Missouri
Rice Research
Update 2012

Southeast Missouri State University

University of Missouri Columbia

University of Missouri Outreach and Extention

Special Report # 01-2011

February 2013

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 is a result of rice research conducted at the Missouri Rice Research Farm and UM Fisher Delta Center Research Farm. The research results were summarized by University of Missouri Fisher Delta Center Experiment Station and Southeast Missouri State University Personnel. *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 producers, 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:
Donn H. Beighley
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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/

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

Missouri Rice Producers Conference
February 19, 2013
Program

8:00 am – Rice Field Conservation Program- Brandon Wirsig, MO Dept. Conservation

8:15 am – Irrigation, Pumps & Wells – Joe Henggeler, MU Delta Center

8:45 am – Arsenic in Rice Issue – Dr. Michael Aide, Southeast - Cape Girardeau

9:15 am – Rice Varieties – Dr. Donn Beighley, Southeast - Malden

9:45 am - Break

10:00 am – Rice Production Issues, Weeds etc. – Dr. Jarrod Hardke, UAR Stuttgart, AR.

10:40 am – SEMO Aquifers – Scott Kaden, MO Dept. Natural Resources, Jefferson City, MO

11:20 am – U.S. Rice Markets – David Reinbott, MU Ag Business Specialist

11:40 am – Rice Market Outlook –Greg Yielding, MO Rice Producers

12:00 pm – Lunch - Provided by the Commercial Sponsors

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Extension Commercial Agriculture Automated Weather Station
Rice Farm (1 mile east of Glennonville, MO)
Monthly Weather Summary
Year: 2012

	Temperature (° F)								Precipitation (In.)	
	Avg Max.	Avg Min.	Avg	Departure	Days ≥90°	Days ≥100°	Days ≤32°	Days ≤0°	Total	Departure
January	51.1	32.4	41.4	6.4	0	0	17	0	1.98	-1.19
February	53.2	35.6	44.6	5.3	0	0	8	0	2.88	-0.42
March	72.3	50.3	61.4	13.2	0	0	1	0	5.28	1.26
April	75.1	51.9	63.6	4.9	0	0	0	0	1.31	-3.14
May	85.9	62.3	74.2	5.9	12	0	0	0	0.85	-3.75
June	88.9	64.7	77.1	-0.2	15	3	0	0	0.74	-2.52
July	93.1	73.0	82.3	1.7	23	3	0	0	2.29	-1.72
August	89.5	65.8	77.2	-2.0	19	0	0	0	1.78	-0.73
September	80.9	59.9	69.7	-1.7	5	0	0	0	4.07	0.83
October	68.7	46.9	57.5	-2.4	0	0	0	0	2.43	-1.15
November	58.5	35.9	46.6	-2.3	0	0	10	0	1.80	-2.56
December	52.5	36.1	44.5	6.8	0	0	15	0	2.93	-1.65
Year	72.5	51.2	61.7	2.9	74	6	51	0	28.34	-16.74

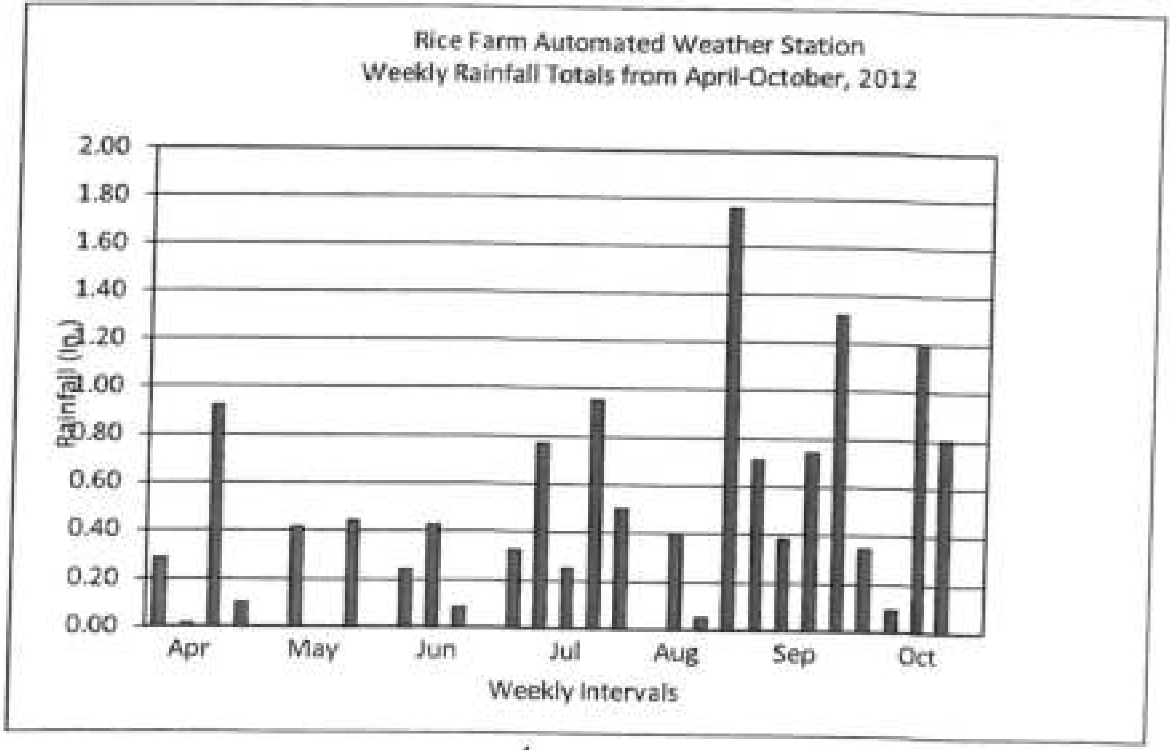

Rice Farm Automated Weather Station
Weekly Rainfall Totals from April-October, 2012

Table 3. Rice variety reactions[1] to diseases (2012).

