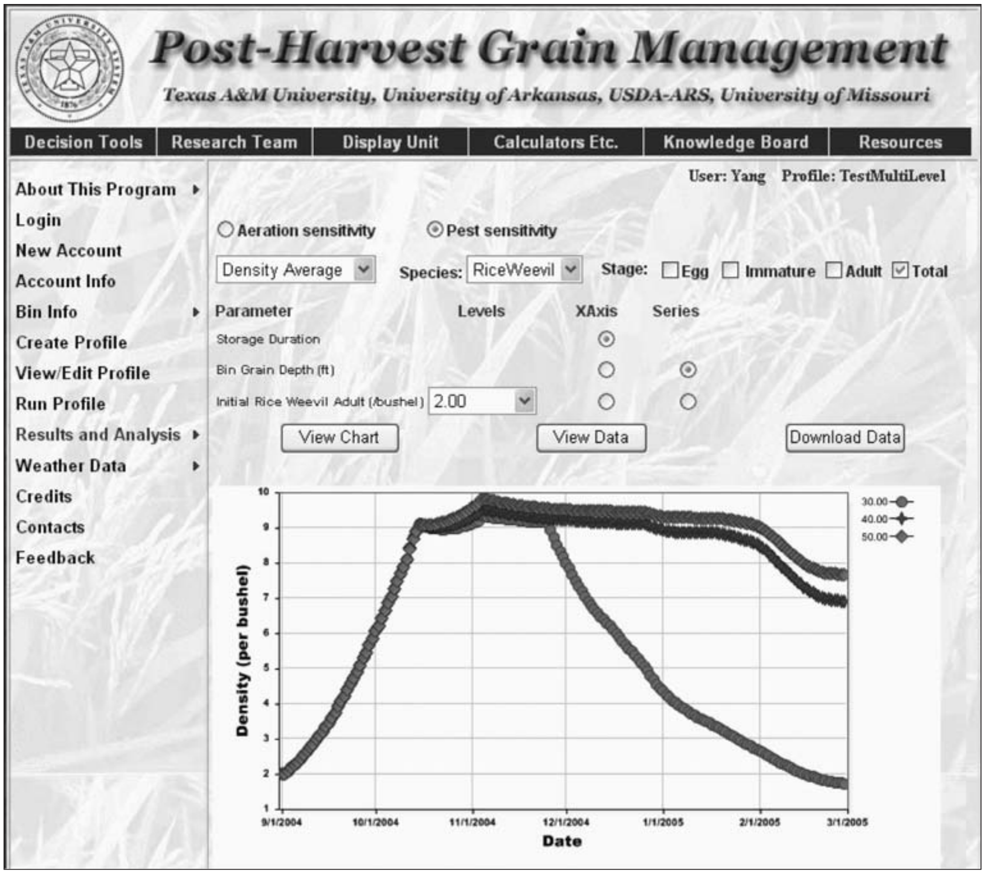


Figure 24. Pest density vs. bin grain depth.

Historical Texas Rice Production Statistics

Table 39. 16-year Texas rice acreage, yields and production comparison.

Crop year	Planted acres*	Main crop** Yield (lb/A)	Ratoon crop** Yield (lb/A)	% MC ratooned**	Total** Yield (lb/A)	Production*** cwt	
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	5,505	165	32	5,558	17,513,703	
1996	263,407	6,022	1,228	46	6,587	17,350,830	
1997	256,944	5,232	895	42	5,608	14,408,971	
1998	271,989	5,413	796	54	5,843	15,891,008	
1999	246,228	5,818	1,361	26	6,172	15,196,150	
2000	211,241	6,360	948	37	6,711	14,176,944	
2001	213,704	6,291	1,264	48	6,898	14,741,250	
2002	204,880	6,744	1,017	34	7,090	14,526,940	
2003	171,953	6,055	2,247	38	6,909	11,880,000	#
2004	216,810	6,231	1,557	35	6,776	14,690,000	#
2005	201,024	6,542	1,955	27	7,070	14,212,274	
2006	147,549	6,913	1,248	39	7,400	10,918,626	##
2007	143,299	6,179	1,948	35	6,860	9,830,311	*
Avg. 1993–2007	**233,734**	**5,933**	**1,170**	**38**	**6,357**	**15,395,595**	
2008	168,039	6,314	1,830	53	7,283	12,238,280	*

* 10,271,940 (2007 sales) * 8,722,088 (2008 sales)
* USDA-FSA certified planted acres ** TAMUS AgriLife Research Beaumont Crop survey data *** Texas Rice Research Foundation check-off collections
\# Modified to account for carryover stocks ## Estimated

Table 40. 16-year Texas rice-planted acres comparison.

