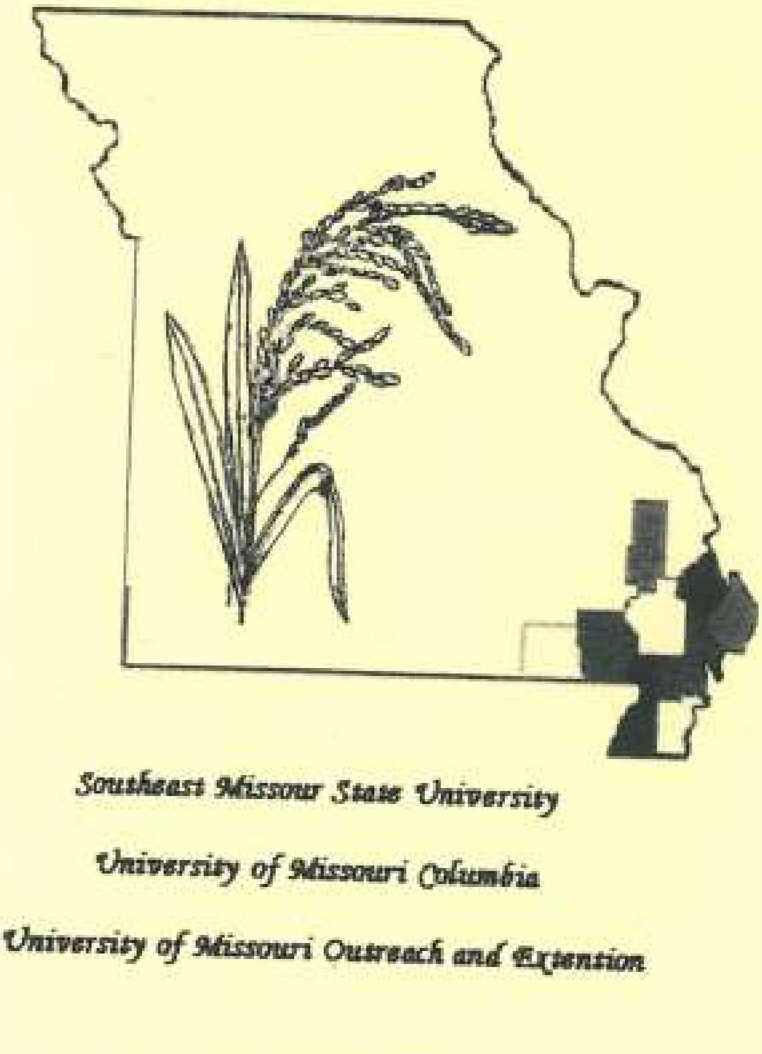
# Missouri Rice Research Update 2010



Southeast Missour State University

University of Missouri Columbia

University of Missouri Outreach and Extention

Special Report #01-2011

February 2011

# Introduction

This report is a compilation of research projects, demonstration efforts, and additional Missouri rice information. Its purpose is to inform producers, research and extension personnel, industry representatives, agribusiness consultants, farm suppliers, and commodity organizations about rice activities in Missouri. The information resulted from contributions of the University of Missouri Agricultural Experiment Station Personnel, and Southeast Missouri State University, United States Department of Agriculture – Wildlife Services. The use of trade or company names in this report does not constitute recommendation or endorsement.

**A special acknowledgement is extended to the Missouri Rice Research and Merchandising Council, Southeast Missouri State University, the University of Missouri College of Agriculture, Food, and Natural Resources, and the Missouri Commercial Agriculture Extension Program for financial support.**

Editors:
Cathy Dickens
Donn Beighley

For further information on Missouri Rice visit these websites:

A SEMO Rice Page on the World Wide Web at
http://www.semo.edu/rice/

A Missouri Rice Page on the World Wide Web at
http://www.ext.missouri.edu/agebb/rice/

A Missouri Rice DD50 Program on the World Wide Web at
http://www.agebb.missouri.edu/rice/ricemodel.htm

# Missouri Rice Producers Conference
## February 23, 2011
## Program

8:30 Weed Control Strategies for Resistance Weeds – Dr. Jason Weirich, MU Delta Center

9:00 Scouting Method for Tadpole Shrimp - Dr. Kelly Tindall, MU Delta Center

9:20 Rice Consumer Taste Panel – Dr. Wonkyo Jung, MU Delta Center

9:40 Break

10:00 Consumers View of Farming and Agriculture – Ray Massey, MU Columbia

10:30 Rice Variety Testing – Dr. Donn Beighley, SEMO Malden

11:00 U.S. Rice Domestic and Foreign Markets – Dwight Roberts, U.S. Rice Producers

11:30 Rice Market Outlook – Melvin Brees, MU FAPRI

12:00 Lunch - Provided by the Commercial Sponsors

# Table of Contents

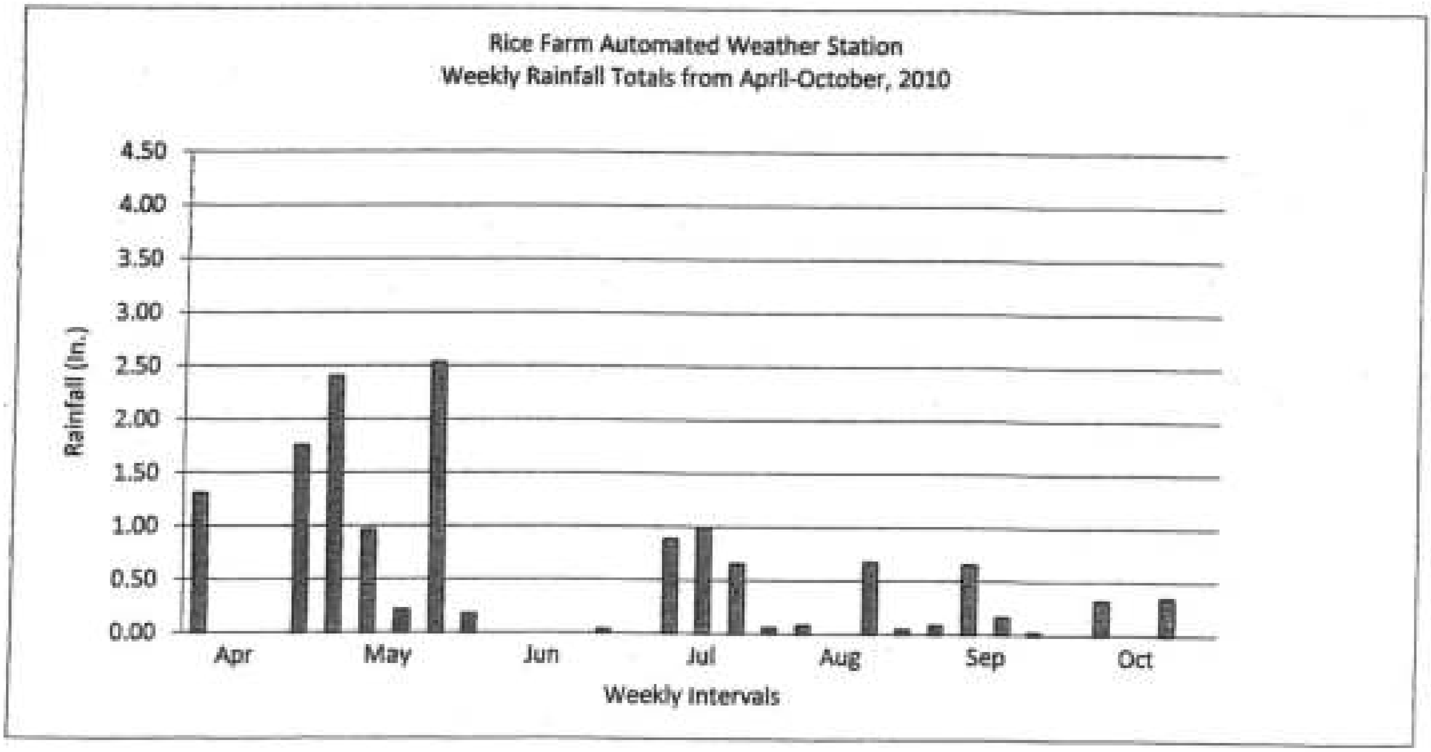
**Extension Commercial Agriculture Automated Weather Station**
**Rice Farm (1 mile east of Glennonville,**
**MO)**
**Monthly Weather Summary**
**Year: 2010**

**Temperature**
**(°F)**

| | Avg Max. | Avg Min. | Avg | Departure | Days ≥90° | Days ≥100° | Days ≤32° | Days ≤0° |
|---|---|---|---|---|---|---|---|---|
| January | 40.6 | 24.0 | 32.3 | -1.0 | 0 | 0 | 21 | 0 |
| February | 42.5 | 27.3 | 34.4 | -3.9 | 0 | 0 | 23 | 0 |
| March | 59.5 | 40.7 | 50.0 | 2.6 | 0 | 0 | 5 | 0 |
| April | 74.4 | 52.3 | 63.8 | 5.8 | 0 | 0 | 0 | 0 |
| May | 80.5 | 61.8 | 70.8 | 3.1 | 2 | 0 | 0 | 0 |
| June | 92.2 | 72.3 | 82.3 | 5.7 | 20 | 0 | 0 | 0 |
| July | 91.0 | 72.8 | 81.4 | 0.8 | 21 | 0 | 0 | 0 |
| August | 92.8 | 70.9 | 81.4 | 3.2 | 22 | 3 | 0 | 0 |
| September | 85.1 | 59.8 | 71.8 | 1.0 | 9 | 0 | 0 | 0 |
| October | 77.2 | 45.1 | 60.8 | 1.4 | 0 | 0 | 1 | 0 |
| November | 61.2 | 38.1 | 49.5 | 1.6 | 0 | 0 | 5 | 0 |
| December | 40.9 | 28.4 | 34.6 | -2.8 | 0 | 0 | 26 | 0 |
| Year | 69.8 | 49.5 | 59.4 | 1.4 | 74 | 3 | 81 | 0 |

**Precipitation (In.)**

| Total | Departure |
|---|---|
| 2.74 | -0.29 |
| 1.47 | -1.72 |
| 4.25 | -0.48 |
| 4.24 | -0.37 |
| 5.08 | 0.56 |
| 0.03 | -3.72 |
| 2.56 | -1.13 |
| 0.79 | -1.68 |
| 0.91 | -2.19 |
| 0.67 | -2.23 |
| 3.44 | -0.97 |
| 1.89 | -2.28 |
| 28.07 | -16.50 |


Rice Farm Automated Weather Station
Weekly Rainfall Totals from April-October, 2010

Rice Variety Reactions to Diseases 2009

| Variety | Sheath Blight | Blast | Straighthead | *Bacterial Panicle Blight* | Narrow Brown Leaf Spot | Stem Rot | Kernel Smut | False Smut | Brown Spot | Lodging | Black Sheath Rot |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Catahoula | VS | R | MS | S | MR | S | S | S | R | MR | MS |
| Cheniere | S | S | MS | S | S | S | S | S | R | MR | MS |
| CL111 | VS | S | S | S | VS | VS | S | S | R | MS | S |
| CL131 | VS | MS | VS | VS | VS | S | S | S | R | R | S |
| CL142 | MS |  | MS | S | S | S | S | S | R | MS | S |
| CL151 | VS | VS | VS | S | S | S | S | S | R | S-MS | S |
| CL161 | VS | S | MS | S | MS | S | S | S | R | MS | S |
| CL171AR | VS | S | MS | S | MS | S | S | S | R | MS | S |
| CL181 | VS | S | MS | S | MS | S | S | S | R | MS | S |
| CL 261 | MS | VS | S | VS | S | VS | MS | MS |  | MS | MS |
| Cocodrie | S | MS | VS | VS | MS | S | S | S | R | MR | MS |
| Francis | MS | VS | MS | VS | S | S | VS | S | R | MS | MS |
| JazzMan | MS | S | S | S | S | S | MS | S | R | MS | MS |
| JES | MS | R | MR | MS | R | VS | MS | MS | R | S | MR |
| RT CL XL729 | MS | MR | MR | MR | MS | MS | MS | S | R | S-MS | MS |
| RT CL XL730 | MS | MR | MR | MR | MS | MS | MS | S | R | S-MS | MS |
| RT CL XL745 | MS | R | R | MR | MS | MS | MS | S | R | S-MS | MS |
| RT XL723 | MS | R | MR | MR | MS | MS | MS | S | R | MS | MS |
| Roy J | MS | S | S | S | MR | S | S | S |  | MR | MS |
| Spring | S | MS | VS | S | MS | VS | MS | MS | R | S-MS | MS |
| Taggert | MS |  | R | MS | MS | S | S | S | R | MS | MS |
| Templeton | MS | R | S | S | S | MS | S | S | R | MS | MS |
| Trenasse | VS | S | VS | S | S | S | S | S | R | MS | MS |
| Wells | S | S | MS | S | S | VS | S | S | R | MS | MS |
| **Medium Grains** |  |  |  |  |  |  |  |  |  |  |  |
| Bengal | MS | S | VS | VS | S | VS | MS | MS | VS | MR | MR |
| Jupiter | MS | S | MS | MR | MS | S | MS | MS | R | S-MS | MR |
| Neptune | MS | MS | VS | S | MS | S | MS | MS | R | MR | MR |

Reaction: R = Resistant; MR = Moderately Resistant; MS = Moderately Susceptible; VS = Very Susceptible
Data prepared by R.D. Cartwright, F.N.Lee Both of Plant Pathology

General characteristics of varieties tested in the Arkansas Rice Performance Trials and Arkansas Rice Disease Monitoring Program.