Cultivar	Sheath Blight	Blast	Straighthead	Bacterial Panicle Blight	Narrow Brown Leaf Spot	Stem Rot	Kernel Smut	False Smut	Lodging	Black Sheath Rot	Sheath Spot
ANTONIO	S	MS		MS				MS	MS		
AREXP1	MS	S	MS	S	S	S	S	S	MS	MS	S
ARIZFQM1003	MS			MR/MS				S	VS		
BENGAL	MS	S	VS	VS	S	VS	MS	MS	MR	MR	
CAFFEY	MS			S	R			MS			
CATAHOULA	VS	R	MS	S	MR	S	S	S	MR	S	
CHENIERE	S	VS	VS	VS	S	S	S	S	MR	MS	
CL111	VS	MS	S	VS	VS	VS	S	S	MS	S	
CL 131	VS	MS	VS	VS	VS	VS	S	S	MR	S	
CL142-AR	MS	S	MS	S	S	S	S	S	S	S	
CL181-AR	VS	MS	MS	VS	S	VS	S	S	MR	VS	
CL 151	S	VS	VS	VS	S	VS	S	S	MR	S	
CL 152	S	S	S	S	R		VS	S			
CL 162	VS	S		VS	R		S	S	S		
CL 261	MS	VS	S	VS	S	VS	MS	S	MS	MS	
COCODRIE	S	S	VS	S	S	VS	S	S	MR	S	
COLORADO	S	VS		S				S			
DELLA-2				S							
FRANCIS	MS	VS	MR	VS	S	S	VS	S	MS	S	
JAZZMAN	MS	S	S	MS	S	S	MS	S	MS	MS	
JAZZMAN-2	VS	MS		VS	MR			S			
JES	S	R	VS	S	R	VS	MS	MS	S	MR	
JUPITER	S	S	S	MR	MS	VS	MS	MS	MS	MR	
MERMENTAU	MS	MS	VS	MS				MS	MS		
NEPTUNE	MS	MS	VS	VS	MS	VS	MS	MS	MR	MR	
REX	S	S	S	S	MS	S	S	S	MR	S	
ROY J	MS	S	S	S	MR	S	VS	S	MR	MS	
RT CL XL729	MS	R	MS	MR	MS	S	MS	S	S	S	
RT CL XL745	MS	R	R	MR	MS	S	MS	S	S	S	S
RT CL XP756	MS							S		S	
RT XL723	MS	R	S	MR	MS	S	MS	S	MS	S	
RT XL 753	MS			MR				S		S	
RT XP 754	MS							S		S	S
TAGGART	MS	MS	R	MS	MS	S	S	S	MS	MS	
TEMPLETON	MS	R	S	MS	S	MS	S	S	MS	MS	
WELLS	S	S	S	S	S	VS	S	S	MS	MS	

[1] Reaction: R = Resistant; MR = Moderately Resistant; MS = Moderately Susceptible; S = Susceptible; VS = Very Susceptible. Reactions were determined based on historical and recent observations from test plots and in grower fields across Arkansas. In general, these reactions would be expected under conditions that favor severe disease development including excessive nitrogen rates (most diseases) or low flood depth (blast).

Table prepared by Y. Wamishe, Assistant Professor/Extension Plant Pathologist and R.D. Cartwright, Associate Director – Ag and Natural Resources

Table 7. General characteristics of cultivars tested in the Arkansas Rice Performance Trials and Arkansas Rice Disease Monitoring Program.

Cultivar	Year Released & Source	Pedigree	Highlights
Antonio	2012 – Texas	Cypress/Cocodrie	A short season, semi-dwarf long-grain with very good yield potential and milling quality. Similar to Cocodrie for agronomic characteristics.
ArizeQM1003	Bayer CropScience	Proprietary hybrid	A mid-season, long-grain hybrid with good yield potential, but weak straw strength. Low amylose so soft cooking.
Bengal	1992 – Louisiana	Mars/M-201//Mars	A short season, semi dwarf, medium-grain with good yield potential and milling quality. It has a preferred large grain size.
Bowman	2007 - Mississippi	RU8603006/3/Mars/Newrex//Tebonnet	A short-season, high-amylose long grain designed for canning rice market. Has good grain and milling yield potential and is susceptible to blast and moderately susceptible to sheath blight and straighthead.
Caffey	2011 - Louisiana	Bengal//Mercury/Rico/3/Mercury/Rico//Bengal	A short season, semi-dwarf medium grain with excellent yield potential and milling quality. Susceptible to blast, sheath blight, and panicle blight.
Cheniere	2003 - Louisiana	Newbonnet/Katy/3/82CAY21/Lemont//L-202	A short season semi-dwarf long-grain with good yield potential and milling quality comparable to Cypress. Susceptible to sheath blight and blast.
CL111	2008 – BASF, Horizon Ag	Proprietary variety	An early season, semi-dwarf long grain similar to CL 131. Susceptible to blast, straighthead, and bacterial panicle blight.
CL 142-AR	2009 – BASF, Horizon Ag	Proprietary variety: Francis//Wells/CL161	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.
CL151	2007 – BASF, Horizon Ag	Proprietary variety: CFX-26/4/Lemont/2001-5/3/Lemont//L-202/Taducan	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.
CL152	2011 – BASF, Horizon Ag	Proprietary variety: Tacauri/3/Cypress//L-202/Tebonnet/4/CL161	A mid-season, semi-dwarf long-grain similar to CL151 with good yield potential and high tolerance to Newpath herbicide. Improved lodging and chalk compared to CL151.
CL162	2011 – BASF, Horizon Ag	Proprietary variety: CL161/Priscilla	A short season, long-grain Clearfield variety with average yield potential and good milling quality. Susceptible to sheath blight, blast, and straighthead.
CL181-AR	2009 – BASF, Horizon Ag	Proprietary variety: Francis/CL161	A midseason, semi-dwarf, long-grain Clearfield with good yield potential and milling quality. Very susceptible to sheath blight and bacterial panicle blight.
CL261	2008 – BASF, Horizon Ag	Proprietary variety: Bengal/CL161	A short-season, medium-grain Clearfield variety similar to Bengal.
CL XL729	2007 – RiceTec, Inc.	Proprietary hybrid	A short-season, long grain with excellent yield potential and moderately susceptible to sheath blight, and moderately resistant to blast.
CL XL745	2008 – RiceTec, Inc.	Proprietary hybrid	A short-season, long grain Clearfield hybrid 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 XP756	2011 – RiceTec, Inc.	Proprietary hybrid	A mid-season, long-grain Clearfield hybrid with excellent good yield potential and average milling quality. Similar to CL XL729.

Table 7 (cont.). General characteristics of varieties tested in the Arkansas Rice Performance Trials and Arkansas Rice Disease Monitoring Program.