County	Rice-planted acres 8-1-06*															
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Chambers	29,932	28,217	20,906	20,411	21,672	17,197	11,432	13,438	13,202	10,937	16,024	12,792	8,088	8,180	13,048	1,262
Brazoria	32,701	29,975	16,818	21,888	18,718	19,241	17,163	15,279	14,077	10,395	15,748	15,976	12,997	11,461	14,833	16,452
Jackson	30,920	27,560	25,235	20,521	20,128	18,355	16,208	14,953	14,005	13,057	14,734	12,713	9,929	10,115	9,519	11,350
Jefferson	33,849	32,324	26,102	24,947	24,422	22,655	18,519	18,575	18,389	15,037	19,954	19,355	14,234	14,112	15,641	13,749
Wharton	63,433	61,118	58,930	50,737	57,530	55,253	52,205	50,520	49,958	41,664	53,413	50,678	35,417	34,928	38,699	43,064
Liberty	23,854	19,386	11,071	14,074	18,706	14,328	8,740	12,705	9,714	7,949	10,475	9,381	5,440	4,387	7,579	7,227
Colorado	41,783	37,551	36,200	36,091	35,698	33,522	31,136	32,110	30,734	28,572	33,273	30,903	25,465	26,517	30,776	31,587
Harris	9,363	8,095	6,654	6,484	6,187	4,875	2,957	1,975	2,083	1,664	1,522	1,067	195	192	395	
Calhoun	5,682	4,875	4,760	2,511	3,851	3,164	1,568	1,468	1,498	1,897	2,488	2,439	2,767	2,086	2,803	2,154
Fort Bend	11,499	11,207	9,418	10,680	10,179	9,006	8,894	8,652	8,615	6,071	7,933	6,409	4,496	4,925	4,358	5,589
Matagorda	35,409	30,246	26,692	26,814	30,518	28,598	23,036	24,958	24,516	18,878	23,672	21,863	18,075	16,913	17,979	24,594
Victoria	4,190	3,824	2,775	2,941	3,302	2,401	1,937	1,977	1,748	1,247	1,356	1,705	564		1,081	1,771
Lavaca	4,040	3,572	3,703	2,682	2,452	2,006	2,523	1,746	1,790	1,582	2,189	1,804	1,039	1,029	1,255	1,057
Galveston	3,780	2,993	2,144	2,110	1,993	1,590	1,360	768	1,166	781	847	833	314	300	654	1,527
Orange	1,520	1,301	732	750	2,248	362	531	354	682	0	90					
Austin	3,172	2,366	2,479	2,878	2,673	2,702	2,435	2,601	1,694	1,684	2,313	2,359	904	1,003	959	1,036
Bowie	1,459	1,600	1,600	1,136	1,329	1,538	1,030	1,435	1,287	1,332	1,510	2,054	608	284	569	517
Red River	1,000	1,050	47	951	941	1,100	709	965	1,017	587	639	639	440			
Waller	7,343	6,785	5,677	6,741	6,694	6,142	6,206	6,951	7,038	7,168	7,868	7,672	6,260	6,038	6,508	6,379
Hardin	752	463	714	899	1,185	1,052	1,093	801	633	738	762	298	235	670	950	460
Hopkins	0	600	750	700	1,563	1,141	1,562	1,473	1,034	713	0					0
Robertson												87	81	159	200	
Lamar															203	215
Cameron															30	
Total	**345,680**	**315,108**	**263,407**	**256,944**	**271,989**	**246,227**	**211,241**	**213,703**	**204,880**	**171,953**	**216,810**	**201,024**	**147,549**	**143,298**	**168,038**	**169,989**

*USDA–FSA certified planted acres

Table 41. Texas crop rice development statistics.