| Variety/Hybrid | Year Released & State | Highlights |
|---|---|---|
| Bengal | 1992 – Louisiana | A short season, semi dwarf, medium-grain with good yield potential and milling quality. It has a preferred large grain size. |
| Catahoula | 2008 - Louisiana | A semi-dwarf, long-grain with good yield and milling potential and resistance to blast. |
| Cheniere | 2003 – Louisiana | A very short season, semi-dwarf long-grain with good yield potential, less oil in bran than Cocodrie, and improved straighthead tolerance. It has L202 and Jodon cooking type. |
| CL 111 | 2008 – BASF, Horizon Ag | An early season, semi-dwarf long grain similar to CL 131. Susceptible to blast, straighthead, and bacterial panicle blight. |
| CL 131 | 2005– BASF, Horizon Ag | A midseason, semi-dwarf long-grain similar to CL 161 with shorter plant height, moderately susceptible to blast, very susceptible to straighthead and sheath blight, but improved grain yield potential. |
| CL 151 | 2008 – BASF, Horizon Ag | A midseason, semi-dwarf long-grain similar to Cocodrie with good yield potential and high tolerance to Newpath herbicide. It is very susceptible to blast, straighthead, and susceptible to lodging and sheath blight. |
| CL 161 | 2002 – BASF, Horizon Ag | A midseason, semi-dwarf, long-grain similar to Cypress with high tolerance to Newpath herbicide. It is very susceptible to sheath blight, susceptible to blast and moderately susceptible to straighthead. |
| CL 142 AR | 2009 – BASF, Horizon Ag | A midseason, semi-dwarf long grain Clearfield similar to Francis with good yield potential, and high tolerance to Newpath herbicide. It is susceptible to blast and bacterial panicle blight, and moderately susceptible to sheath blight and straighthead. |
| CL 171 AR | 2006 - BASF, Horizon Ag | A midseason, semi-dwarf, long-grain similar to Wells with high tolerance to Newpath herbicide. It is susceptible to sheath blight, moderately susceptible to blast and straighthead. Yield is similar to CL 161. |
| CL 181 AR | 2009 – BASF, Horizon Ag | A midseason, semi-dwarf, long grain Clearfield with good yield potential and milling quality. |
| CL XL 729 | 2006 – Rice Tec, Inc. | A short-season, long grain with excellent yield potential and moderately susceptible to sheath blight, and moderately resistant to blast. |
| CL XL 730 | 2005– Rice Tec, Inc. | A short-season, long grain with excellent yield potential and moderately susceptible to sheath blight, and moderately resistant to blast. Somewhat susceptible to lodging under extreme conditions. |
| CL XL 745 | 2007– Rice Tec, Inc. | A short-season, long grain with excellent yield potential, moderately susceptible to sheath blight, and moderately resistant to blast, and susceptible to lodging. Reported to have improved tolerance to shattering. |
| CL XP 746 | 2008 – Rice Tec, Inc. | A short-season, long grain with excellent yield potential and high tolerance to Newpath herbicide, moderately susceptible to sheath blight, and moderately resistant to blast. Reported to have improved tolerance to shattering. |
| Cocodrie | 1997 – Louisiana | A short season semi-dwarf long-grain with good yield potential and milling quality. Susceptible to sheath blight and other diseases. High bran oil content makes it somewhat of a milling concern to certain buyers. |

| Variety/Hybrid | Year Released & State | **Highlights** |
|---|---|---|
| Francis | 2002 – Arkansas | A very short season, long-grain with excellent yield potential, susceptible to rice blast and very susceptible to kernel smut. It is the best long grain for high pH and salt soils of NE Arkansas west of Crowley's ridge but should not be stressed for water due to blast concerns. |
| Jazzman | 2009 - Louisiana | A long grain aromatic variety with high yield and good milling quality. |
| JES | 2009 - Arkansas | A Jasmine type aromatic rice with good yield potential and milling quality. |
| Jupiter | 2005 - Louisiana | A medium grain type with excellent yield potential with superior resistance to Blast and straighthead while exhibiting better tolerance to panicle blight than Bengal. Milling quality is similar to Bengal. |
| Neptune | 2008 - Louisiana | A semi-dwarf medium grain with very high yield potential with good levels of resistance to current Blast races. It has excellent milling quality with a "bold" grain is similar to Bengal. |
| Taggert | 2009 - Arkansas | A late mid-season, long grain variety with excellent yield potential across years with resistance to Brown Spot while moderately susceptible to sheath blight and bacterial panicle blight. It has average milling quality. |
| Templeton | 2009 - Arkansas | A mid-season, long-grain variety with good yield potential, resistant to Blast and Brown Spot while moderately susceptible to sheath blight and bacterial panicle blight. It appears to have average milling quality. |
| Trenasse | 2005 - Louisiana | A very short season, long grain with excellent yield potential. It is very susceptible to sheath blight, straighthead, and susceptible to blast. |
| Wells | 1999 - Arkansas | A short season, long grain with excellent yield potential, average to good milling quality, large kernel size similar to Lemont, but is susceptible to rice blast. Only moderately susceptible to kernel smut and most other diseases and is the most widely adapted long grain rice in Arkansas. |
| XL 723 | 2003- Rice Tec Hybrid | A short-season long-grain hybrid with excellent yield potential, average milling quality, but resistant to blast and moderately susceptible to sheath blight. |

# Scouting Method for Tadpole Shrimp

**Kelly V. Tindall and Kent Fothergill**

Tadpole shrimp are a relatively new pest of Missouri rice. In 2008, at least 4000 acres had tadpole shrimp present and of those infested, approximately 2000 acres were economically impacted. Infestations also caused approximately 100 acres to be replanted. Sexually mature tadpole shrimp are found as early as 9–12 days after floods are established; therefore, rice plants have <9 days to break the surface of the flood (i.e., the time at which rice is no longer vulnerable), before tadpole shrimp are large enough to uproot seedling rice. Tadpole shrimp are pests of water-seeded rice fields. Rice planted by drill-seeded or dry-seeded methods has an adequate root system when fields are flooded, and tadpole shrimp are not pests in these systems. Once rice is no longer vulnerable to tadpole shrimp damage, tadpole shrimp may serve as a biological control agent for mosquitoes and/or weeds.

Hybrid rice varieties are planted at a lower seeding rate than conventional varieties, making them more susceptible to tadpole shrimp damage than higher seeding rates. For example, losing 10% of a stand planted at 30 lbs/A is more detrimental than losing 10% of a stand planted at 90 lbs/A.

In 2010, we initiated a distribution survey to determine where this pest occurs in rice producing areas of Missouri. Initially, we examined fields approximately four to six weeks after they were planted. Fields were randomly selected. Aquatic sweep nets were drug along the soil surface in attempts to capture tadpole shrimp. This methodology resulted in many negative fields. Field histories were unknown and samples were conducted during the time when control measures may have been used for other early season rice pests. Most foliar products available for early season pests of rice are also active on tadpole shrimp. Because there were so many negative fields, an alternative strategy was implemented.

After harvest, 8 in x 8 in soil samples were collected. The soil depths of the sampled areas were approximately 2 inches. Low areas of the field were targeted because tadpole shrimp will congregate in areas were water remains on the field after it is drained. There was a distance of 50 to 100 ft between samples. Five samples per field were collected and brought back to the lab for further processing

Tadpole shrimp eggs require a period of drying; therefore, soil should be dried completely. After soil has been dried thoroughly, place soil in a plastic container that allows the soil to be spread to a depth no greater than 1 inch. Add water to the plastic containers to simulate a 2 inch flood and maintain the flood for 15 to 21 days. The containers should be kept in an area that is warm and exposed to light so that the tadpole shrimp will hatch (room temperature should suffice). After 2 to 3 weeks, tadpole shrimp, if present, should be visible. A bright light may aid in the detection of the tadpole shrimp. Additionally, the water may appear muddy, indicating their presence as well. When examining samples, many arthropods other than tadpole shrimp were recovered, so it is important to wait at least two weeks before reading samples to ensure proper identification. The longer they have to develop, the more likely that they will be identified correctly.

This methodology is used by researchers who study short term water systems and it appears to be effective for determining the presence of tadpole shrimp in rice fields. If samples test positive for tadpole shrimp, the farmer should be aware there is a risk associated with water-seeding the field and should consider drill seeding that field. If the farmer must water seed, efforts should be made to seed the field as quickly as possible after the water is put in the field. Additionally, the field should be watched closely to ensure stand loss does not become problematic in the field.

Preliminary results of the tadpole shrimp distribution study have shown that tadpole shrimp are in several rice producing areas in Missouri. One trend that we are seeing with the data suggests that tadpole shrimp are widely distributed geographically; however, not every field within an area is infested. We have several samples still being processed. Tadpole shrimp are transferred from field to field via floodwaters, wind, birds and other wildlife. They are also likely transferred via equipment used in an infested field as well as transferred on the soles of boots when walking in and infested field and then walking in a non-infested field. The latter two mechanisms of transfer could be avoided by adopting better sanitary practices when moving between rice fields.

The methodology developed in this study provides an easy to use tool that can be utilized by farmers and their scouts to determine the presence of tadpole shrimp before making planting decisions. In situations where hybrid rice and/or water seeded rice will be utilized, the knowledge that a field has viable tadpole shrimp eggs in the soil should be useful in determining scouting frequency and aggressiveness of treatment for early season rice pests. While the study methodology was effective for discovery of tadpole shrimp, current data are not sufficient to determine economic thresholds and the likelihood of false negatives (samples that fail to show presence of tadpole shrimp from infected field). It is hoped that future work will develop this tool further so that farmers will have the knowledge needed to protect their investment.

# Medium-grain Rice Consumer Taste Preference Test

**Won K. Jung, Ph.D., Rice agronomist**

**University of Missouri-Delta Research Center**

Medium-grain rice is the primary type consumed by many Asians as a staple food. The average Asian American consumes 70-100 lbs of medium-grain rice per year. During the past several years, the price of high quality medium-grain rice has increased because of increased demand and an unstable market situation. In the consumer market, the price of Japonica type medium-grain rice is often two to three times the price of Indica type medium-grain rice or long-grain rice because of greater taste preference for the Japonica type.

Currently, most US domestic japonica type medium-grain rice is produced in California. Recently, significant issues with water quantity and quality and with environmental concerns have been negative factors preventing increased medium-grain rice production in California. On the other hand, some other states in the mid-South production area, including Arkansas and Louisiana, have increased medium-grain rice production. An increase in total medium-grain rice production might be expected to decrease market prices, but a shift in the region of production and the influence of the greater taste preference for Japonica type medium-grain rice by consumers could allow increased production in states such as Missouri while maintaining the price benefits of these types.

The taste preference of medium-grain rice is related to various factors including genetic characteristics, crop and soil management technologies, and post-harvest processing. Japonica type of medium-grain rice has been considered high quality rice in the marketplace when compared to Indica type medium-grain rice. In terms of composition, the preferred Japonica type rice has less than 7% protein and less than 20% amylose content in the kernel. Recent research analyzed factors affecting consumer preference for medium-grain rice and found that taste accounted for 73% of the choice compared with only 16% for price.

Results summarized as follows:

- Medium-grain rice yield decreased by reduced N fertilizer application.
- Medium-grain rice grain protein (<7%) and amylose content (<22%) were lowered by reduced N fertilizer application.
- 73% of rice taste testing participant answered that the "taste" is their first priority to purchase rice at the market.
- Jupiter variety got the most higher scores of rice taste properties
- Most of medium-grain rice varieties, which are used in this research, got better score of participant's in-home taste test. Jupiter got the highest score in-home test.

This result implies that medium-grain rice consumer preference tends to move from price to taste and quality.

Table1. Relative rice taste preference test scores of MO grown medium-grain rice compare to CA grown rice*.

| | Bengal | CL261 | Jupiter | Neptune | Nishiki* |
|---|---|---|---|---|---|
| Shape | 0.93 | 0.82 | 1.00 | 0.92 | 1.0 |
| Smell | 0.98 | 0.95 | 1.06 | 0.99 | 1.0 |
| Taste | 0.99 | 0.94 | 1.11 | 0.98 | 1.0 |
| Stickiness | 1.05 | 1.00 | 1.07 | 1.01 | 1.0 |
| Texture | 0.97 | 0.91 | 1.06 | 0.98 | 1.0 |
| Overall | 0.99 | 0.91 | 1.09 | 0.99 | 1.0 |

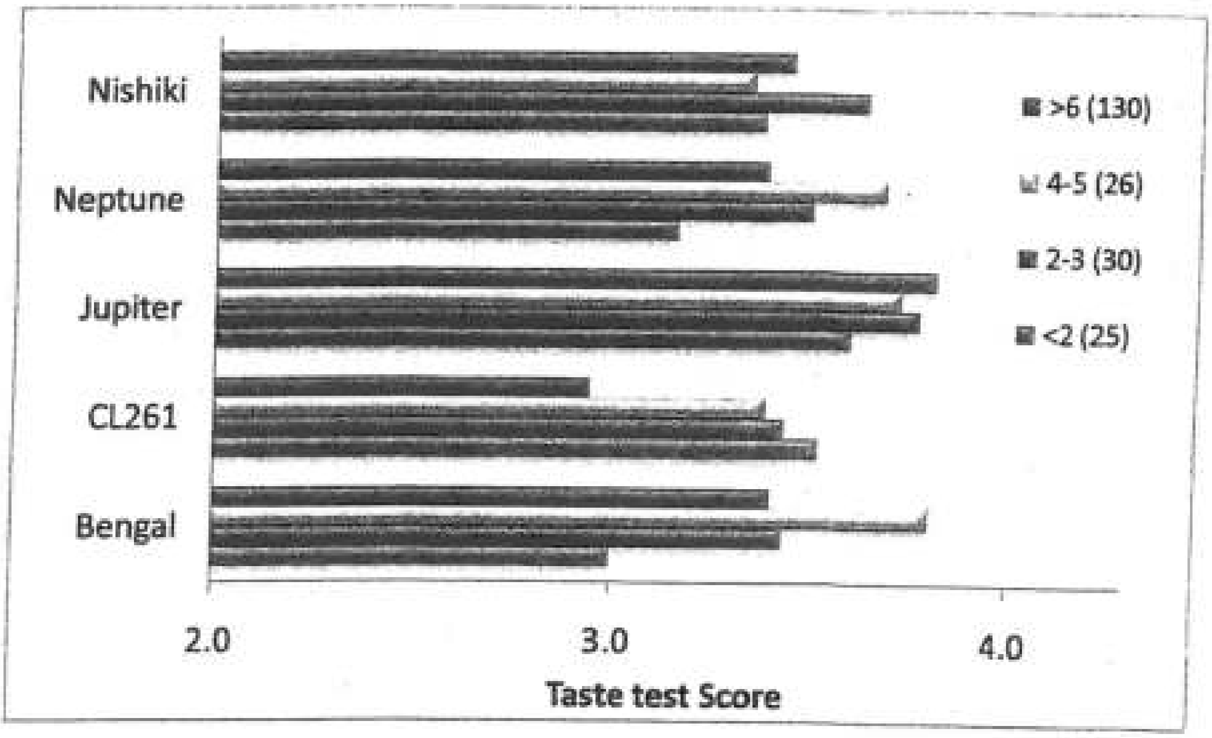


Figure 1. Overall Rice taste test scores by how often rice is eaten in a week (n=211).

# 2010 Effect of Flood Depth Study

**Donn Beighley, Cathy Dickens, Trent Brewer,**
**Michael Kean and Scott Wheeler**

As rice production acres continue to increase in southeast Missouri the effects of different rice production practices are being tested by the rice researchers as an aid to the Missouri rice producer community. The effect of flood depth study was initiated to see if there were either positive or negative effects when rice is produced at different flood depths. This aspect of rice production is important as energy costs for pumping continue to increase.

## Experimental Procedure

### Location

Rice plots were established at the Missouri Rice Research Farm near Glennonville, MO. The plots at the Rice Research Farm were planted on 19 May on a continuous rice field. The trial consisted of four conventional varieties (Jupiter, Francis, Trenasse and Wells) to determine if there were varietal effects due to flood depth.