Variety/Hybrid	Year Released & State	Pedigree	Highlights
Colorado	2012 – Texas	Cocodrie/L-202	A short season, long-grain semi-dwarf with good yield potential and good milling quality.
Della-2	2012 – Louisiana	Cypress//L-205/Della	A long-grain aromatic with very good grain quality. Improved lodging compared to Della.
Drew	1996 – Arkansas	Newbonnet/Katy	A mid-season, long-grain with average yield potential and milling quality. It is blast resistant, straighthead tolerant, and has a larger kernel size than Kaybonnet.
Francis	2002 – Arkansas	Lebonnet/9902/3/Dawn/9695/Starbonnet/4/LaGrue	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	Chinese aromatic/Ahrent	A Jasmine-type aromatic rice with good yield potential and milling quality.
Jazzman-2	2011 – Louisiana	RU0302195/RU0302125	A Jasmine-type aromatic rice with improved yield and milling compared to Jazzman. Susceptible to sheath blight, bacterial panicle blight, and straighthead.
Jupiter	2006 – Louisiana	Mercury//Mercury/Koshihikari/3/Bengal//Mercury/Rico	A short season, semi dwarf, medium-grain with excellent yield potential and milling quality. It has a small grain size but has resistance to bacterial panicle blight.
Mermentau	2012 – Louisiana	AR1188/Cocodrie//9502088/LaGrue	A short season, semi-dwarf, long-grain variety with good yield potential and physical characteristics similar to Cocodrie, Cheniere, and Catahoula.
Rex	2010 – Mississippi	Rosemont//Rexmont/IR36	A short season, semi-dwarf long-grain variety with excellent yield potential and good milling quality. Very good straw strength, but is susceptible to most diseases.
RoyJ	2010 – Arkansas	LaGrue//Katy/Starbonnet/5/Newbonnet/Katy//RA73/Lemont/4/Lebonnet/9902/3/Dawn/9695//Starbonnet	A mid-season, long-grain variety with excellent yield potential and good milling quality. Excellent straw strength. Susceptible to blast and moderately susceptible to sheath blight.
Taggart	2009 – Arkansas	LaGrue//Katy/Starbonnet/5/LaGrue//Lemont/RA73/3/LaGrue/4/LaGrue	A mid-season, long-grain variety with very good yield potential and average milling quality. Resistant to straighthead. Moderately susceptible to sheath blight and rice blast.
Templeton	2009 – Arkansas	Drew/5/Newbonnet/3/Dawn/9695//Starbonnet/4/Katy/Starbonnet	A mid-season, long-grain variety with good yield potential and good milling quality. Similar to Wells, but with resistance to all strains of blast.
Wells	1999 Arkansas	Newbonnet/3/Lebonnet/CI9902//Labelle	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.
XL723	2005 – RiceTec, Inc.	Proprietary hybrid	A short-season long-grain hybrid with excellent yield potential, average milling quality; resistant to blast and moderately susceptible to sheath blight.
XP753	2011 – RiceTec, Inc.	Proprietary hybrid	A short-season long-grain hybrid with excellent yield potential.
XP754	2011 – RiceTec, Inc.	Proprietary hybrid	A mid-season long-grain hybrid with excellent yield potential and good milling quality.

Soil Profile Arsenic Concentration Distributions in Missouri Soils Having Cambic and Argillic Soil Horizons.

Michael Aide and Donn Beighley - Southeast Missouri State University
David Dunn – U.M.T.E. Fisher Delta Research Center

ABSTRACT

Understanding of the pedogenic (soil formation) pathways associated with arsenic (As) transformations in soil profiles is important to understanding arsenic soil chemistry and discriminating between natural background and anthropogenic arsenic (As). Twenty soil series, some with multiple pedons, were assessed to determine if the As distributions in soil profiles exhibit discrete maxima that correspond to the presence of agrillic (clay enriched subsoil) horizons. The majority of pedons exhibiting argillic horizon expression show a Fe-oxyhydroxide and As maxima corresponding precisely with the argillic horizon. Pearson correlation coefficients verify the close correspondence of Fe and As. Soil profiles having cambic (no clay enrichment in the subsoil) horizons may also show As and Fe accumulations. Some coarse-textured, well-drained to moderately-well drained Entisols and Inceptisols have Fe-oxyhydroxide accumulation in their cambic horizons, promoting As accumulation. Conversely, silty-textured and poorly-drained to somewhat poorly drained Entisols and Inceptisols have C and Cg horizons that show As concentrations that have somewhat uniform Fe and As concentrations throughout their soil profiles. Analysis of selected pedons demonstrates that clay fraction Fe and As are closely correlated and that the As and Fe concentrations are greater than those from the corresponding whole soil.

Introduction

Arsenic (As) in the environment may be a consequence of either human activities or mineral weathering of arsenic bearing minerals and its subsequent migration using geologic and soil formation pathways. Anthropogenic As activities include: (i) particulates and aerosols emanating from coal-fired power plants, (ii) mining and smelting operations, (iii) application of As-bearing agricultural pesticides, (iv) poultry feed additives, and (v) irrigation with As-bearing water. In southeastern Missouri the prior usage of As-bearing herbicides and poultry litter on lands previously cropped to cotton (*Gossypium hirsutum* L.) and are now cropped to rice (*Oryza sativa* L.) is a concern.

The World Health Organization has established a provisional maximum tolerable daily intake of inorganic As as 2 µg As/ kg body weight. Inorganic As intake may lead to gastrointestinal, cardiovascular and central nervous symptoms, bone marrow depression, haemolysis, hepatomegaly, melanosis, polyneuropathy, and encephalopathy. Inorganic As is a non-threshold class 1 carcinogen.

Rice is of considerable concern because rice is naturally an As accumulating plant, a feature attributed to its culture in paddy soils. In water flooded agriculture, the soil develops a suboxic to anoxic soil regime wherein Fe-oxyhydroxides are reduced and degraded; permitting adsorbed and co-precipitated As to have greater aqueous activities

Soil Chemistry of Arsenic

In the natural environment As exists as two distinct chemically species: (i) arsenite as H_3AsO_3 –$H_2AsO_3^-$ or $As(OH)_3$ and (ii) arsenate as the oxyanion $H_2AsO_4^{1-}$ or $HAsO_4^{2-}$. Arsenite is considered to be 25 to 60 times more toxic than arsenate. In soils, arsenite and arsenate (i) form complexes with soil organic matter, (ii) become adsorbed onto Al- and Fe-oxyhydroxides, (iii) become adsorbed onto phyllosilicates, (iv) leach or percolate to deeper soil horizons, and (v) undergo plant uptake Arsenate will undergo microbial mediated reduction in suboxic and anoxic soils to form arsenite.

Results and Discussion

Association of As, Fe and Soil Depth

The Alred, Calhoun, Caneyville, Crowley, Frenchmill, Menfro, Rueter, Scholten and Amagon pedons have agillic horizons, which also have greater abundances of Fe-oxyhydroxides in the argillic horizon. These pedons further show a significant correlation of Fe-oxyhydroxide abundance with As concentrations (Table 3). The Dubbs pedon possesses an argillic horizon, but also demonstrates a lithologic discontinuity and a narrow range of Fe-oxyhydroxide content, contributing to the significant lack of a Fe-As correlation. The Irondale and Knobtop pedons have contrasting parent materials within their soil profiles, i.e., loess overlying rhyolite residuum/colluvium. These differences and the shallowness of each soil reduces the likelihood of any significant Fe-As correlation. All of these argillic horizon bearing soils have small As contents (1 to 2 mg As/kg) in the eluvial horizons (surface and near surface horizons) and appreciably greater As concentrations in the deeper argillic horizons. The Alred, Rueter, Menfro, pooled Amagon-Calhoun pedons show substantial As accumulations in the argillic horizons, presumably because of As sorption on Fe-oxyhydroxides and also their possible co-eluviation with clay.