	Date Crop Stages/Events Reached 50 percent of Surveyed Rice Areas				
	Planted	**Seed. Em.**	**Pan. Diff.**	**Headed**	**Harvested**
East Zone					
2009	17–Apr	24–Apr	12–Jun	17–Jul	4–Sep
2008	11–Apr	18–Apr	20–Jun	18–Jul	22–Aug
2007	27–Apr	4–May	29–Jun	13–Jul	31–Aug
2006	10–Apr	21–Apr	18–Jun	12–Jul	16–Aug
2005	13–Apr	21–Apr	18–Jun	15–Jul	24–Aug
Mean 2005–2009	16–Apr	24–Apr	19–Jun	15–Jul	26–Aug
Northwest Zone					
2009	3–Apr	10–Apr	12–Jun	3–Jul	14–Aug
2008	28–Mar	11–Apr	13–Jun	27–Jun	15–Aug
2007	13–Apr	20–Apr	22–Jun	6–Jul	17–Aug
2006	19–Mar	9–Apr	7–Jun	2–Jul	7–Aug
2005	2–Apr	9–Apr	8–Jun	1–Jul	12–Aug
Mean 2005-2009	1–Apr	12–Apr	12–Jun	3–Jul	13–Aug
Southwest Zone					
2009	27–Mar	10–Apr	12–Jun	26–Jun	4–Sep
2008	4–Apr	11–Apr	20–Jun	18–Jul	15–Aug
2007	6–Apr	20–Apr	22–Jun	6–Jul	24–Aug
2006	18–Mar	15–Apr	12–Jun	15–Jul	9–Aug
2005	10–Apr	13–Apr	11–Jun	6–Jul	19–Aug
Mean 2005–2009	1–Apr	14–Apr	15–Jun	8–Jul	20–Aug
Rice Belt					
2009	3–Apr	10–Apr	12–Jun	3–Jul	21–Aug
2008	4–Apr	11–Apr	13–Jun	11–Jul	15–Aug
2007	13–Apr	20–Apr	22–Jun	6–Jul	24–Aug
2006	22–Mar	14–Apr	12–Jun	13–Jul	9–Aug
2005	8–Apr	14–Apr	12–Jun	6–Jul	18–Aug
Mean 2005–2009	4–Apr	14–Apr	14–Jun	8–Jul	17–Aug