All the varieties were evaluated within the same trial. The yield trial was arranged in a randomized complete block design with six replications. Each plot consisted of seven rows, 12 feet long, with a between-row spacing of 7.5 inches.

Plots were planted with an Almaco no-till plot drill. Pre-flood fertilizer was applied at a rate of 180 lb nitrogen for all lines. For primary weed control, 12 oz. Command applied post plant, 3 qt. Stam and ½ lb. Facet herbicides were applied prior to flooding. There were no insecticides applied. The different flood depths (0, 2, 4, 6, and 8 inches) were maintained throughout the growing season. The zero flood depth was difficult to maintain as there was the problem of backflow from the surrounding field through the drain pipe and the effect of rainfall. The plots were harvested with a research plot combine. The grain from the plots was weighed and moisture was determined.

Data was recorded for: Emergence date, the number of days to 50% heading, plant height, lodging, and yield for each variety in the field. Milling quality was determined at the Rice Lab located at the Crisp Bootheel Education Center located in Malden, MO.

## Results

The average yield of the flood depth study at the MO Rice Farm was 84 Bu/A with the four inch depth having the highest yield (106 Bu/A) followed by eight inches, six inches, two inches and zero inches, respectively. There was not much difference in yield from four to eight to six inches but after the six inch depth the yields dropped off by an average of 17 Bu/A. Table 1.

Across the different flood depths Trenasse had the highest average yield (107 Bu/A) and the highest yield of 133 Bu/A at the eight inch depth. Jupiter had the lowest average yield at 59 Bu/A. Trenasse was the highest yielding across all depths. Table 2.

There was a two day difference in number of days (82 to 85 days) to 50% heading between the different flood depths. The zero depth was required one to two days longer to reach 50% heading than did the other depths. This was also observed for the individual varieties.

The average plant height was 37 inches and there as only a one inch difference between flood depths for plant height.

The percent lodging averaged less than 10 percent in 2010.

The average percent total kernel milling quality was 69 percent with little difference any depth except at the zero depth (60%). The average percent whole kernel milling quality was 54 percent. The zero depth was 42 percent while the other four depths averaged 58 percent. There was some difference between depths for percent whole rice. This differed from 2009 when the whole rice percentage was the same across the water depths.

**Summary**

The main effect of increasing flood depth was observed to be on the yield component although small effects were observed for days to 50% heading and percent whole rice milling quality. 2010 yields were highest at the four inch depth while the six and eight inch flood depth where slightly decreased but yields do not decrease appreciably until the flood depth approaches two and zero inches at which time yields did decrease by an average of 17 Bu/A.

When one looks across years the four inch continues to be the highest yielding depth followed by six inches, eight inches, two inches and zero inches. The yield decreases dramatically at the zero depth as compared to the other four depths and particularly compared to the four inch depth. The value of this information is in the pumping costs from one depth to another and the corresponding yields at those depths. There has been no noticeable difference in disease incidence at the various water depths as one might expect when Blast is prevalent.

The percent whole rice values were similar for all depths except for the eight inch depth which was approximately three percentage points less for both 2009 and 2010.

One noticeable difference between the zero flood depth and the other depths was the higher incidence of algae / scum in the alleys. There were definitely fewer weeds in the zero flood depth than the other depths. And the incidence of aquatic weeds appeared to greater as the flood depth increased.

| Table 1. | 2010 Agronomic Trait Data at Different Flood Depth | | | | | |
|---|---|---|---|---|---|---|
| Water Depth (Inches) | Bu/A | Days to 50% Heading | Plant Height (Inches) | Percent Lodging | Percent Total Rice | Percent Whole Rice |
| 0 | 56 | 87 | 36 | 0 | 60 | 42 |
| 2 | 72 | 85 | 36 | 0 | 72 | 56 |
| 4 | 106 | 85 | 38 | 0 | 71 | 58 |
| 6 | 90 | 84 | 37 | 0 | 72 | 59 |
| 8 | 98 | 85 | 37 | 0 | 71 | 57 |
| Avg | 84 | 85 | 37 | 0 | 69 | 54 |

| Table 2. | 2010 Variety Yields (Bu/A) at Different Flood Depth | | | | | |
|---|---|---|---|---|---|---|
| Variety | Zero Inches | Two Inches | Four Inches | Six Inches | Eight Inches | Avg. |
| Francis | 68 | 60 | 117 | 95 | 98 | 88 |
| Trenasse | 70 | 96 | 125 | 113 | 133 | 107 |
| Wells | 37 | 84 | 105 | 89 | 101 | 83 |
| Jupiter | 47 | 48 | 78 | 65 | 59 | 59 |
| Avg. | 56 | 72 | 106 | 90 | 98 | 84 |

# The 2010 Effect of Planting Date on Rice Varieties

Donn Beighley, Cathy Dickens, Michael Kean,
and Trent Brewer

In southeast Missouri there are a narrowing number of rice varieties grown that meet the needs of Missouri rice producers. These varieties are planted as the weather and the field conditions permit during the period from early April to late June. However, the time of planting may vary from year-to-year based on the planting environment, i.e. the weather. Consequently we attempt to provide as much information possible concerning varietal performance with respect to harvest date, yield, quality and their agronomic traits when planted at different dates between early April and post wheat harvest in mid-June.

## Experimental Procedure

### Location

Rice plots were established at the Missouri Rice Research Farm near Glennonville, MO on a Crowley silt loam. The plots were planted on: 15 April (early-April), 30 April (late April to early May), and 1 June (late May to early June). At each planting date there were seven varieties that represent the major rice varieties grown in southeast Missouri as well as four experimental varieties. The released varieties were: Cheniere, Francis, Jupiter, Neptune, Taggart, Templeton, and Wells.

### Field Plot Design

Each planting date was evaluated as a separate trial and all varieties were included at each date. Each test was arranged in a randomized complete block design with four replications. Each plot consisted of seven rows, 12 feet long, with a between-row spacing of 7.5 inches.

### Entries

Seed of all public varieties were obtained from: Karen Moldenhauer – UA, Stuttgart, AR and Steve Linscombe – LSU, Crowley, LA and Horizon AG.

### Plot Management

The drill plots were planted with an Almaco no-till plot drill. For primary weed control, 12 oz. Command was applied post plant, 4 qt. Duet and ¾ lbs. Facet herbicides were applied prior to flooding. A pre-flood fertilizer was applied at a rate of 180 lbs N. The flood was maintained throughout the growing season. There were no insecticides applied. A single row was harvested to determine milling quality. Milling quality was determined on two replications of each variety from each planting date.

### Data Recorded

Agronomic notes taken on each plot included: Emergence date, days to 50% percent heading, plant height, lodging and any disease reactions observed as well as measuring yield for each variety. Emergence date was noted as the date when ten plants per square foot were emerged. The days to 50% heading is determined by counting the days from emergence to the presence of 50% of the panicles at least partially emerged from the boot. Height was taken as the average distance in inches from the soil surface to the top of the panicle. Lodging, which indicates the degree of erectness, was scored on a scale of 0 to 100 with 0 indicating all plants in a plot were erect (no lodging) and 100 percent indicating all plants were lodged. Total and head milling yield were determined after milling a sample of each variety in the study.

## Results

### Yield:

In 2010 when the variety yields were averaged for each planting date it was observed that the mid- April planting date had the highest overall yields at 139 Bu/ A. It was followed by the early-June (102 Bu/A), and early-May (91 Bu/A) Table 1. In previous years the early April planting date resulted in the highest overall yields. However since we were unable to plant the early April date in 2010 we did not have this data.

Across all planting dates Taggart and Francis were the highest yielding long grain types (148 and 127 Bu/A, respectively) while Neptune was the highest yielding medium grain type (125 Bu/A) Table 2.

### Days to Emergence

The number of days from planting to emergence ranged from 18 days at mid-April to 7 days at the early June planting date. Ten fewer days, on average are required for days from planting to emergence when comparing mid- April (18 day average) to early June date (7 day average) Table 1.

Neptune and Trenasse continue to have an emergence date that is about one to three days later than the average of the varieties at all planting dates.

### Days to 50% Heading

Across planting dates the average number of days to 50% heading ranged from 68 days at early June up to 87 days planted mid-April (Table 1). A similar trend was observed within varieties. Taggart had the longest average period between emergence and 50% heading date (85 days) while Jupiter and Francis had the fewest (79 days) (Table 2).

### Plant Height

When averaged across all varieties the plant height did not change noticeably mid- April to the later planted dates Table 1. There was a similar trend for the individual varieties. Taggart was the tallest varieties (40 inches) while Neptune was the shortest varieties (33 inches) when averaged across all planting dates Table 2.

**Lodging**

Lodging was not of any consequence in any of the varieties in 2010.

**Milling Yield / Quality**

The percent whole rice yield values for 2010 were higher at the mid- April date and slightly lower at the late April and much lower at the early June planting date. The percent total yield decreased slightly from the mid-April to the late April date to the early June planting date. This may have been a result of the hot dry drying conditions that occurred throughout the fall in 2010.

The highest overall milling quality was from the mid- April date (71 / 57) and the lowest was the early June date (69 / 39) Table 1.

Across varieties Neptune (74 / 62) had the highest average milling quality and Templeton had the lowest average (69 / 48). The trend appears to be that the medium grain varieties consistently have the highest milling values across all planting dates and this trend is observed in most years Table 2.

## Summary

The results of the 2010 date of planting yield trials indicates that the mid- April planting did result in higher yields than later planting dates and that the early-June yields were the lowest observed of all the planting dates.

The results of the milling quality analysis indicated that the mid- April date had the best values.

Table 1.

| | 2010 Planting Date Agronomic Trait Averages | | | | | | |
|---|---|---|---|---|---|---|---|
| Planting Date | Days to Emergence | Days to 50% Heading | Plant Height (Inches) | Percent Lodging | Bu / A | Percent Total Rice | Percent Whole Rice |
| Mid-April | 18 | 87 | 36 | 30 | 139 | 71 | 57 |
| Late April | 11 | 82 | 36 | 30 | 91 | 71 | 57 |
| Early June | 7 | 68 | 36 | 10 | 102 | 69 | 39 |

Table 2.

| | 2010 Variety Averages across Three Planting Dates | | | | | |
|---|---|---|---|---|---|---|
| Variety | Days to 50% Heading | Plant Height (Inches) | Percent Lodging | Bu / A | Percent Total Rice | Percent Whole Rice |
| Cheniere | 81 | 35 | 10 | 100 | 72 | 58 |
| Francis | 79 | 38 | 10 | 127 | 70 | 50 |
| Jupiter | 79 | 35 | 10 | 120 | 72 | 62 |
| Neptune | 81 | 33 | 0 | 125 | 74 | 62 |
| Taggart | 85 | 40 | 10 | 148 | 71 | 52 |
| Templeton | 83 | 39 | 20 | 108 | 69 | 48 |
| Wells | 80 | 36 | 10 | 103 | 70 | 41 |

# 2010 Missouri Rice Variety Performance Trials

Donn Beighley, Cathy Dickens, Trent Brewer, Michael Kean, Travis Wagner,
Kelly Tindall, Gene Stevens, David Dunn, Allen Wrather, and Wonko Jung

In 2010 the Missouri Rice Council, University of Missouri-Delta Center and Southeast Missouri State University conducted the Missouri rice variety trials as a cooperative effort. These trials are conducted as a service to Missouri rice producers to provide a reliable, unbiased, up-to-date source of information for comparing rice varieties grown in the southeast Missouri environment.

## Experimental Procedure

### Location

Rice plots were established at two locations in 2010: the Missouri Rice Research Farm near Glennonville, MO and at the Delta Center Farm at Portageville, MO. The Rice Research Farm yield trial consisted of drill-seeded plots following soybeans, drill-seeded plots following rice and water-seeded plots following rice which were planted on 15 April, 19 May and 29 April, respectively on a Crowley silt loam. The plots at the Delta Center were drill seeded on 1 June on a Sharkey clay and under the center pivot area on 7 May. The seed planted in the water seeded trial were treated with Apron-Maxim-Zinc for rice water weevils. The trial consisted of 27 public, private, and experimental varieties.

### Field Plot Design

All the varieties were evaluated within the same trial. The yield trial was arranged in a randomized complete block design with four replications. Each plot at the Missouri Rice Farm consisted of seven rows, 12 feet long, with a between-row spacing of 7.5 inches while the plots at the Delta Center were 16 feet long. The water seeded plot size was 12 foot long by 4.4 feet wide.

### Entries

Seed of all public varieties were obtained from: Karen Moldenhauer / James Gibbons – UA, Stuttgart, AR; Steve Linscombe – LSU, Crowley, LA; Anna McClung – USDA-ARS / Dante Tabien, Beaumont, TX; Dwight Kanter – MSU, Stoneville, MS, and Horizon Ag.

### Plot Management

Plots were planted with an Almaco no-till plot drill. Pre-flood fertilizer was applied at a rate of 180 lb nitrogen. In the water seeded trial 60 lb urea was applied post emergence, 60 lb N applied at panicle initiation and 60 lb N applied 14 days later.

For primary weed control, 12 oz. Command applied post plant, 2 pts. Prowl, 2 oz. Aim, 78 oz. Permit, 4 qt. Rice Shot and ¾ lb. Facet per acre were applied prior to flooding. There were no insecticides applied. The flood was maintained throughout the growing season. The plots at the Rice Research Farm were harvested with an Almaco research plot combine or a Wintersteiger plot combine depending on the field being harvested while Wintersteiger plot combine only was used at the Delta Center. The grain from the plots was weighed and moisture was determined.

**Data Recorded**

Depending on the location and test was recorded for: emergence date, the number of days to 50% heading, plant height, lodging, and yield for each variety in the field. Milling quality was determined in the laboratory. Emergence date was the date there were ten plants per square foot on the drill-seeded trial and ten plant per square foot emerged from the water surface in the water-seeded trial. The days to 50% heading was determined from the number of days from emergence to the presence of 50% of the panicles at least partially emerged from the boot. Plant height was taken as the average distance in inches from the soil surface to the top of the panicle on the plant. Lodging, which indicates the degree of erectness, was scored on a scale of 0 to 10 with 0 indicating all plants in a plot were erect (no lodging) and 10 indicating all plants were lodged. Yields were adjusted to 12 percent moisture and reported on a bushel per acre basis. Milling quality was determined at the Rice Lab located at the Crisp Bootheel Education Center located in Malden, MO.

## RESULTS

The 2010 Missouri Rice Variety Trials resulted in less than optimum yields for the five management practices under which they were tested. Brown spot and Straighthead were the only diseases observed. The Brown Spot was in the trial grown under the center pivot.