The Clana, Haymond, Lilbourn, Malden, Portageville, Tiptonville, Wakeland and Wilbur series do not exhibit argillic horizons, rather they possess cambic horizons overlying C material. The pooled coarse-textured and well to moderately well drained Clana, Malden and Lilbourn pedons show significant As-Fe Pearson correlations, with small As concentrations in the epipedons (2 to 3 mg As/ kg) and moderate As concentrations (6 to 7.7 mg As/kg) in the deeper Bw horizons. The Bw horizons show some reddish colors attributed to Fe-oxyhydroxide accumulation. The silty, poorly to somewhat-poorly drained Wakeland, Wilbur and Haymond series have C and Cg horizons lacking appreciable Fe concentrations, a feature routinely attributed to gleization. The lack of a sufficient range in the Fe and As concentrations therefore limits the ability to obtain a significant Pearson correlation.

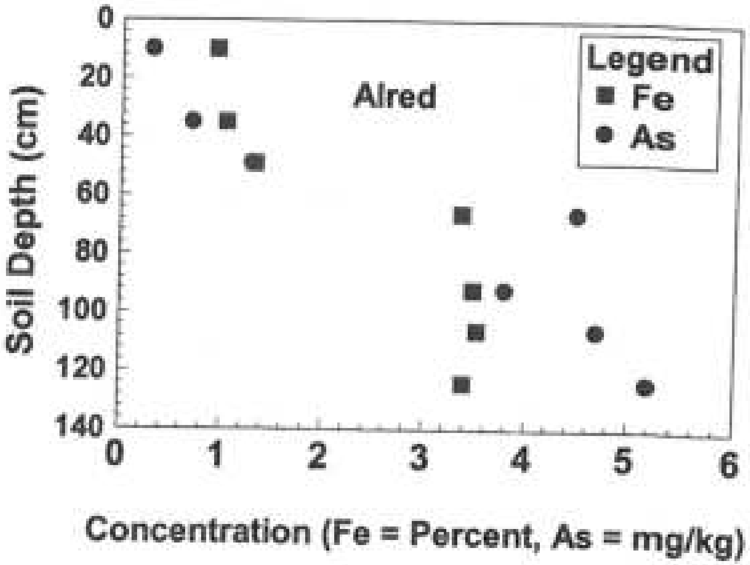


Figure 2a. Distribution of Fe and As throughout the Alred soil profile.

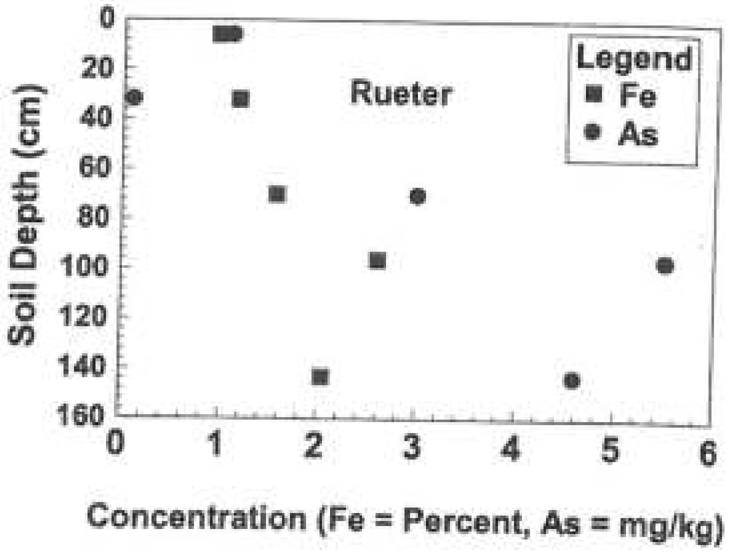


Figure 2b. Distribution of Fe and As throughout the Rueter soil profile.

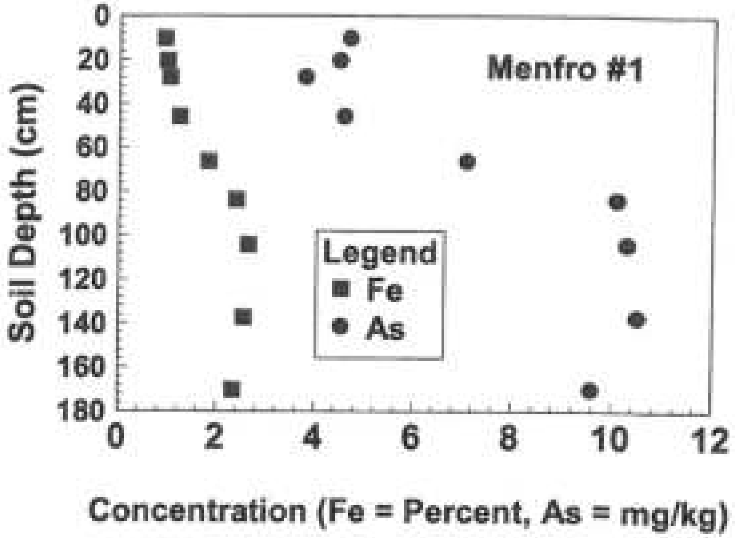


Figure 3a. Distribution of Fe and As throughout the Menfro #1 soil profile.

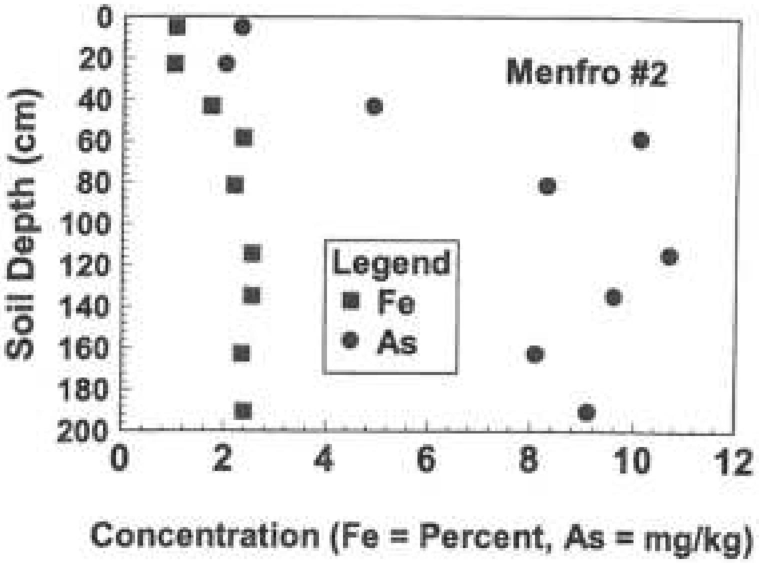


Figure 3b. Distribution of Fe and As throughout the Menfro#2 soil profile.