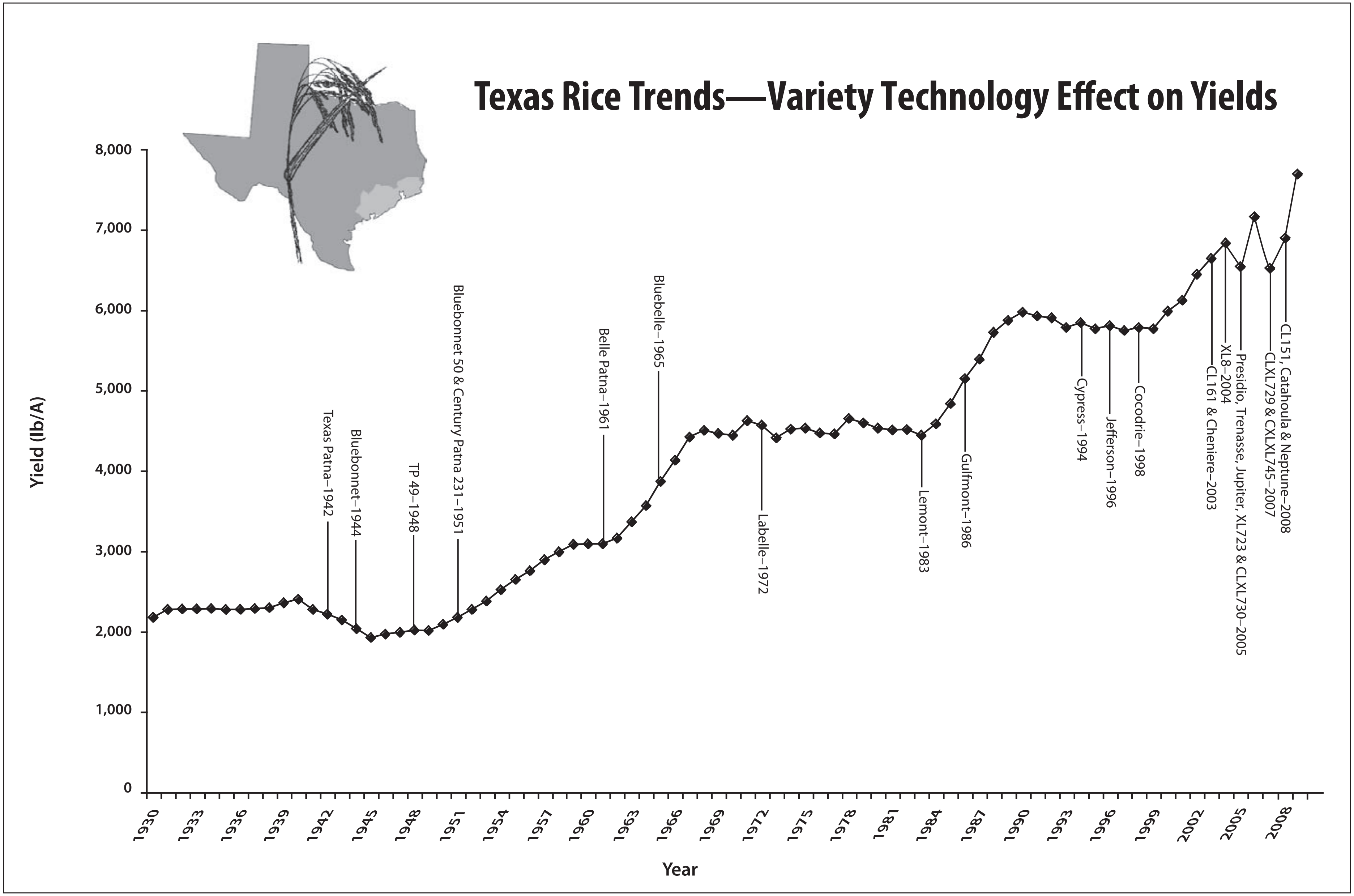


Figure 25. Texas Rice — Variety Technology Trends Effect on Yields (1930-2009).

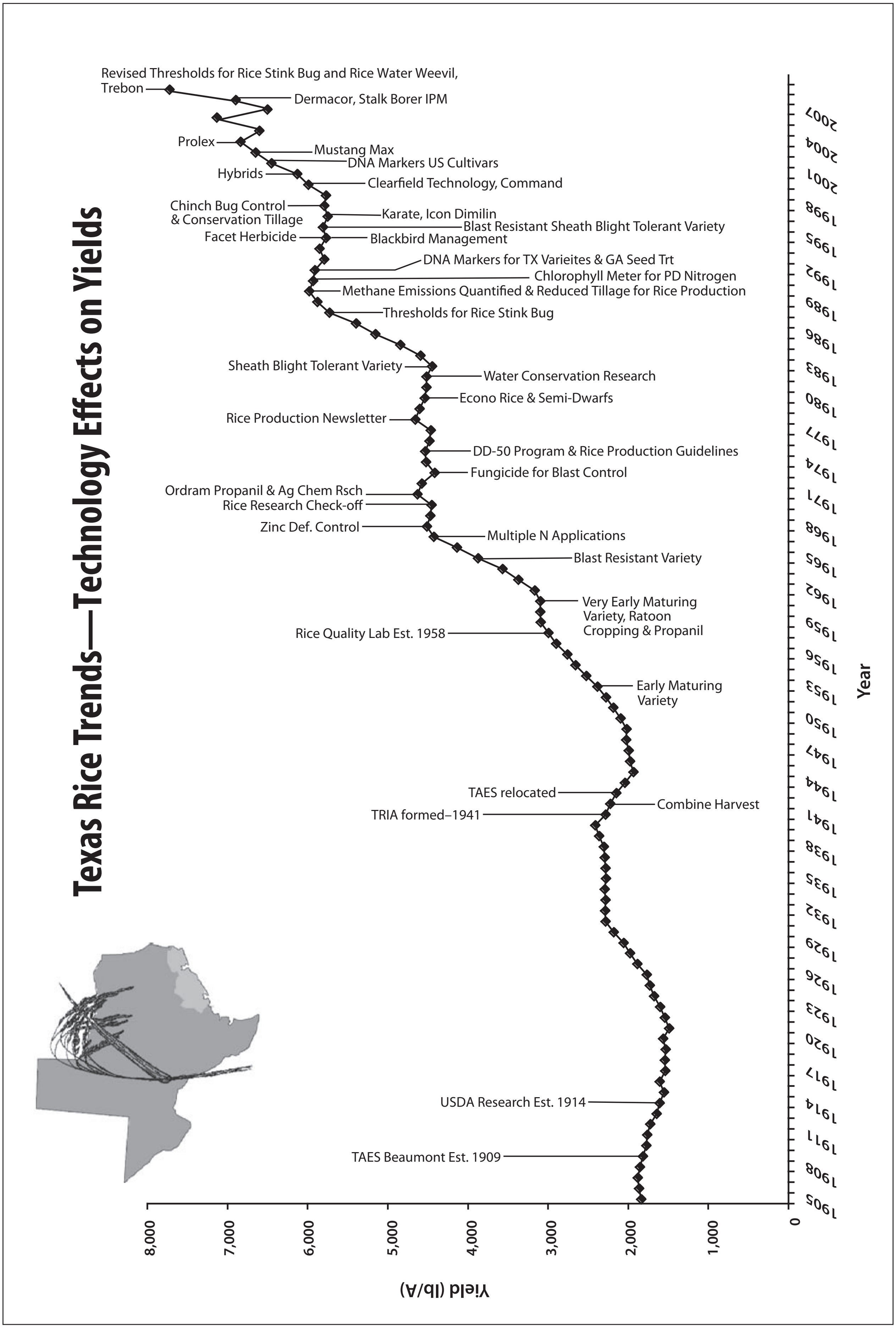


Figure 26. Texas Rice — Technology Trends Effect on Yields (1904-2009).