**Yield (Table 1, 2 and 3) Location Averages**

The average yields were as follows: conventional drill test (MO Rice Farm) – 164 Bu/A, continuous rice drill test (MO Rice Farm) – 113 Bu/A, conventional drill test (UM Delta Center) – 193 Bu/A, center pivot drill test (UM Delta Center) - 154, and the water-seeded test (MO Rice Farm) - 129 Bu/A. The water-seeded trial yields were not lower than expected in light of the later planting date as compared to previous years.

**Long Grain Type (Table 1)**

Differences among varieties were observed across all trials. The top yielding line across all trials was Templeton (AR.) followed by Rondo (TX), CL142, Mo0318016, and Roy Jay (AR). In the conventional drill-seeded trial at the Missouri Rice Farm Mo0318016 was the top yielding lines at 204 Bu /A followed by RoyJay, Rex (MS) and Catahoula (LA). In the conventional drill-seeded trial at the UM Delta Center Templeton was the top yielding line at 223 Bu /A followed by Taggart, RoyJay, and Wells. In the continuous rice drill-seeded trial at the Missouri Rice Farm Rondo and CL142 topped the test at 149 Bu/A followed by CL151, Taggart, and JES. The top yielding line in the water-seeded trial was Jazzman at 164 Bu /A followed by Cheniere and Francis.

The new long grain releases were CL111and CL142 which yielded 145 and 151 Bu /A across five locations.

**Medium Grain Type (Table 1)**

The top yielding line across all trials was RU0002146, at 153 Bu/A followed by Jupiter and Neptune. Jupiter was the top line in the Missouri Rice Farm conventional drill-seeded trial (177 Bu/A) and the continuous rice drill-seeded trial (103 Bu/A). RU0002146 was the top line in the Missouri Rice Farm water-seeded trial (129 Bu/A) and the Center Pivot trial (213 Bu/A).

**Days to Emergence (Table 1)**

In 2010 the number of days from planting to emergence for the continuous rice water-seeded (9 days) and continuous rice drill-seeded emergence (8 days). Seventeen days were required for the MO Rice Farm trial to emerge.

**Days to 50% Heading (Table 1)**

Days to 50% heading was taken in only the MO Rice Farm trials. In the water-seeded trial the average number of days to 50% heading was 75 days, 85 days for the continuous rice trial and 89 days for the conventional rice trial behind soybeans. The range of the difference between the different trials was 1.46 days. The average number of days to 50% heading observed for the varieties in the combined trials ranged from 80 days for Trenasse to107 days for RoyJay.

**Plant Height (Table 1)**

The 2010 average plant heights across locations were 37 inches. Individual location plant heights were 40 inches for the MO Rice Farm, 38 inches for the continuous rice trial, 342 inches for the center pivot trial, and 37 inches for the UM Delta Center drill-seeded trial.

**Lodging (Table 1)**

Lodging averaged no lodging to 30% in all the trials across all varieties.

**Milling Quality (Table 1)**

Average percent milling quality values across all trials was 71/58. The continuous rice trial had an overall milling quality values at 70/58 and the conventional rice trial had the highest at 72/55. The other averages were UM Delta Center (71/62), center Pivot (72/63) and water-seeded averaged 70/53. In 2010 the differences between the five locations for percent total rice were smaller than that of the difference between the percent whole rice between the five locations.

**Rice Disease Data**

No significant disease symptoms were observed in 2010 other than the Brown Spot under the center pivot and some Straighthead in tests at the Rice Farm.

Table 1.

2010 Rice Variety Yield Trial Agronomic Data

| Variety | GT | Days to 50% Heading (3x) | Plant Height (5x) | Percent Lodging (5x) | Bu/A (5x) | % Total Rice (5x) | % Whole Rice (5x) |
|---|---|---|---|---|---|---|---|
| Catahoula | L | 92 | 37 | 0 | 141 | 73 | 60 |
| Cheniere | L | 92 | 36 | 0 | 147 | 73 | 60 |
| Francis | L | 91 | 39 | 0 | 152 | 71 | 58 |
| Jazzman | L | 91 | 39 | 5 | 146 | 70 | 59 |
| JES | L | 91 | 34 | 15 | 143 | 69 | 56 |
| Rex | L | 92 | 38 | 0 | 151 | 71 | 60 |
| Rondo | L | 93 | 38 | 0 | 159 | 69 | 59 |
| RoyJay | L | 96 | 43 | 0 | 153 | 70 | 54 |
| Taggart | L | 95 | 40 | 0 | 158 | 70 | 55 |
| Templeton | L | 95 | 39 | 0 | 164 | 71 | 56 |
| Trenasse | L | 82 | 37 | 15 | 146 | 70 | 56 |
| Wells | L | 92 | 39 | 5 | 135 | 72 | 56 |
| LA2140 | L | 91 | 38 | 0 | 132 | 70 | 57 |
| Mo0256872 | L | 90 | 36 | 5 | 142 | 72 | 60 |
| Mo0237654 | L | 90 | 37 | 0 | 141 | 72 | 60 |
| Mo0302006 | L | 91 | 35 | 0 | 149 | 71 | 60 |
| Mo0318016 | L | 91 | 38 | 0 | 156 | 69 | 58 |
| RU0202195 | L | 90 | 37 | 0 | 145 | 71 | 58 |
| Mo0204044 | L | 86 | 37 | 5 | 138 | 71 | 57 |
| Mo0204074 | L | 89 | 38 | 10 | 140 | 70 | 55 |
| CL111 | L | 90 | 37 | 0 | 145 | 71 | 54 |
| CL142 | L | 92 | 42 | 0 | 151 | 71 | 51 |
| CL151 | L | 90 | 38 | 15 | 144 | 71 | 58 |
| CL181 | L | 95 | 33 | 0 | 135 | 71 | 60 |
| Jupiter | M | 89 | 36 | 0 | 152 | 72 | 63 |
| Neptune | M | 92 | 34 | 0 | 134 | 72 | 65 |
| RU0002146 | M | 85 | 37 | 10 | 153 | 71 | 59 |

Table 2.

2010 Variety Yields (Bu/A) by Location

| Variety | Rice Farm Drilled | Continuous Rice Drilled | Water-Seeded | Center Pivot Drilled | Delta Center Drilled | | Five Location Average |
|---|---|---|---|---|---|---|---|
| Templeton | 146 | 117 | 147 | 185 | 223 | | 164 |
| Rondo | 171 | 149 | 148 | 146 | 181 | | 159 |
| Taggart | 174 | 134 | 127 | 145 | 209 | | 158 |
| Mo0318016 | 204 | 107 | 138 | 144 | 190 | | 156 |
| RoyJay | 193 | 119 | 135 | 119 | 199 | | 153 |
| Francis | 176 | 113 | 154 | 156 | 162 | | 152 |
| Rex | 182 | 114 | 122 | 163 | 175 | | 151 |
| CL142 | 168 | 149 | 143 | 176 | 120 | | 151 |
| Mo0302006 | 168 | 111 | 95 | 190 | 179 | | 149 |
| Cheniere | 164 | 110 | 154 | 151 | 159 | | 147 |
| Trenasse | 126 | 124 | 136 | 173 | 171 | | 146 |
| Jazzman | 126 | 114 | 164 | 153 | 172 | | 146 |
| RU0202195 | 173 | 109 | 140 | 118 | 186 | | 145 |
| CL111 | 176 | 117 | 127 | 122 | 184 | | 145 |
| CL151 | 156 | 136 | 130 | 157 | 143 | | 144 |
| JES | 117 | 128 | 132 | 217 | 122 | | 143 |
| Mo0256872 | 168 | 94 | 100 | 164 | 185 | | 142 |
| Catahoula | 179 | 120 | 123 | 120 | 165 | | 141 |
| Mo0237654 | 172 | 110 | 124 | 141 | 158 | | 141 |
| Mo0204074 | 145 | 111 | 118 | 164 | 160 | | 140 |
| Mo0204044 | 149 | 85 | 150 | 129 | 179 | | 138 |
| Wells | 142 | 101 | 134 | 106 | 193 | | 135 |
| CL181 | 169 | 105 | 102 | 149 | 148 | | 135 |
| LA2140 | 175 | 107 | 108 | 126 | 142 | | 132 |
| | | | | | | | |
| RU0002146 | 169 | 61 | 129 | 213 | 191 | | 153 |
| Jupiter | 177 | 103 | 115 | 173 | 191 | | 152 |
| Neptune | 173 | 97 | 89 | 168 | 145 | | 134 |

# Using Nitrogen Stabilizers to Effectively Limit Rice Paddy Water Nitrate Accumulation And Promote Early Season Rice Growth

**Michael T. Aide, Richard K. Withers, and Donn Beighley**

## INTRODUCTION

Nitrogen is a key element in plant nutrition and is vital to the growth and development of rice (*Oryza sativa* L.). Rice root systems are able to uptake nitrogen primarily in two forms: (1) ammonium ($NH_4^+$) and (2) nitrate ($NO_3^-$). Rice, being an aquatic plant, shows a preference for ammonium uptake. Ammonium ($NH_4^+$) will be electrostatically retained by the soil's cation exchange complex; however, nitrate ($NO_3^-$) lacks the retention capacity afforded by the clay and soil organic matter fractions and will demonstrate a substantially greater leaching potential.

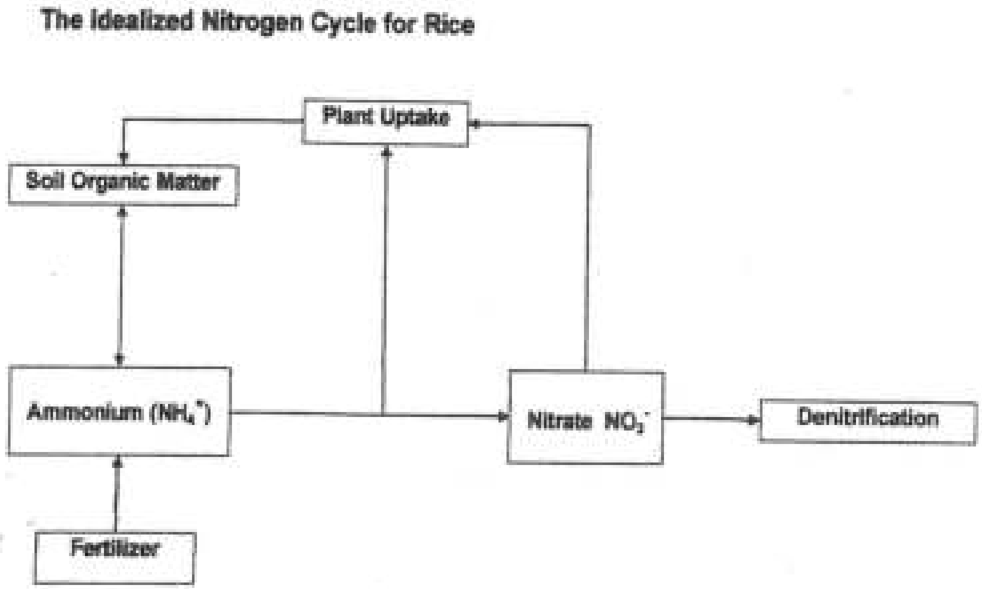


Figure 1. The idealized nitrogen cycle for rice.

Nitrogen mineralization is a general term indicating the microbial decomposition of soil organic matter and the subsequent production of ammonium. Soil organic matter fractions include: (1) particulate matter (plant residues, manure, and animal remains), (2) living organs (roots) and living organisms, and (3) humus (partially decomposed and stabilized organic materials). Soil organic matter decomposes relatively rapidly in moist (near field capacity), aerated (well-drained and permeable soils), and warm (25-35°C) soils.

Nitrification is a nitrogen pathway involving the microbial-mediated conversion of ammonium ($NH_4^+$) to nitrate ($NO_3^-$). Ammonium is converted to nitrite ($NO_2^-$) .

The aerobic bacteria *Nitrosomonas* is the primary microorganism responsible for the oxidation of ammonium. Subsequently, *Nitrobacter* facilitates the rapid oxidation of nitrite to nitrate. The entire process may be completed within three days if the soil moisture is near 60% of field capacity and the soil temperature approaches 30°C (86ºF).

Denitrification is the anaerobic, microbial reduction of nitrate to $N_2$, NO or $N_2O$, which happens mostly during periods of extreme soil wetness. The process is conducted by anaerobic bacteria according. Denitrification is usually presumed to occur in warm, anaerobic soil conditions, especially in heavy-textured soils. Partial water saturation of fine-textured soils may be a source of nitrogen loss. Denitrification is inhibited at soil temperatures greater than 60°C and at or below 4°C. At pH levels greater than six, $N_2$ is the dominant bi-product of denitrification; however, at pH levels more acid than pH 5.5, is the dominant denitrification product is nitric oxide (NO). Between pH 5.5 and 6, the dominant denitrification bi-product is nitrous oxide ($N_2O$).

### Urea Hydrolysis and Urease Enzymes

Urea undergoes soil hydrolysis to produce carbon dioxide and ammonia. Urease is a series of naturally-occurring, extracellular enzymes produced by fungi, bacteria and actinomycetes that catalyze urea hydrolysis. The soil concentration of urease is not ready measurable; however, the urease activity is a measurable soil quantity. Soils having greater amounts of soil organic matter and/or litter-residues are likely to possess greater urease activity. The optimum soil temperature for urease activity is 37ºC (99ºF); however, urease activity may be measured as low as 2ºC.

Ammonia volatilization increased to a maximum within two days after urea application. Maximum ammonia volatilization corresponded with the daily temperature maximum and drying soil moisture conditions. Ammonia volatilization was dramatically reduced because of NBTP. and the imposition of flood was critical to minimizing ammonia volatilization.

This volatilization of ammonia is a particularly serious economic loss of nitrogen and typically results between 5 and 25% loss of nitrogen from surface-applied urea fertilizer or the corresponding amount in urea-ammonium nitrate formulated UAN solutions. Rainfall and tillage incorporation of urea generally reduces ammonia volatilization losses. Soil volatilization generally increases with alkaline soil pH, an abundance of calcium carbonate, higher soil temperatures, and greater rates of ammonium in the soil.

Much research attention has been devoted to regulating urease activity to reduce ammonia volatization losses. The inhibition of urease activity from commercial products should ideally have the following properties: (1) non-toxic to plants, soil organisms, fish and mammals, (2) should migrate with urea in the soil, (3) be relatively stable for effective inhibitory activity, and (4) inexpensive.

## MATERIALS AND METHODS

### Experimental Design and Soil-Water Laboratory Analysis

A greenhouse pilot project having a factorial, completely randomized design was conducted with nitrogen fertilizer types as the main treatment and delayed flood at fertilizer application as the secondary treatment. The main treatment consisted of 120 lbs N per acre equivalent provided as: (i) urea, (ii) superU, and (iii) untreated check (No nitrogen). The secondary treatment consisted of delaying the post-N fertilization flood for 0, 5 and 10 days. The fertilizer treatments were staggered to allow all treatments to be flood irrigated simultaneously. Nitrogen was applied at the five-leaf stage to simulate the dry-seeded, delayed-flood rice culture system. SuperU (46-0-0) is an efficient nitrogen fertilizer having the urease inhibitor N-(n-butyl) thiophosphoric triamide, plus dicyandiamide to limit the conversion of ammonium to nitrate.