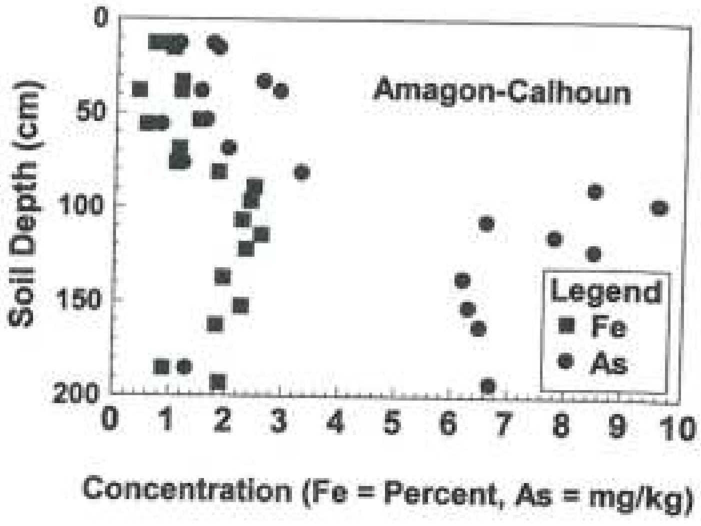


Figure 4. Distribution of Fe and As throughout the pooled Amagon and Calhoun soil profiles.

Arsenic and Soil Morphology

The majority of soils having argillic horizon expression demonstrate greater aqua-regia digestion As and Fe-oxyhydroxide concentrations in the argillic horizon than the overlying eluvial horizons, including the epipedons. Arsenic and Fe-oxyhydroxide correlations are most likely predicated on the close association of Fe-oxyhydroxides with the enhanced clay contents of the argillic horizons. Arsenic is either surface adsorbed or occluded during episodes of Fe-oxyhydroxide formation. Arsenic may also adsorb directly to phyllosilicate surfaces. In general, soils having cambic soil horizons show Fe-oxyhydroxide and As accumulations in the cambic horizons having oxic soil regimes, where Fe-oxyhydroxide expression is field observed and quantified by aqua-regia digestion; however, soil having cambic horizons in soils having suboxic to anoxic regimes may not have sufficient Fe-oxyhydroxide accumulation to demonstrate Fe-As interactions. Gleization in these poorly to somewhat poorly-drained Entisols and Inceptisols sufficiently reduces the Fe-oxyhydroxide expression that Fe and As maxima are not apparent within these soil profiles.

Table 1. Classification and drainage class of soils

Soil Series	Classification	*Drainage Class*
Alred	Loamy-skeletal over clayey, siliceous, semiactive, mesic Typic Paleudalfs	*well drained*
Amagon	Fine-silty, mixed, active, thermic Typic Endoaqualfs	*poorly drained*
Calhoun	Fine-silty, mixed, active, thermic Typic Glossaqualfs	*poorly drained*
Caneyville	Fine, mixed, active, mesic Typic Hapludalfs	*well drained*
Clana	Mixed, thermic Aquic Udipsamments	*moderately well drained*
Crowley	Fine, smectitic, thermic Typic Albaqualfs	*somewhat poorly drained*
Dubbs	Fine-silty, mixed, active, thermic Typic Hapludalfs	*well drained*
Frenchmill	Loamy-skeletal, mixed, active, mesic Typic Paleudults	*well drained*
Haymond	Coarse-silty, mixed, superactive, mesic Dystric Fluventic Eutrudepts	*well drained*
Irondale	Loamy-skeletal, mixed, active, mesic Typic Hapludults	*well drained*
Knobtop	Fine-silty, mixed, active, mesic Aquic Hapludults	*moderately well drained*
Lilbourn	Coarse-loamy, mixed, superactive, nonacid, thermic Aeric Fluvaquents	*somewhat poorly drained*
Malden	Mixed, thermic Typic Udipsamments	*excessively drained*
Menfro	Fine-silty, mixed, superactive, mesic Typic Hapludalfs	*well drained*
Portageville	Fine, smectitic, calcareous, thermic Vertic Endoaquolls	*poorly drained*
Reuter	Loamy, mixed, superactive, mesic, shallow Vitritorrandic Haploxerolls	*well drained*
Scholten	Loamy-skeletal, siliceous, active, mesic Typic Fragiudults	*moderately well drained*
Tiptonville	Fine-silty, mixed, superactive, thermic Oxyaquic Argiudolls	*moderately well drained*
Wakeland	Coarse-silty, mixed, superactive, nonacid, mesic Aeric Fluvaquents	*somewhat poorly drained*
Wilbur	Coarse-silty, mixed, superactive, mesic Fluvaquentic Eutrudepts	*moderately well drained*

Macronutrient, Micronutrient and Arsenic Partitioning in Three Rice Varieties

Donn Beighley and Michael Aide*
Southeast Missouri State University

INTRODUCTION

Rice is of considerable concern because rice is naturally an Arsenic (As) accumulating plant, a feature attributed to its culture in paddy soils. In water flooded agriculture, the soil develops a suboxic to anoxic soil regime; permitting adsorbed and coprecipitated As to have greater aqueous activities. In a survey of polished rice, the total arsenic concentration varies from 65.3 to 274.2 µg As/kg with a mean of 114.4 µg As/kg. In the survey, inorganic arsenic averaged 72% of the total arsenic concentration (82.0 µg As/kg). Another survey estimated total arsenic and inorganic arsenic in samples of USA rice, noting that total As averaged 210±190 µg As/kg and inorganic As peaked near 150 µg As/kg.