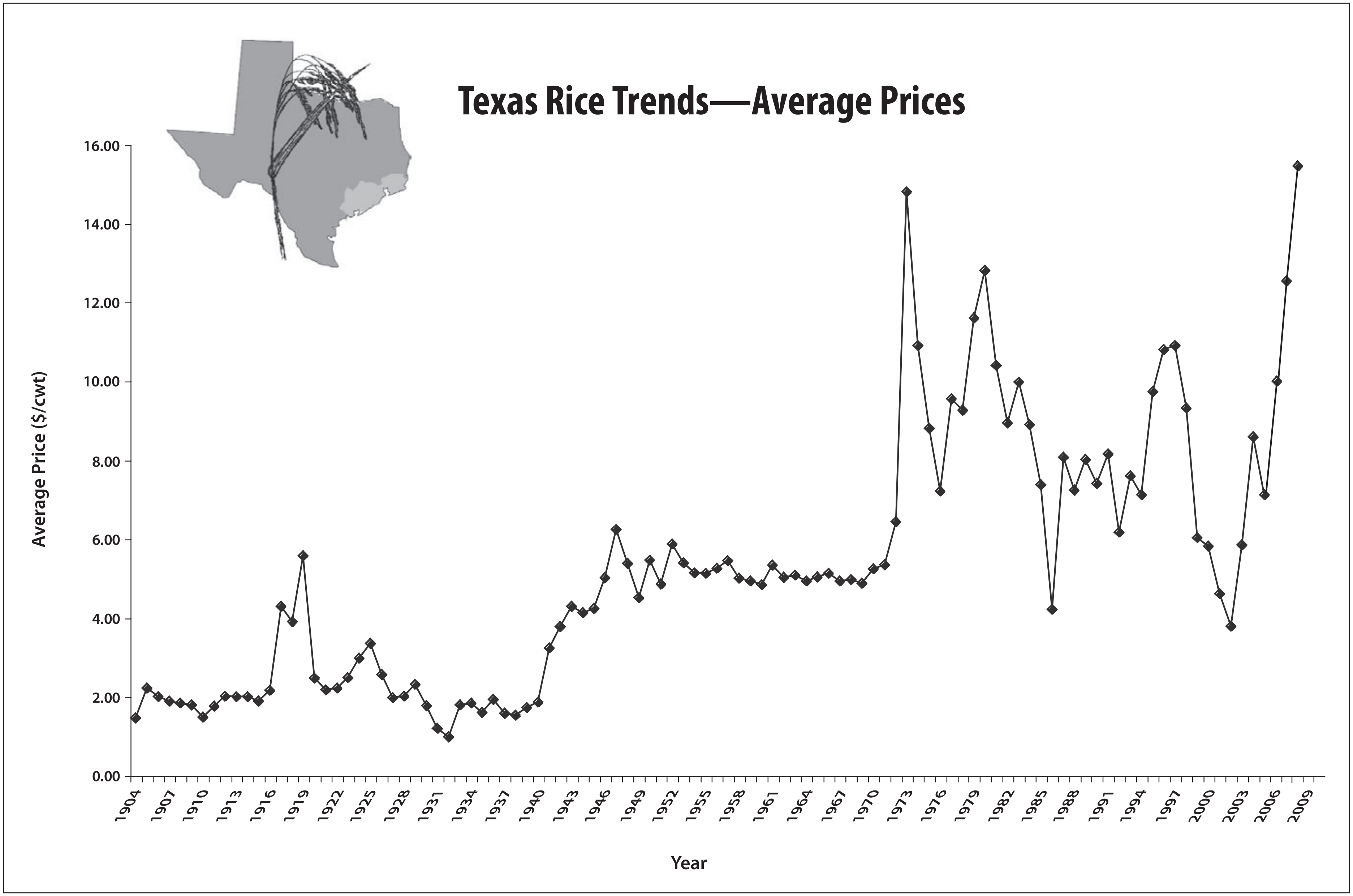


Figure 27. Texas Rice — Average Price Trends (1904-2008).

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