Greenhouse containers consisted of plastic trays (34 cm length x 24 width cm x 18 cm depth) having 7.5 cm soil. The soil series selected was the A horizon of the somewhat poorly-drained Crowley series (fine, montmorillonitic, active, thermic Typic Albaqualfs) that had been previously cropped to soybeans (*Glycine Max.* L). The rice variety 'Wells' was planted and allowed to grow. Distilled water was used for all plant watering and flooding.

Tissue testing (N, P, K, Ca, Mg, S, Na, Al, Fe, Mn, Zn, B, and Cu) and plant biomass accumulation were used to assess nutrient uptake patterns and were conducted at 25 days post flooding. Plant analysis was performed by Midwest Laboratories (Omaha, NE).

Water and soil samples were collected at 0, 2, 4, 11, 18 and 25 days post flooding. Routine soil testing, including soil nitrate-N, ammonium-N and sulfate-S, was performed at the University Missouri-Columbia soil testing laboratory (Delta Center, Portageville, MO). Water analysis for ammonium, nitrate and sulfate were also performed using the University Missouri-Columbia soil testing laboratory (Delta Center, Portageville, MO). Water concentrations of Ca, Mg, K and Na were performed using air-acetylene atomic adsorption spectrophotometry at Southeast MO State University.

## RESULTS AND DISCUSSION

### Soil Characteristics

The soil has a silt loam texture (18% clay, 76% silt, and 9% sand) and an acid soil pH. Soil organic matter (loss on ignition) content is approximately 2%. The cation exchange capacity (CEC) at 9.8 cmol $_{(p+)}$/kg is considered to be low, but within the normal variation for soils having a silt loam texture. The CEC is dominated by exchangeable calcium and the exchangeable sodium concentration is low, resulting in a very low exchangeable sodium percentage.

### Water Characteristics

The paddy water chemistry, after two days of flooding, had a slightly acid to moderately alkaline reaction (Table 2). At later sampling dates the pH for all treatments converged towards a neutral reaction. Calcium was the dominant cation and nitrate was the dominant measured anion.

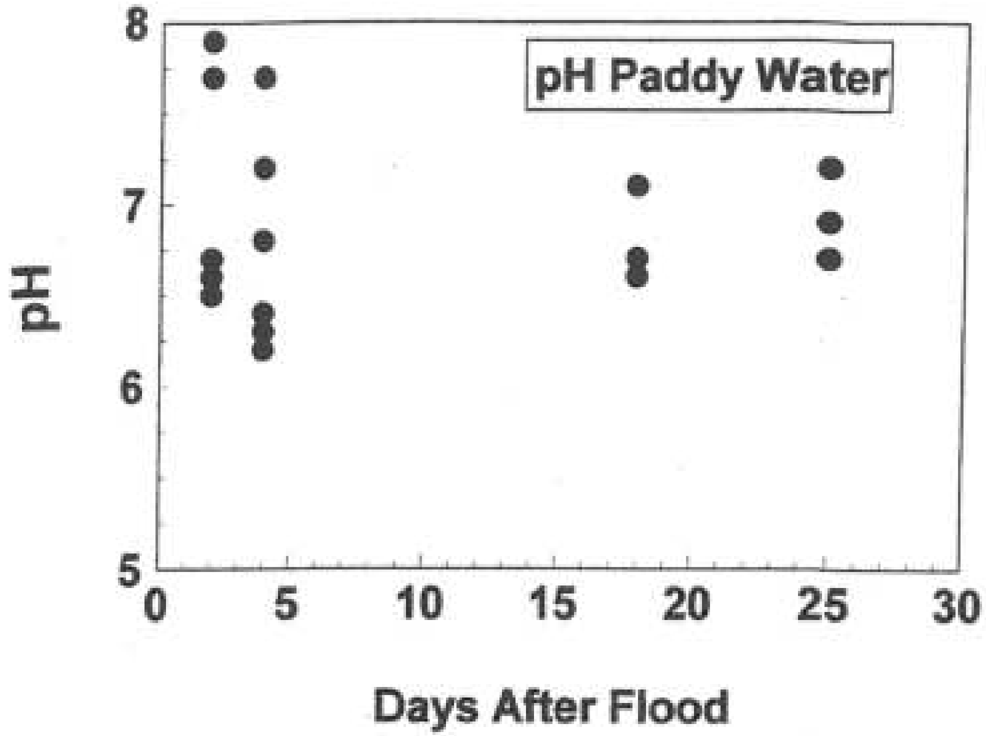


Figure 3. Distribution of paddy water pH with respect to days after flood application

### Nitrate and Ammonium Water Concentrations

Nitrate and ammonium water concentrations were assessed 2, 11, 18 and 25 days after flood application. Nitrogen was applied either 0, 5 or 10 days prior to flood irrigation. Ammonium concentrations in water were markedly greater with no flood water delay, with the 10 day flood delay treatments showing the smallest ammonium concentrations. In all treatments, the ammonium concentrations were greatest for the urea treatments, intermediate for the SuperU treatments and least for the untreated check (no nitrogen). For the later sampling dates the ammonium concentrations uniformly declined, presumably attributed to plant uptake and nitrification.

Water nitrate concentrations increased from the day 2 sampling to the day 18 and 25 sampling. The greatest nitrate water concentrations occurred on days 11, 18 and 25 for the no flood delay treatments. The small water nitrate concentrations in the 5 and 10 day flood delay systems were similar. The water nitrate concentrations of the urea and SuperU nitrogen treatments were generally similar and they both showed greater water nitrate concentrations than the untreated check. The increase in soil nitrate was largely attributed to nitrification.

### Soil Ammonium and Nitrate Concentrations

Soil ammonium and nitrate concentrations were assessed for the 0, 5 and 10 day flood delay systems for each of the nitrogen sources and the untreated check. Ammonium soil concentrations 18 days after flood application showed greater concentrations for the SuperU treatments after 0 and 5 day flood delay, whereas urea showed greater concentrations for the 10 day flood delay treatments. Soil sampling at 25 days showed after imposition of flood showed that the SuperU treatments had the greatest ammonium concentrations at 0 and 10 day flood delay, whereas urea showed greater ammonium concentrations at the 5 day delay flood treatment. Interestingly, with the immediate attainment of flood, SuperU is more efficient in the plant uptake of nitrogen in rice.

Soil nitrate concentrations are much smaller than the corresponding soil ammonium concentrations. For all flood delay treatments, the SuperU nitrogen sources showed either smaller or equivalent soil nitrate concentrations than the urea nitrogen source. Soil nitrate concentrations at 18 and 25 days after flood application were relatively small, regardless of the nitrogen source.

### Rice Growth and Nutrient Uptake

Rice tissue nitrogen was promoted from deficiency status in the untreated check to sufficiency in the urea and SuperU treatments. Urea and SuperU were largely equivalent in their percent nitrogen contents. The well known "dilution effect" states that some plants will produce plant tissue at a rate proportional to the amount of nutrient (nitrogen) uptake, with the result that a plant may uptake additional nutrient and acquire proportionally more biomass. The result is that the nutrient concentrations are relatively similar, even though one plant is substantially larger. With the exception of sulfur, which appears to be borderline deficient, all other nutrients appear adequate for rice culture.

Plant height is greatest for the SuperU and least for the untreated check. The SuperU treatments resulted in more tillering, thus plant biomass. The implication is that SuperU provided plant available nitrogen more efficiently than urea.

### Oxidation-Reduction in the Soil-Water-Atmosphere System

SuperU contains a urease inhibitor (N-(n-butyl) thiophosphoric triamide) and a nitrification inhibitor (dicyandiamide). The presence of SuperU slows both urea hydrolysis and nitrification, effectively limiting denitrification and the spector of paddy water nitrate accumulation.

The amount of nitrate in the paddy water is a concern. The SuperU treatment appears to offer a possible solution to limiting nitrate accumulation in paddy water and reducing the spector of nitrate accumulation in adjacent surface waters.

Table 2. Water characteristics after two days of flood

| treatment | flood delay | replication | pH | Ca mg/L | Mg mg/L | Na mg/L | NO3 mg/L | NH4 mg/L | SO4 mg/L |
|---|---|---|---|---|---|---|---|---|---|
| control | 0 | 1 | 6.4 | 6 | 1.8 | 0.5 | 5.5 | 0.2 | 0.5 |
| control | 0 | 2 | 6.5 | 4.1 | 1.2 | 1.1 | 4.2 | 0.1 | 0.1 |
| control | 5 | 1 | 6.5 | 6 | 2.3 | 1 | 3.1 | 0.1 | 0.1 |
| control | 5 | 2 | 6.4 | 4.7 | 1.8 | 1.1 | 3.9 | 0.1 | 0.1 |
| control | 10 | 1 | 6.7 | 3.7 | 1.2 | 1.2 | 2.7 | 0.1 | 0.1 |
| control | 10 | 2 | 6.7 | 9.1 | 3.1 | 0.9 | 3.3 | 0.1 | 0.1 |
| urea | 0 | 1 | 7.8 | 27.3 | 5.3 | 1.9 | 5.1 | 119 | 0.1 |
| urea | 0 | 2 | 7.9 | 49.3 | 5.8 | 1.9 | 4.4 | 202 | 0.1 |
| urea | 5 | 1 | 7.6 | 5.3 | 3.2 | 3.3 | 4.6 | 33 | 0.1 |
| urea | 5 | 2 | 7.3 | 6.6 | 2.6 | 3 | 3.9 | 14 | 0.1 |
| urea | 10 | 1 | 6.7 | 6.1 | 1.9 | 1.9 | 5.8 | 3.5 | 0.1 |
| urea | 10 | 2 | 6.6 | 5.7 | 1.7 | 1.6 | 6.4 | 0.6 | 0.1 |
| superU | 0 | 1 | 7.8 | 29.8 | 5.2 | 2.2 | 3.9 | 107 | 0.1 |
| superU | 0 | 2 | 7.6 | 21.3 | 4.9 | 2 | 2.9 | 99 | 0.1 |
| superU | 5 | 1 | 7.2 | 5.6 | 2 | 1.6 | 3.5 | 25 | 0.1 |
| superU | 5 | 2 | 7.2 | 11.6 | 3.9 | 1.7 | 3.6 | 16 | 0.1 |
| superU | 10 | 1 | 6.7 | 10.2 | 3.7 | 1.7 | 3.9 | 1.9 | 0.1 |
| superU | 10 | 2 | 6.4 | 15.5 | 4.3 | 1.6 | 8 | 0.3 | 0.1 |

Table 3. Rice tissue analysis (18 Days after Flood or DAF)

| Treatment | DAF | percent N | percent P | percent K | percent Mg | percent Ca | percent S | Percent Na | mg/kg Fe | mg/kg Mn | mg/kg B | mg/kg Cu | mg/kg Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| control | 0 | 1.39 | 0.46 | 1.74 | 0.38 | 0.82 | 0.09 | 0.003 | 94 | 2902 | 20 | 8 | 32 |
| control | 5 | 1.27 | 0.56 | 1.91 | 0.47 | 0.98 | 0.11 | 0.002 | 105 | 3274 | 15 | 5 | 34 |
| control | 10 | 1.27 | 0.57 | 1.69 | 0.41 | 0.88 | 0.1 | 0.002 | 127 | 2998 | 20 | 6 | 32 |
| mean | | 1.31 | 0.53 | 1.78 | 0.42 | 0.89 | 0.1 | 0.002 | 109 | 3058 | 18 | 6 | 33 |
| std | | 0.07 | 0.06 | 0.12 | 0.05 | 0.08 | 0.01 | 0.001 | 16.8 | 193.1 | 2.9 | 1.5 | 1.2 |
| urea | 0 | 2.82 | 0.54 | 1.67 | 0.38 | 0.67 | 0.12 | 0.006 | 87 | 2208 | 18 | 12 | 32 |
| urea | 5 | 3.05 | 0.44 | 1.64 | 0.35 | 0.56 | 0.08 | 0.005 | 65 | 848 | 18 | 10 | 41 |
| urea | 10 | 2.5 | 0.5 | 1.64 | 0.37 | 0.63 | 0.08 | 0.003 | 84 | 2009 | 18 | 10 | 33 |
| mean | | 2.79 | 0.49 | 1.65 | 0.37 | 0.62 | 0.09 | 0.005 | 79 | 1688 | 17 | 11 | 35 |
| std | | 0.28 | 0.05 | 0.02 | 0.02 | 0.06 | 0.02 | 0.002 | 11.9 | 734.5 | 1.2 | 1.2 | 4.9 |
| superU | 0 | 3.14 | 0.52 | 1.65 | 0.32 | 0.62 | 0.11 | 0.002 | 85 | 1540 | 16 | 8 | 32 |
| superU | 5 | 2.86 | 0.47 | 1.65 | 0.34 | 0.66 | 0.1 | 0.007 | 96 | 1576 | 16 | 7 | 28 |
| superU | 10 | 2.27 | 0.44 | 2.08 | 0.35 | 0.64 | 0.09 | 0.005 | 90 | 2061 | 18 | 8 | 31 |
| mean | | 2.76 | 0.48 | 1.79 | 0.34 | 0.64 | 0.1 | 0.005 | 90 | 1726 | 17 | 8 | 30 |
| std | | 0.44 | 0.04 | 0.25 | 0.02 | 0.02 | 0.01 | 0.003 | 5.5 | 291 | 1.2 | 0.6 | 2.1 |

std is the standard deviation of the main treatment

Table 4. Rice tissue analysis (25 Days after Flood or DAF)

| Treatment | DAF | percent N | percent P | percent K | percent Mg | percent Ca | percent S | Percent Na | mg/kg Fe | mg/kg Mn | mg/kg B | mg/kg Cu | mg/kg Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| control | 0 | 1.4 | 0.51 | 1.98 | 0.35 | 0.67 | 0.1 | 0.001 | 66 | 2844 | 7 | 5 | 32 |
| control | 5 | 1.29 | 0.61 | 1.69 | 0.48 | 0.93 | 0.09 | 0.001 | 60 | 2792 | 12 | 4 | 36 |
| control | 10 | 1.46 | 0.52 | 1.85 | 0.41 | 0.96 | 0.1 | 0.001 | 149 | 2639 | 10 | 4 | 35 |
| mean | | 1.38 | 0.55 | 1.84 | 0.41 | 0.85 | 0.1 | 0.001 | 92 | 2758 | 10 | 4 | 34 |
| std | | 0.09 | 0.06 | 0.15 | 0.07 | 0.16 | 0.01 | 0 | 50 | 107 | 2.5 | 0.6 | 2.1 |
| | | | | | | | | | | | | | |
| urea | 0 | 3.17 | 0.57 | 1.35 | 0.37 | 0.7 | 0.14 | 0.005 | 94 | 1946 | 9 | 8 | 35 |
| urea | 5 | 3.03 | 0.41 | 2.04 | 0.23 | 0.33 | 0.11 | 0.003 | 66 | 780 | 8 | 11 | 41 |
| urea | 10 | 3.31 | 0.41 | 1.81 | 0.24 | 0.37 | 0.09 | 0.002 | 57 | 855 | 7 | 7 | 31 |
| mean | | 3.17 | 0.46 | 1.73 | 0.28 | 0.47 | 0.11 | 0.003 | 72 | 1194 | 8 | 9 | 36 |
| std | | 0.1 | 0.1 | 0.4 | 0.1 | 0.2 | 0.03 | 0.002 | 19 | 653 | 1 | 2.1 | 5 |
| | | | | | | | | | | | | | |
| superU | 0 | 3.6 | 0.5 | 1.09 | 0.32 | 0.52 | 0.11 | 0.001 | 76 | 1888 | 9 | 8 | 30 |
| superU | 5 | 3.57 | 0.61 | 1.23 | 0.31 | 0.51 | 0.1 | 0.001 | 76 | 1651 | 8 | 7 | 28 |
| superU | 10 | 2.88 | 0.36 | 1.71 | 0.23 | 0.38 | 0.1 | 0.002 | 77 | 996 | 7 | 7 | 27 |
| mean | | 3.35 | 0.49 | 1.34 | 0.29 | 0.46 | 0.1 | 0.001 | 76 | 1512 | 8 | 7 | 28 |
| std | | 0.41 | 0.13 | 0.33 | 0.05 | 0.09 | 0.01 | 0.001 | 1 | 462 | 1 | 0.6 | 1.5 |

std is the standard deviation of the main treatment

# Using Nitrogen Stabilizers to Promote Early Season Rice Growth

**Michael T. Aide, Richard K. Withers, and Donn Beighley**
**Department of Agriculture**
**Southeast MO State University**