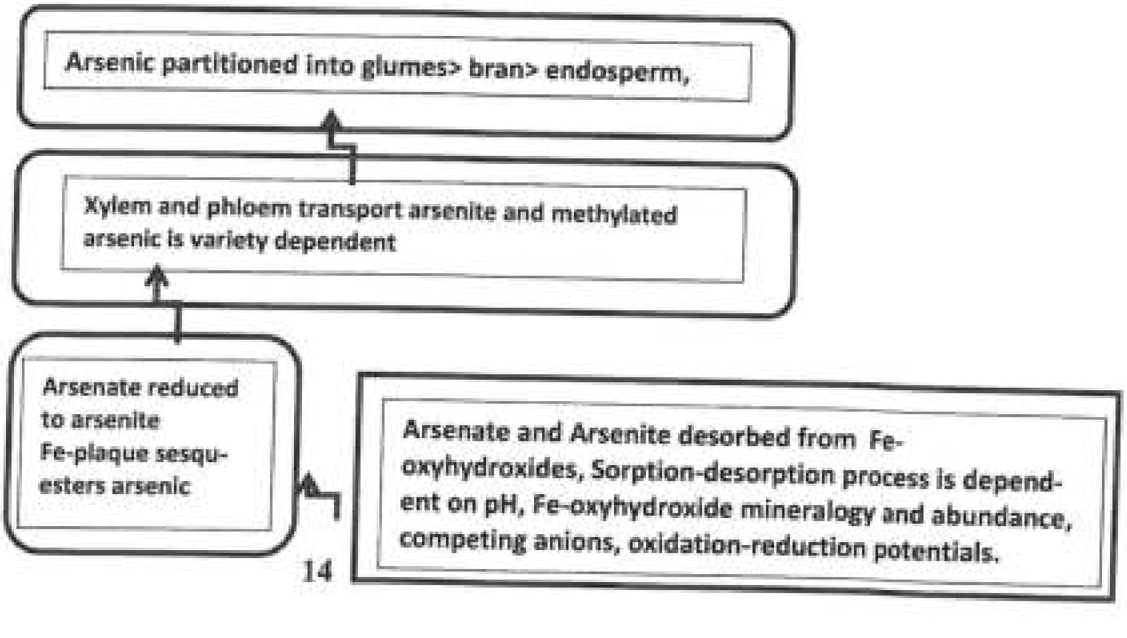
Arsenic in Soil

In the natural environment As exists as two distinct chemically species: (i) arsenite and (ii) arsenate. Arsenite is considered to be 25 to 60 times more toxic than arsenate. In soils, arsenite and arsenate (i) form complexes with soil organic matter, (ii) become adsorbed onto Al- and Fe-oxyhydroxides, (iii) become adsorbed onto phyllosilicates, (iv) leach or percolate to deeper soil horizons, and (v) undergo plant uptake. Arsenate will undergo microbial mediated reduction in suboxic and anoxic soils to form arsenite. The optimal pH for arsenate adsorption on Al- and Fe-oxyhydroxides ranges from pH 7 to 10, whereas the optimal pH for arsenite adsorption on Al- and Fe-oxyhydroxides varies across the pH range of 4 to 7.

Arsenic Uptake in Rice

The rhizosphere is the narrow soil zone adjacent to a root and is influenced by root secretions and a relative abundance of soil microorganisms, strongly influencing nutrient cycling, disease suppression and nutrient availability.

Figure 1 depicts the pathways for arsenic accumulation in rice seed



Arsenic Partitioning Among Plant Organs

In a recent study, the majority of the total arsenic in rice seed was associated with the husk (glumes) (12.42 mg As/kg), Bran (6.24 mg As/kg), and endosperm (0.54 mg As/kg). Inorganic arsenic was estimated to range from 7.90 mg As/kg for the husk, 3.47 mg As/kg for the bran and 0.17 mg As/kg for the endosperm. Arsenic was more concentrated in the aleurone layer and the outer portions of the endosperm, a feature attributed to the presence of the ovular vascular trace. The embryo show greater arsenic concentrations than the inner portion of the endosperm. These authors concluded that the majority of arsenic in the husk was xylem transported, whereas the majority of the arsenic in the endosperm was phloem transported.

Objective of the Present Investigation

This investigation was established to assess the arsenic uptake patterns of three rice cultivars and determine the typical arsenic levels in the paddy seed and non-seed biomass.

MATERIALS AND METHODS

The research was conducted at the Missouri Rice Research Farm near Glennonville, Missouri. The soil is representative of the Crowley Series. These soils consist of silty, very deep, somewhat poorly drained, very slowly permeable soils. The soil has no known history of arsenic application by arsenic-bearing herbicides or other agrichemical products. The root zone arsenic concentrations are the subject of a recently submitted manuscript by the authors and are estimated to be range from 2 to 3 mg As/kg in the A and E horizons using aqua-regia digestion with inductively coupled plasma emission spectroscopy-mass spectroscopy (ICP-MS) analysis.

Rice was cultured in a field experiment having a randomized block deign with three rice varieties as the main treatment and five nitrogen treatments as the secondary treatments. All variety-nitrogen treats were replicated four times. The three varieties included 'Cl111', 'Wells', and a not yet released experimental hybrid 'Hybrid'. Nitrogen treatments, consisting of urea, were applied at equivalent rates of 0 (untreated check), 90, 120, 150, and 180 lbs N/acre. No nitrogen was applied at internode elongation.

Rice culture consisted of drill-seeded, delayed-flood, with planting in mid-May and an October harvest. Harvest was by plot combine. Rice Tissue testing (N, P, K, Ca, Mg, S, Na, Al, Fe, Mn, Zn, B, Cu and As) and plant biomass accumulation were used to assess nutrient uptake patterns at pre-internodal elongation and at harvest. Rice samples for tissue testing included whole stem-leaf tissues and paddy (rough) rice. Nitrogen P, K, Ca, Mg, S, Na, Al, Fe, Mn, Zn, B, Cu were determined by inductively coupled plasma emission spectroscopy (ICP) after aqua-regia digestion, whereas arsenic was determined by hydride generation and ICP. Total biomass and panicle weight sampling involved randomly selecting 10 plants from each replicate, followed by drying at 70°C for two days and weighing. Harvest index was calculated as dry weight of paddy seed relative to dry weight of total plant above-ground biomass.

RESULTS AND DISCUSSION

Rice yields varied from approximately 117 to 184 bushels/acre across all treatments (Figure 2). Yields of rice peaked at 90 lbs N/acre for the 'Hybrid' and 'Wells' varieties, whereas rice yields for 'CL111' peaked at 120 lbs N/acre. Nitrogen rates greater than 120 lbs N/acre were non-significantly smaller. Plant tissue nitrogen concentrations at internode elongation were 2.35% N for 'CL111', 2.50 % N for 'Hybrid' and '2.20 for 'Wells', whereas potassium (K) plant tissue concentrations were 1.98 % K for 'CL111', 2.20 % K for 'Hybrid' and 1.78 % K for 'Wells'. The potassium plant tissue concentrations were somewhat deficient, suggesting that potassium deficiencies were partially responsible for limiting yields at the higher nitrogen rates.