## Goal

To determine if nitrogen stabilizers permit a greater nitrogen recovery by rice at a delayed flood timing regimes of 24 hours, five days and ten days.

## Introduction

See "Using Nitrogen Stabilizers to Effectively Limit Rice Paddy Water Nitrate Accumulation And Promote Early Season Rice Growth" by Michael T. Aide, Richard K. Withers, and Donn Beighley (This Issue).

## Experimental Design

A field design having a randomized and replicated block design with (1) nitrogen fertilizer types (control, urea, urea with Agrotain-Plus, SuperU) as the main treatment and (2) timing of the delayed-flood (24 hours, five days and 10 days) as the secondary treatment. The main treatment consisted of 150 lbs N per acre equivalent provided as: (i) urea, (ii) superU, (iii) urea and agrotain-Plus, and (iv) untreated check (No nitrogen). Nitrogen was be applied at the five-leaf stage to simulate the dry-seeded, delayed-flood rice culture system. SuperU (46-0-0) is an efficient nitrogen fertilizer having the urease inhibitor N-(n-butyl) thiophosphoric triamide, plus dicyandiamide to limit the conversion of ammonium to nitrate.

The rice variety 'Wells' was planted. Separate levee constructions permitted independent water flooding for the 24 hour, 5 day and 10 day delayed-flood program. Tissue testing (N, P, K, Ca, Mg, S, Na, Al, Fe, Mn, Zn, B, and Cu) and plant biomass accumulation were used to assess nutrient uptake patterns at pre-internodal elongation and at harvest. Total biomass and panicle weight sampling involved randomly selecting 10 plants from each replicate, followed by drying at 70ºC for two days and weighing. Soil samples were collected at planting. Harvest was by plot combine.

## Results and Discussion

### Mid-season Nutrient Concentrations in Rice Tissue

Just prior to internode elongation, rice plant tissue sampling was analyzed for N, P, K, Ca, Mg, S, Na, Fe, Mn, B, Cu and Zn. Rice plant tissue N concentrations were appropriate for rice culture and were statistically equivalent for urea, urea-Agrotain-Plus, and the SuperU treatments, regardless of the flood delay regime (Figure 1). The untreated check (no nitrogen treatments) was deficient to slightly deficient depending upon the flood delay regime. The flood delay regime did not significantly influence the rice tissue nitrogen concentrations.

Phosphorus (P) rice plant tissue concentrations were appropriate for the commercial culture of rice; however, the potassium (K) rice plant tissue concentrations were slightly to moderately deficient appropriate for the commercial culture of rice. No statistical P and K rice tissue concentration differences were observed because of N source with or without nitrogen stabilizers (urea, urea with Agrotain-Plus, SuperU, untreated check). Additionally, the flood delay program did not show any statistical differences in the plant tissue P and K concentrations. The rice plant tissue concentrations for Ca, Mg, S, Na, Fe, Mn, B, Cu and Zn were appropriate for the commercial culture of rice and no significant differences involving the untreated check, the nitrogen sources or the flood delay program (Table 1).

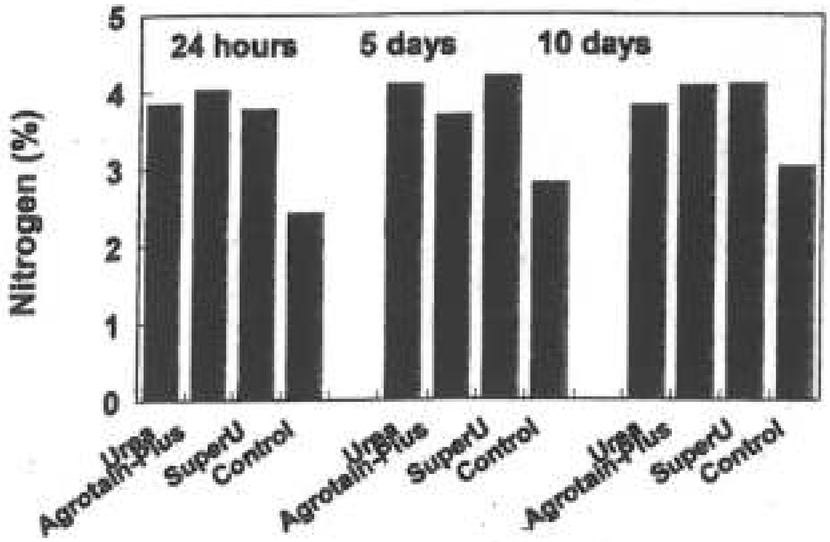


Figure 1. Rice plant tissue nitrogen concentrations just prior to internode elongation (5 July-2010).

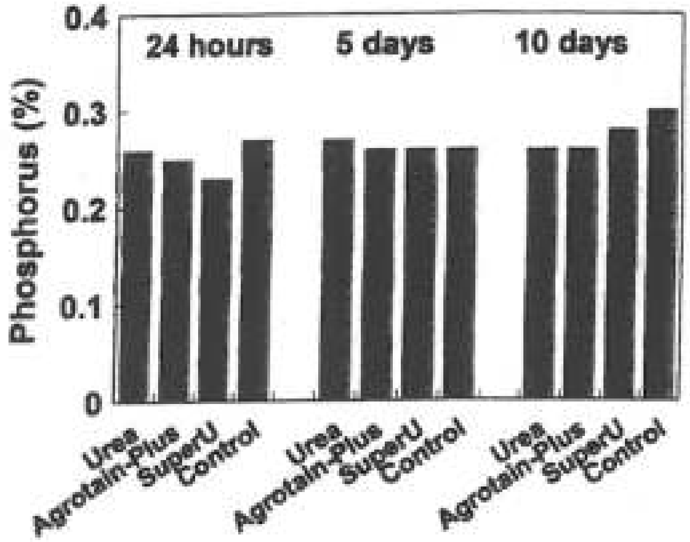


Figure 2. Rice plant tissue phosphorus concentrations just prior to internode elongation (5 July-2010).

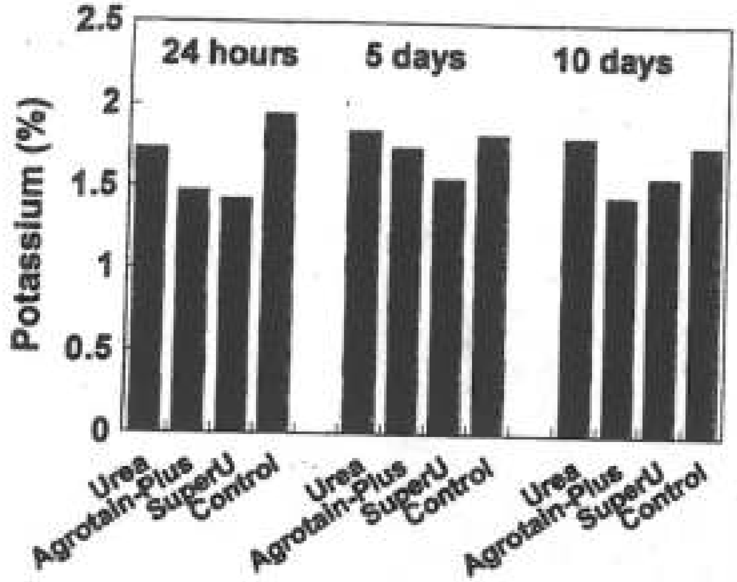


Figure 3. Rice plant tissue potassium concentrations just prior to internode elongation (5 July-2010).

**Yield Components**

At harvest, plant height was assessed to infer overall plant vigor. Nitrogen application, regardless of the nitrogen source, produced appreciably taller rice plants (Figure 4). Within treatments, N sources and the presence of nitrogen stabilizers did not statistically influence plant height. The flood delay regime furthermore did not statistically influence plant height.

Panicle weight (primarily determined by the number of seed per panicle and seed weight) was not statistically influenced by the nitrogen source or the presence of nitrogen stabilizers (Figure 5). All nitrogen treatments appreciably increased panicle weight relative to the untreated check; however, most of these differences were not statistically significant (alpha = 0.05). The flood delay program did not influence panicle weight.

Nutrient concentrations at harvest for each nitrogen source treatment were preformed for vegetative rice tissues selected from the individual flood delay treatments and seed from the 24 hour flood delay program (Table 2). N, P, K, Mg, Ca, S, Na, Fe, Mn, B, Cu and Zn from the post-harvest rice and seed tissues did not show any statistical differences attributed nitrogen source or the presence of nitrogen stabilizers. The flood-delay program did not result in any statistical differences in the post harvest rice tissue nutrient concentrations.

Overall harvest yields were low, presumably because of the potassium deficiency, high temperatures at critical periods of the growing season, and a slightly poorer plant stand than desired (Figure 6).Yields were significantly lower for the five day flood delay program; however, these plots also showed a slightly poorer stand development relative to the 24 hour and 10 day flood delay plots. In all cases, treatments receiving nitrogen treatments were significantly greater yielding than the untreated check. Field observations showed a much greater tillering capacity (more harvestable panicles per acre) because of nitrogen application. Within a flood delay treatment, there were no significant yield differences with nitrogen source or the presence of nitrogen stabilizers.

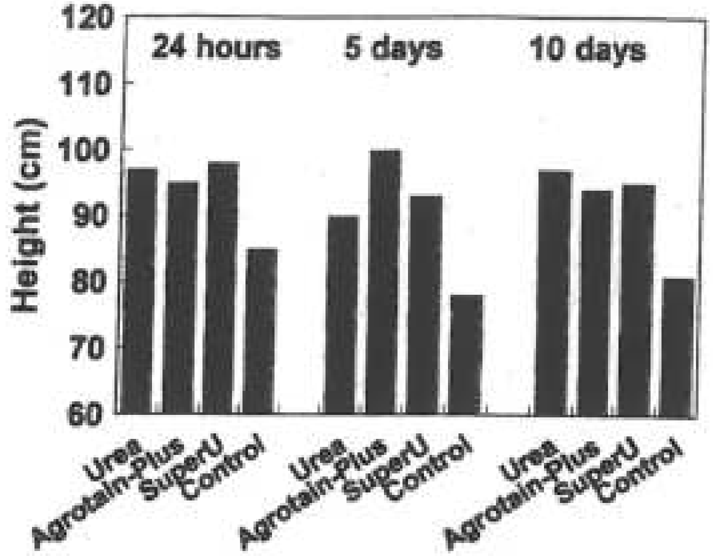


Figure 4. Plant height at harvest reflecting nitrogen source-nitrogen stabilizers.

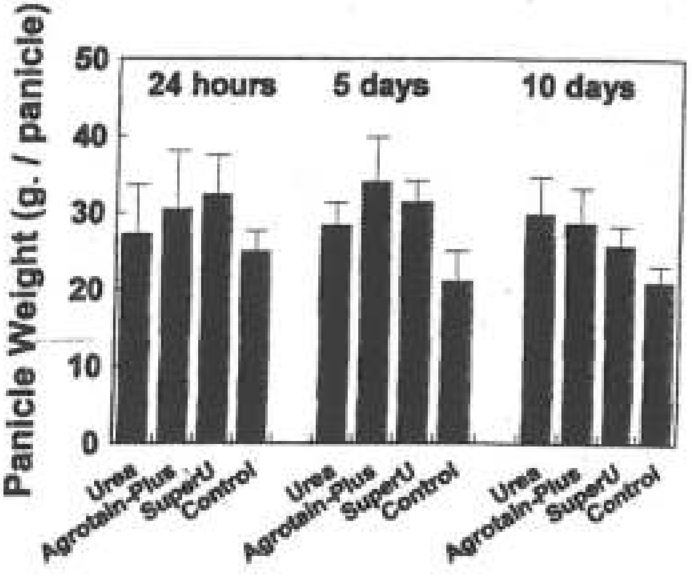


Figure 5. Panicle weight at harvest reflecting nitrogen source-nitrogen stabilizers.

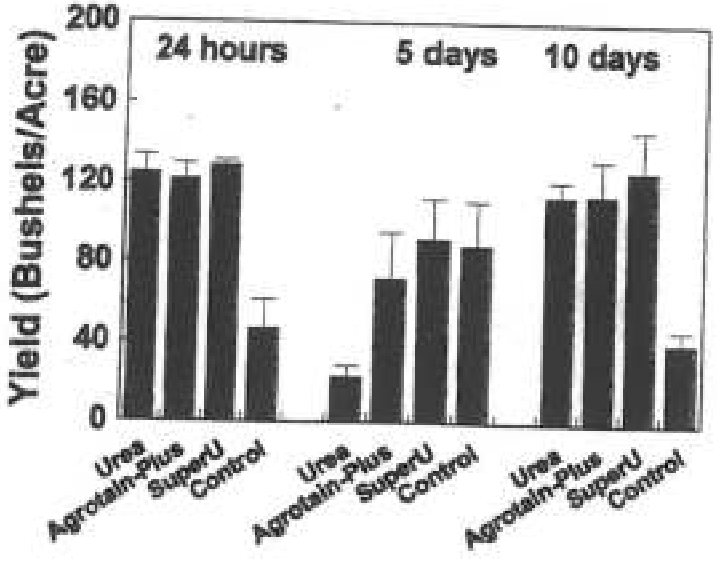


Figure 6. Rice yields reflecting nitrogen source-nitrogen stabilizers.

## Summary and Observations/Conclusions

A moisture laden spring will provide sufficient water to dissolve urea and subsequently incorporate ammonium-nitrogen into the soil. In a drier spring, urea may more readily hydrolyze to ammonia and volatize, escaping into the atmosphere. Ammonium may also undergo nitrification and alter to nitrate. Flood application could Promote anoxic soil conditions (flood soils lacking oxygen), thus promoting denitrification.

The benefits of SuperU and Argrotain-Plus are somewhat weather related. SuperU and Agrotain-Plus should be more effective in promoting early season rice growth when soil conditions promote ammonia volatilization and also when nitrate production is optimized prior to flood water application.

The effects of delayed flood were not highly evident because of saturating soil water conditions attributed to rainfall after fertilization. The nitrogen in superU and urea with Agrotain-Plus are equivalent to urea when rainfall is sufficient to reduce the risk of volatilization of ammonia and when the sequence of nitrification followed by denitrification is reduced. For other climate (weather) scenarios, nitrogen stabilizers should protect from nitrogen losses attributed to volatilizations and denitrification.

Table 1. Plant tissue analysis prior to internode elongation.

| Treatment | Rate | N<br>percent | P<br>percent | K<br>percent | Mg<br>percent | Ca<br>percent | S<br>percent | Na<br>percent | Fe<br>mg/kg | Mn<br>mg/kg | B<br>mg/kg | Cu<br>mg/kg | Zn<br>mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| urea | 0 | 3.86 | 0.26 | 1.74 | 0.3 | 0.47 | 0.27 | 0.029 | 96 | 724 | 11 | 11 | 43 |
| urea | 5 | 4.11 | 0.27 | 1.85 | 0.28 | 0.48 | 0.26 | 0.033 | 108 | 684 | 10 | 9 | 30 |
| urea | 10 | 3.83 | 0.26 | 1.82 | 0.27 | 0.42 | 0.25 | 0.048 | 197 | 665 | 7 | 9 | 34 |
| mean | | 3.93 | 0.26 | 1.8 | 0.28 | 0.46 | 0.26 | 0.037 | 134 | 691 | 9.3 | 9.7 | 36 |
| std | | 0.15 | 0.01 | 0.06 | 0.02 | 0.03 | 0.01 | 0.01 | 55 | 30 | 2.1 | 1.2 | 6.7 |
| Agrotain+ | 0 | 4.04 | 0.25 | 1.48 | 0.27 | 0.57 | 0.27 | 0.021 | 100 | 882 | 9 | 8 | 29 |
| Agrotain+ | 5 | 3.71 | 0.26 | 1.75 | 0.24 | 0.43 | 0.24 | 0.021 | 130 | 760 | 7 | 8 | 47 |
| Agrotain+ | 10 | 4.09 | 0.26 | 1.46 | 0.27 | 0.47 | 0.28 | 0.039 | 100 | 859 | 8 | 8 | 33 |
| mean | | 3.95 | 0.26 | 1.6 | 0.26 | 0.49 | 0.263 | 0.027 | 110 | 834 | 8 | 8 | 36 |
| std | | 0.21 | 0.01 | 0.16 | 0.02 | 0.07 | 0.021 | 0.01 | 17 | 65 | 1 | 0 | 9.5 |
| control | 0 | 2.44 | 0.27 | 1.95 | 0.2 | 0.53 | 0.2 | 0.009 | 90 | 790 | 6 | 7 | 25 |
| control | 5 | 2.82 | 0.26 | 1.83 | 0.17 | 0.56 | 0.23 | 0.009 | 94 | 790 | 7 | 8 | 32 |
| control | 10 | 3.04 | 0.3 | 1.77 | 0.23 | 0.54 | 0.23 | 0.025 | 115 | 791 | 6 | 8 | 30 |
| mean | | 2.77 | 0.28 | 1.9 | 0.2 | 0.54 | 0.22 | 0.014 | 100 | 790 | 6.3 | 7.7 | 29 |
| std | | 0.3 | 0.02 | 0.09 | 0.03 | 0.02 | 0.017 | 0.009 | 13 | 1 | 0.6 | 0.6 | 3.6 |
| superU | 0 | 3.79 | 0.23 | 1.43 | 0.3 | 0.56 | 0.26 | 0.033 | 101 | 837 | 8 | 8 | 28 |
| superU | 5 | 4.21 | 0.26 | 1.56 | 0.27 | 0.46 | 0.27 | 0.031 | 125 | 691 | 8 | 7 | 31 |
| superU | 10 | 4.11 | 0.28 | 1.58 | 0.28 | 0.43 | 0.27 | 0.039 | 111 | 814 | 8 | 9 | 35 |
| mean | | 4.04 | 0.26 | 1.5 | 0.28 | 0.48 | 0.267 | 0.034 | 112 | 781 | 8 | 8 | 31 |
| std | | 0.22 | 0.03 | 0.08 | 0.02 | 0.07 | 0.006 | 0.004 | 12 | 79 | 0 | 1 | 3.5 |

Table 2. Plant analysis at harvest.

| Fertilizer | Flood Delay | Percent |  |  |  |  |  |  | Parts per Million (mg/kg) |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | N | P | K | Mg | Ca | S | Na | Fe | Mn | B | Cu | Zn |
| **Control** | 0 | 0.76 | 0.21 | 2.01 | 0.24 | 0.46 | 0.09 | 0.013 | 68 | 1050 | 2 | 3 | 30 |
|  | 5 | 0.51 | 0.21 | 1.88 | 0.21 | 0.25 | 0.07 | 0.009 | 67 | 584 | 1 | 2 | 28 |
|  | 10 | 0.57 | 0.17 | 1.92 | 0.21 | 0.36 | 0.07 | 0.008 | 75 | 894 | 1 | 2 | 35 |
|  | seed | 1.22 | 0.28 | 0.29 | 0.11 | 0.04 | 0.08 | 0.001 | 71 | 136 | 5 | 4 | 28 |
| **SuperU** | 0 | 0.62 | 0.21 | 1.84 | 0.36 | 0.48 | 0.09 | 0.081 | 91 | 1236 | 5 | 2 | 40 |
|  | 5 | 0.85 | 0.22 | 1.94 | 0.26 | 0.27 | 0.08 | 0.011 | 93 | 776 | 3 | 2 | 52 |
|  | 10 | 0.48 | 0.18 | 1.75 | 0.25 | 0.32 | 0.07 | 0.009 | 67 | 813 | 2 | 3 | 36 |
|  | seed | 1.27 | 0.4 | 0.35 | 0.17 | 0.04 | 0.09 | 0.001 | 109 | 219 | 2 | 3 | 31 |
| **Agrotain+** | 0 | 0.85 | 0.21 | 1.92 | 0.27 | 0.34 | 0.09 | 0.01 | 72 | 997 | 3 | 2 | 39 |
|  | 5 | 0.65 | 0.25 | 1.75 | 0.3 | 0.28 | 0.08 | 0.03 | 117 | 905 | 3 | 2 | 53 |
|  | 10 | 0.45 | 0.18 | 1.72 | 0.26 | 0.34 | 0.07 | 0.009 | 64 | 855 | 2 | 2 | 33 |
|  | seed | 1.3 | 0.34 | 0.4 | 0.14 | 0.04 | 0.09 | 0.001 | 87 | 202 | 2 | 4 | 31 |
| **Urea** | 0 | 0.56 | 0.2 | 1.49 | 0.29 | 0.21 | 0.05 | 0.068 | 84 | 748 | 3 | 1 | 47 |
|  | 5 | 0.75 | 0.21 | 1.64 | 0.23 | 0.24 | 0.08 | 0.008 | 67 | 605 | 1 | 2 | 32 |
|  | 10 | 0.65 | 0.16 | 1.69 | 0.39 | 0.39 | 0.007 | 0.009 | 62 | 1001 | 3 | 2 | 34 |
|  | seed | 1.24 | 0.45 | 0.45 | 0.2 | 0.06 | 0.1 | 0.001 | 115 | 288 | 3 | 4 | 39 |

# Nitrogen Fertilization for Sprinkler Irrigated Rice

**Gene Stevens, Jim Heiser, Matt Rhine, and David Dunn**
**University of Missouri-Delta Center**

Two challenges to pivot irrigated rice are nitrogen management and weed control. In 1988 and 1989, research at the Delta Center conducted by Steve Hefner and Paul Tracy showed fluctuating aerobic/anaerobic soil conditions inherent with a furrow-irrigated rice system may facilitate increased N losses. Soil and plant N concentrations indicated that the most efficient N application for furrow-irrigated rice occurred when the majority of N was applied 4 weeks after panicle differentiation.

A study was begun in 2008 to compare rice production with sprinkler irrigation to flood irrigation with different nitrogen fertilization programs. The objective is to reduce water use with sprinkler irrigated rice without using more nitrogen fertilizer or pesticides and produce equivalent or greater yields to flood irrigated rice. The research is partially funded by the Parks, Soils and Water Sales Tax and is administered by the Soil and Water Conservation Program in the Dept of Natural Resources. Valmont Industries, Inc. and Mid-Valley Irrigation donated the center pivot used for the project.

Results from sprinkler irrigated rice research at the University of Missouri Delta Center indicated a water usage savings of up to 28% compared to the traditional flooding of rice fields in 2008. Water usage was also decreased in 2009 and 2010 for sprinkler irrigated rice but only 10% savings were observed. These comparisons were made using a side inlet flooding system which has been shown to be up to 60% more efficient than the conventional cascade method of flooding. Additionally, grain yields from several sprinkler irrigated plots compared favorably, and in many situations surpassed the grain yields with the same nitrogen treatments applied to the flooded study.

During the course of these studies, many other production challenges were faced. It has been our goal to meet these challenges with a systems approach as an alternative to developing entire studies to determine what may or may not work. Some of these challenges include selection of cultivars that may be better suited to this system, weed control programs, and seeding rate adjustments. These studies have been and will continue to be conducted to determine if water, nitrogen and pesticide usage can be decreased with the use of sprinkler irrigation while producing equivalent or higher yield than in a flooded rice production system.

## Application of treatments

Tests areas under sprinkler irrigation were generally planted in early to mid-May at the UM Delta Center Marsh Farm (Table 1). The dry urea/flooded rice studies used as a comparison were planted in late May to early June at the UM Delta Center Lee Farm. First tiller nitrogen treatments for the sprinkler irrigated rice/dry urea and fertigation UAN studies and flooded rice/dry urea study application dates are also shown in Table 1. In 2008, the first fertigation treatment was applied in a split application on June 24 and July 1, 2008* due to a diluted solution being inadvertently used. The error was discovered and corrected. All studies were planted with two conventional varieties (Cybonnet, CL171 in 2008 and Templeton and CL171 in 2009-2010) and one Hybrid (CLXL730 in 2008-2009 and CLXL729 in 2010). The change in cultivars was due to disease resistance and shattering concerns with the previously planted cultivars.

## Results

Yield data from all three tests in 2008 tended to be lower than expected due to shattering (grain falling off the plant) and lodging (plants falling over) as a result of heavy winds sustained from the remnants of Hurricane Ike on September 14. An estimate of these losses is presented in Table 2. Yields from the pivot irrigated/dry urea study had higher yields than the same nitrogen treatments applied to flooded rice for all three varieties/hybrids. Fertigation treatments yielded higher than the flooded dry urea for both the Clearfield variety and hybrid but not the conventional variety 'Cybonnet' (Figure 1) when 180 lb total N was applied in 2008.

Across all three years, rice yields in the fertigation experiment increased numerically as N rate increased, until yields peaked at 135 lb N/ac (Table 3). Yields were not significantly higher at any N rate higher than 135 lb N/ac in both conventional and hybrid cultivars. Rice yields also behaved differently at the same total N rate, based on how the N was applied. Yields were significantly higher for hybrid cultivars at 135 lb N/ac when only 25% of the N was applied at V4 (first tiller), with 75% of the total N being applied at 5 weekly intervals, instead of applying 50% of the N at V4 growth stage. Yields also increased by 8 bu/ac for conventional cultivars in the same situation. Averaged across years and N rates, hybrid rice cultivars yielded 35 bu/ac higher than conventional cultivars. At 135 lb N/ac in the 25/75 application scheme, hybrid cultivars averaged 173 bu/ac, compared to 134 bu/ac with conventional cultivars. Hybrids and conventional cultivars also differed in milling quality in response to the N split method. Milling quality was higher when N was applied in a 25/75 split with conventional varieties. Hybrid milling quality was higher in the 50/50 split program and higher than conventional varieties regardless of which method was used.

The effect of N form on rice yield varied from year to year, and differed between hybrid and conventional cultivars. At 135 lb N/ac in 2008, yields of conventional cultivars benefited from dry urea applications by 18 bu/ac, while hybrid yields increased by 43 bu/ac when applying N through fertigation over versus only dry urea. At 135 lb N/ac in 2009, both conventional and hybrid cultivars benefited by fertigating, yielding 48 and 27 bu/ac higher than dry urea plots for conventional and hybrid cultivars, respectively. In 2010, however, 135 lb N/ac applied as dry urea yielded 29 bu/ac more than fertigations for conventional cultivars, and 62 bu/ac more for hybrid cultivars. When averaged across years, however, no significant difference was found between yields of dry urea or liquid N plots.

Across all three years, rice yields were not significantly different when applying 45 lb/ac midseason N as dry urea on sprinkler irrigated rice (Figure 2). On flood irrigated rice, however, rice yields increased when midseason N was applied as dry urea at total N rates above 135 lb/ac (Figure 3). Flood irrigated rice fertilized with 180 lb/ac dry urea N at V4 yielded 189 bu/ac. When applying 135 lb N/ac preflood followed by 45 lb/ac N midseason, rice yields increased by 22 bu/ac. When applying only 45lb/ac N during the growing season, yields were numerically higher when N was applied at preflood compared to midseason on both flooded and sprinkler irrigated rice.

Irrigation method, which was confounded with soil texture, affected rice yields differently at different N rates. When N was applied at 45 and 90 lb N/ac dry urea, rice yields under flooded conditions were 20 and 31 bu/ac higher, respectively. However, at N rates above 90 lb N/ac, there was little difference between flooded and sprinkler irrigated rice yields (Table 4).