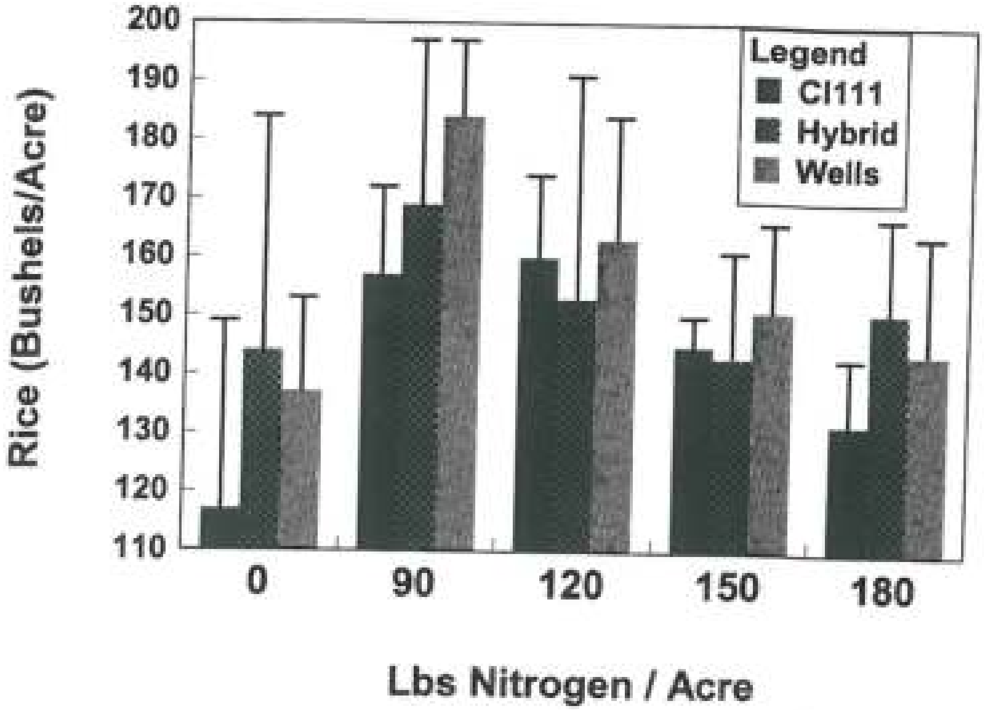


Figure 2. Rice yields for three varieties based on five nitrogen rate treatments. (Error bars are standard deviation of four replicates)

Plant height was primarily cultivar dependent (Figure 3). Plant height increased progressively from the untreated check to 120 lbs N/acre for 'CL111', whereas 'Wells' height increased from the untreated check to 90 lbs N / acre, then declined at higher nitrogen application rates. Height for the 'Hybrid' remained constant across all nitrogen treatments.

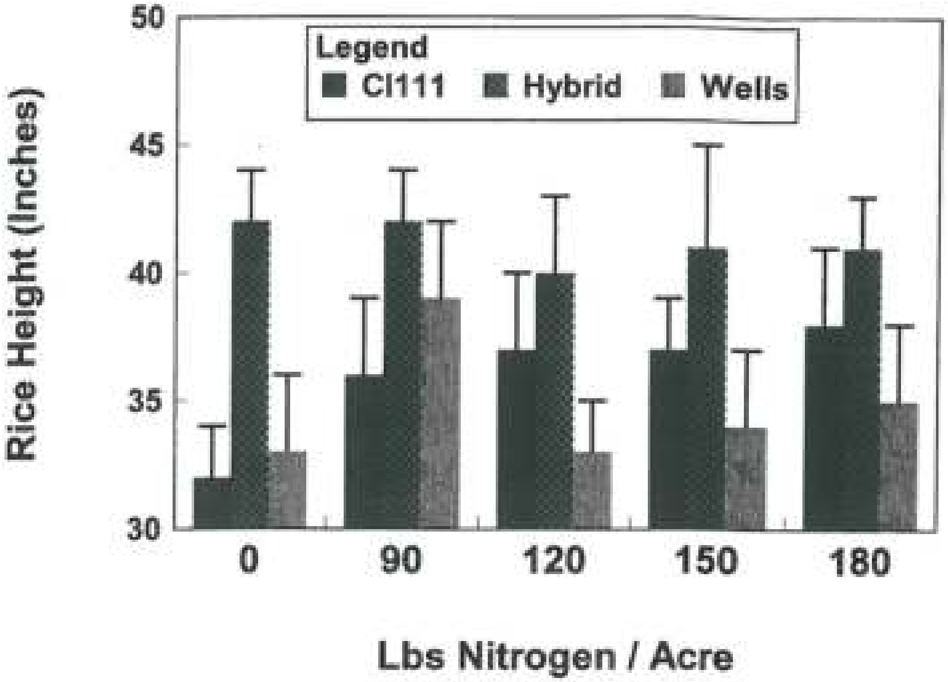


Figure 3. Rice height for three varieties based on five nitrogen rate treatments. (Error bars are standard deviation of four replicates)

The rice harvest index (ratio of seed dry weight to seed-stem-leaf dry weight) did not significantly vary by variety or nitrogen treatment (Figure 4). The harvest index value of 0.55 infers that the seed dry weight is roughly equivalent to the leaf-stem dry weight. Thus nutrient concentrations may be appropriate estimators for total nutrient uptake by seed and leaf-stem.

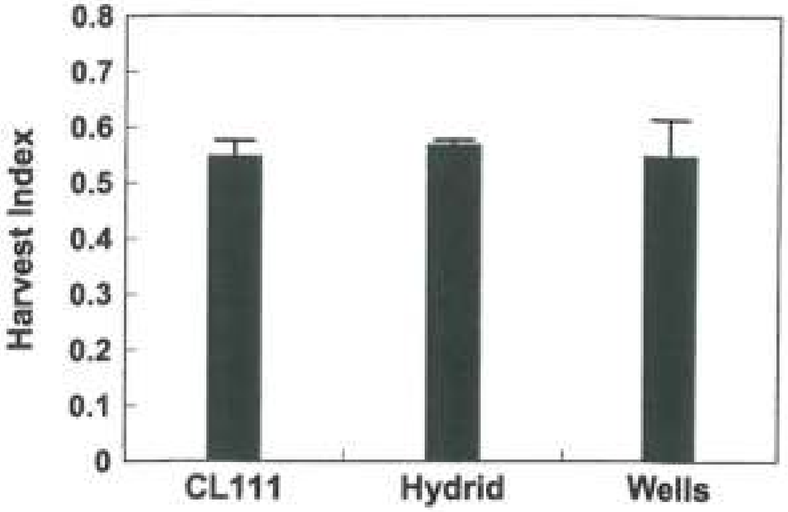


Figure 4. Rice harvest index for three varieties based on five nitrogen rate treatments. (Error bars are standard deviation of four replicates)

Nutrient concentrations in seed and stem-leaf were determined to assess the sink strength of seed. Nitrogen, phosphorus and copper were preferentially assimilated in seed (Figure 5 and 6; Tables 1 and 2). Conversely, Potassium was preferentially retained in leaf-stem (Figure 7 and Table 1). Calcium, magnesium, iron, manganese, boron and arsenic were similar to potassium in showing a preference to maintain higher concentrations in the leaf-stem component. Zinc and sulfur were approximately equally partitioned among the seed and stem-leaf components. Of all nutrients, arsenic show the least tendency to be seed assimilated (Figure 7). The 'CL111' variety showed the greatest whole plant arsenic accumulation; however, seed assimilation of arsenic was non-significantly different among the varieties.