Water usage (Figure 4) was lower for the pivot irrigated rice study as compared to the flooded study in all three years. In 2008, approximately 23 inches of water were applied to the sprinkler irrigated study area. The flooded test received approximately 32 inches of water throughout the growing season. This represents a decrease of 28 percent. Less water was applied to both flooded and sprinkler irrigated fields in 2009 and 2010 but the decrease from flooded to sprinkler was only around 10 percent each year.

Other management practices which may need to be altered when growing rice with pivot irrigation include weed control programs and seeding rates. Flooding rice not only irrigates the crop but contributes 40-60% of the weed control. As a consequence, more herbicide applications may need to be made. Our weed control program continues to evolve and relies heavily on scouting and timely applications. The basis of our program is ½ rate of Command PRE, ½ rate Command + Prowl at 1 leaf and Stam + Facet at 2-3 leaf and tillering. Any additional applications should be on an as needed, problem specific, basis. In our study areas, many "add-on" herbicides were helpful for weed control including halosulfuron (Permit), bentazon/acifluorfen (Storm), carfentrazone (Aim), and triclopyr (Grandstand). The use of the Clearfield herbicide resistant rice system may have little value in this system unless red rice becomes a problem. This system utilizes the herbicides NewPath (imazethapyr) and Beyond (imazamox) herbicides from the Acetolactase Synthase (ALS) family of herbicides. The main weed problem faced in these studies was Palmer Amaranth. In many areas, this weed is resistant to ALS herbicides.

The low seeding rates of hybrids may also need to be increased when used in this system. The reduced number of rice plants in a given area took longer to close canopy. As a result weeds had more time to emerge and compete with the rice plants. We believe that a higher seeding rate may reduce this early season competition and allow for fewer herbicide applications later in the season.

## Conclusion

In areas where quality and quantity of irrigation water are not suitable for the common cultural flooding method of rice production, it is reasonable to speculate that a pivot irrigation system could be used. Our studies have indicated that grain yields comparable to the flooding method are achievable and can even be surpassed with a center pivot sprinkler irrigation system. Not only would this system be suitable for areas where rice production is not practiced because of the topography and soil types not being conducive to flooding, but may useful for traditional rice producers as a way to conserve water, and consequentially reduce fuel usage.

Dry urea fertilization with this system was also shown to be effective, however not at the levels realized with the fertigation system in most circumstances. The probable cause for this is nitrogen loss due to volatilization and runoff. Urea is used for flooded rice production but only if the crop is going to be flooded soon after urea application or is already flooded. The pellets of urea convert from dissolved ammonia to ammonia gas when not incorporated into the soil. The nitrogen is then lost to the atmosphere. When the soil is flooded the ammonia gas is held by the flood water and reaches equilibrium with the soil and is still plant available. With this system, irrigating the crop may only cause more volatilization. In addition, increasing the amount of irrigation with this system may also lead to runoff of the urea because there are

no structures such as levees to retain the water as there would be in a flooded production system. We believe these are the main reasons for the lower yields in the dry urea/pivot irrigated study compared to the fertigation study.

Varietal selection may be more important with this system also. Diseases such as blast are known to be more destructive when the rice plants are under water stress. Varieties and hybrids with higher levels of resistance to this and other diseases should be selected to insure that yield losses are kept to a minimum.

Additional research will reveal the best programs to reduce this input and should also help to increase crop yield further.

**Table 1.** Study planting and N application dates for 2008-2010

| Year | Study | Planting Date | First Tiller Urea | Mid-Season | Late Boot | Fertigations |
|---|---|---|---|---|---|---|
| 2008 | Sprinkler Urea | 5/6 | 6/6 | 7/28 | 8/13 | |
| | Sprinkler UAN | 5/6 | 6/6 | | | 6/24, 7/1*, 7/9, 7/16, 7/29, 8/13 |
| | Flooded Urea | 5/22 | 6/23 | 7/29 | 8/15 | |
| 2009 | Sprinkler Urea | 5/18 | 6/16 | 7/27 | 8/20 | |
| | Sprinkler UAN | 5/18 | 6/16 | | | 6/24, 7/2, 7/8, 7/17, 7/28 |
| | Flooded Urea | 5/23 | 6/25 | 7/31 | 8/21 | |
| 2010 | Sprinkler Urea | 5/11 | 6/8 | 7/21 | 8/23 | |
| | Sprinkler UAN | 5/11 | 6/8 | | | 6/16, 6/23, 6/30, 7/8, 7/15 |
| | Flooded Urea | 6/3 | 6/22 | 7/26 | 8/25 | |

**Table 2.** Shattered kernel counts and yield loss estimates of three rice cultivars at the University of Missouri-Lee Farm on Sharkey clay flood irrigated during 2008 growing season.

| Cultivar | Kernels/ft$^2$ | Yield loss bushels/ acre† |
|---|---|---|
| Cybonnet | 51 | 3 |
| CL171 | 285 | 14 |
| CLXL730 | 532 | 32 |

† Calculated from tables in the Arkansas Rice Production Handbook (Univ Ark Coop Ext Service Bull. MP192).

**Table 3.** Rice grain yield from fertigation programs averaged across years at Portageville, Missouri in 2008-2010.

| Rice | N program | Total N | Rough rice yield | Milled whole kernels |
|---|---|---|---|---|
| | | lb N/ac | lb grain /ac | ----%---- |
| Conventional | 1 | 0 | 101 | 56.9 |
| | 2 | 45 | 121 | 58.4 |
| | 3 | 45 | 106 | 57.5 |
| | 4 | 90 | 98 | 59.8 |
| | 5 | 90 | 116 | 61.6 |
| | 6 | 135 | 126 | 58.1 |
| | 7 | 135 | 134 | 62.3 |
| | 8 | 150 | 134 | 58.3 |
| | 9 | 150 | 130 | 58.2 |
| | 10 | 180 | 132 | 57.6 |
| | 11 | 180 | 132 | 59.5 |
| Hybrid | 1 | 0 | 118 | 60.7 |
| | 2 | 45 | 152 | 58.3 |
| | 3 | 45 | 158 | 59.3 |
| | 4 | 90 | 168 | 60.6 |
| | 5 | 90 | 158 | 58.7 |
| | 6 | 135 | 101 | 64.5 |
| | 7 | 135 | 121 | 58.1 |
| | 8 | 150 | 106 | 58.2 |
| | 9 | 150 | 98 | 63.8 |
| | 10 | 180 | 116 | 60.8 |
| | 11 | 180 | 126 | 63.8 |

**Table 4.** Rice yields averaged across conventional and hybrid rice with urea fertilizer applications (no fertigation) on a flooded Sharkey clay soil at Hayward, Missouri and pivot irrigated Tiptonville silt loam, Dundee sandy loam, and Reelfoot loam and sandy loam at Portageville, Missouri.

| Irrigation | Total N | Rough rice yield | Milled whole kernels |
|---|---|---|---|
| | lb N/ac | Bu./ac | ---%--- |
| Flood | 0 | 109 | 54.8 |
| | 45 | 157 | 55.9 |
| | 90 | 169 | 55.8 |
| | 135 | 154 | 57.8 |
| | 180 | 152 | 57.8 |
| | 225 | 155 | 56.7 |
| Pivot | 0 | 115 | 51.7 |
| | 45 | 137 | 52.6 |
| | 90 | 138 | 54.3 |
| | 135 | 149 | 55.8 |
| | 180 | 148 | 52.1 |
| | 225 | 155 | 53.4 |

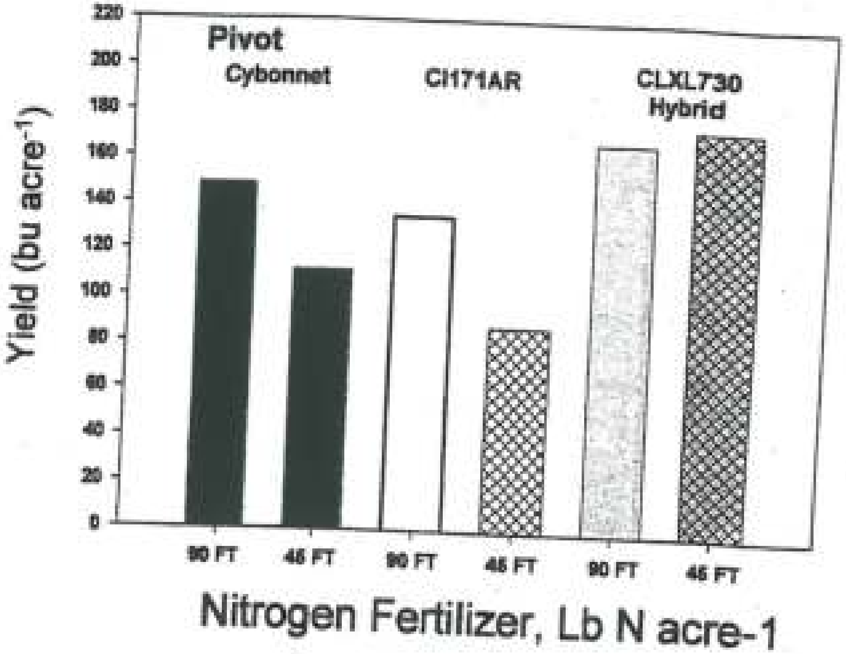


**Figure 1.** Rice yields of rice cultivars and hybrid supplied with 135 lb total N/acre split between dry and fertigation with 90 or 45 lb dry urea applied at first tiller (FT) on a Tiptonville silt loam and irrigated with center pivot system in 2008. Plots that received 90 and 45 lbs N per acre at first tiller were fertigated with five 9 lbs N/application and 18 lbs N/application, respectively, in 7 day intervals.

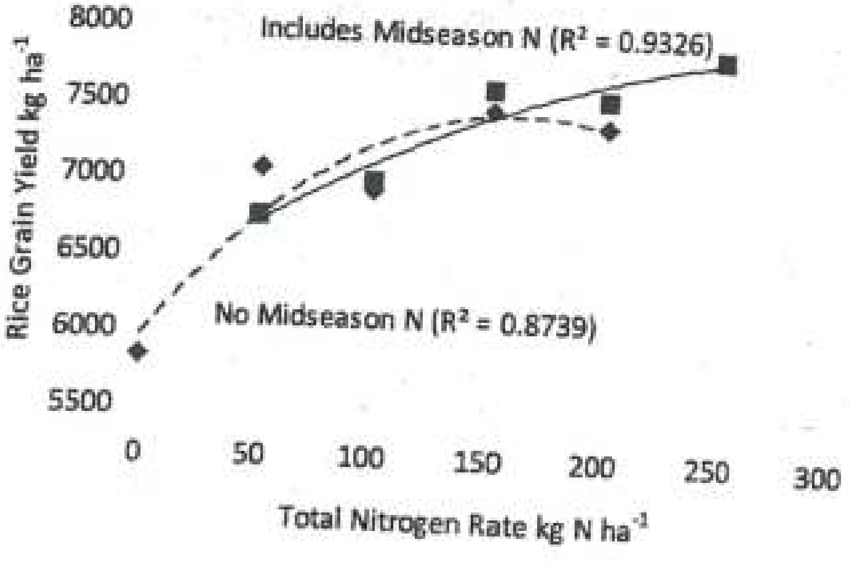


**Figure 2.** Effect of midseason N fertilization with dry urea on pivot rice yields averaged across conventional and hybrid cultivars and year (2008, 2009, and 2010) on a Tiptonville silt loam at Portageville, Missouri.

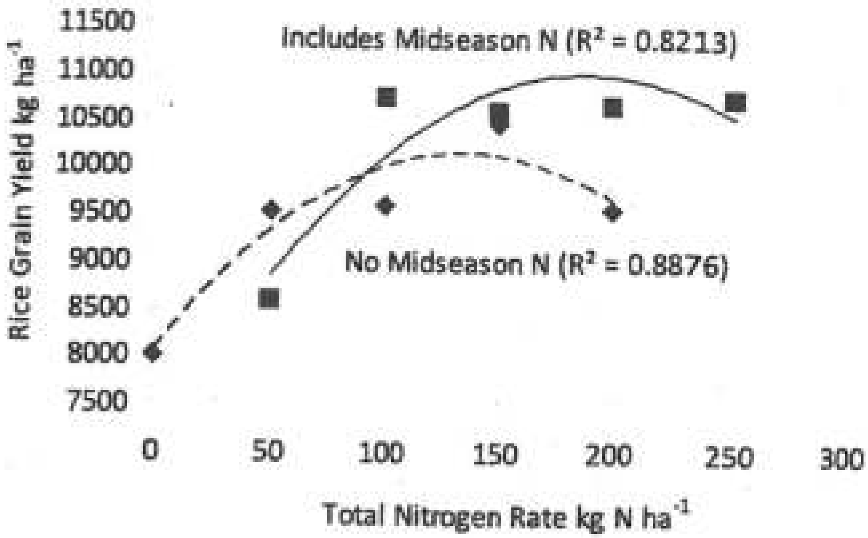


**Figure 3**. Effect of midseason N fertilization with dry urea on flooded rice yields averaged across conventional and hybrid cultivars and year (2008, 2009, and 2010) on a Sharkey clay soil at Hayward, Missouri.

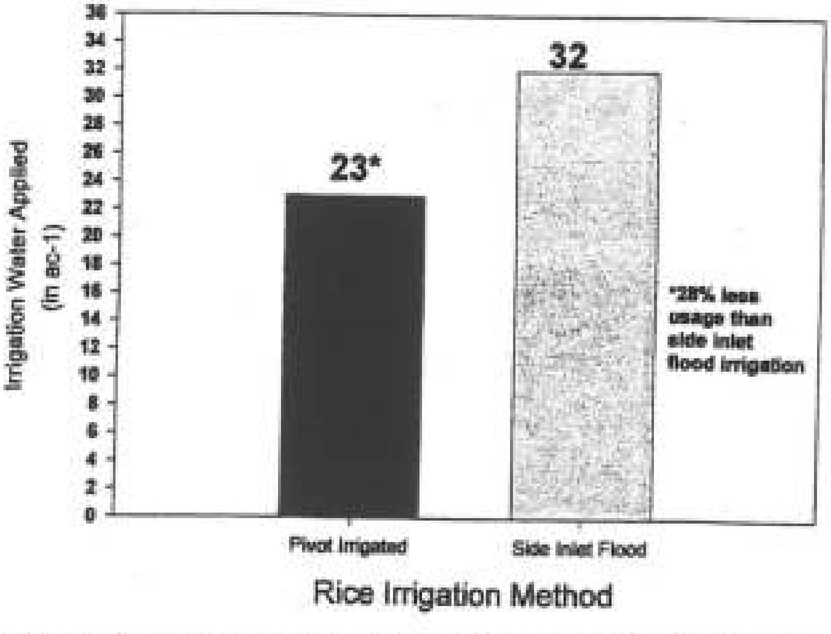


**Figure 4.** Irrigation applied with center pivot irrigation and side-inlet flooding on rice during 2008 growing season.