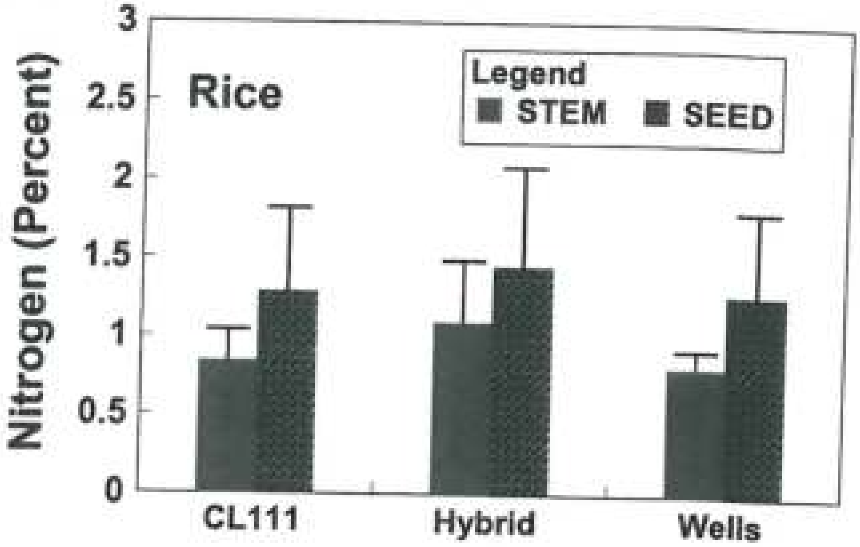


Figure 5. Nitrogen partitioning in three rice varieties. (Error bars are standard deviation of five replicates)

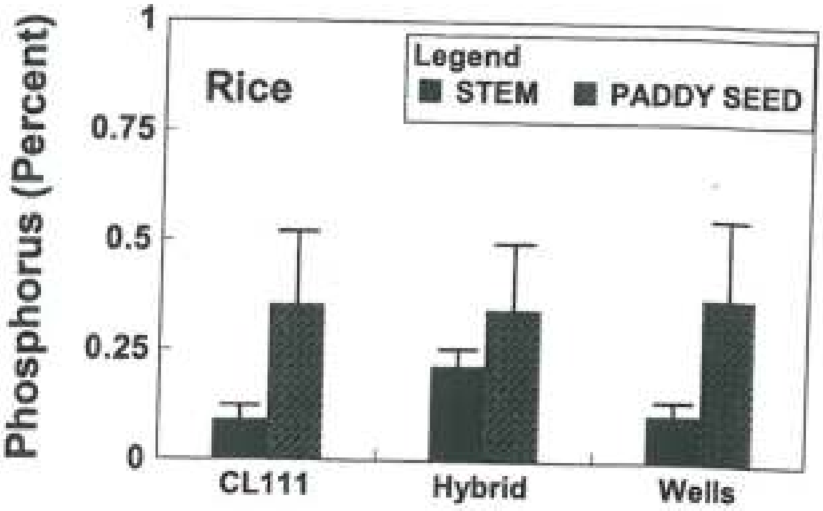


Figure 6. Phosphorus partitioning in three rice varieties. (Error bars are standard deviations of five replicates)

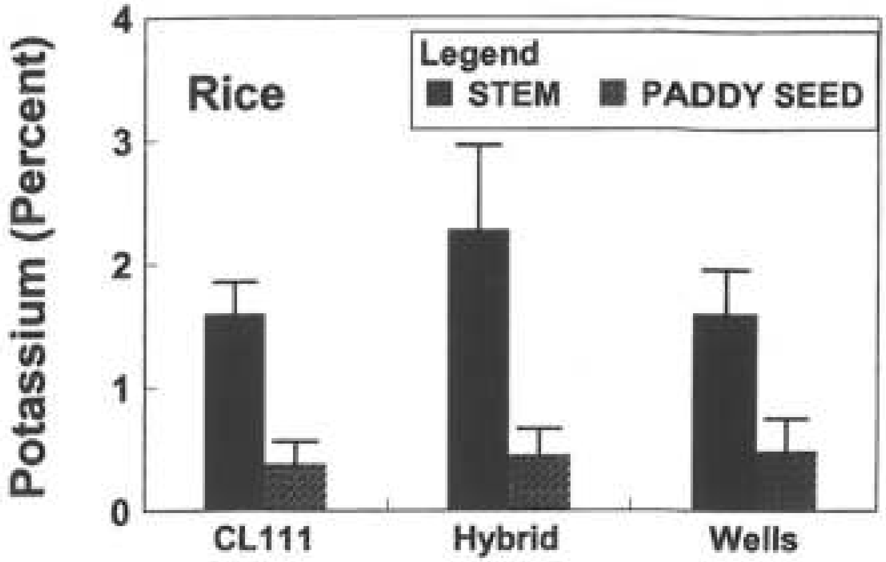


Figure 7. Potassium partitioning in three rice varieties. (Error bars are standard deviations of five replicates)

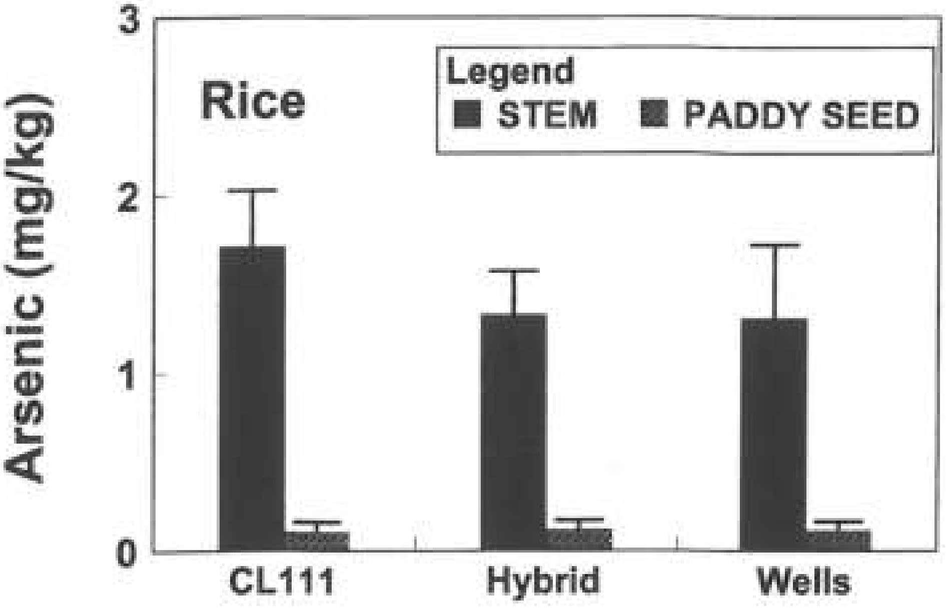


Figure 8. Arsenic partitioning in three rice varieties. (Error bars are standard deviations of five replicates)

Table 1. Macronutrient concentrations at harvest partitioned between grain and vegetative biomass

Nutrient	Vegetative Plant Mass			-----------Seed-------		
	CL111	Hybrid	Wells	CL111	Hybrid	Wells
	------------------Percent------------------------------------					
Nitrogen						
Mean	0.82	1.10	0.81	1.28	1.45	1.28
Standard Deviation	0.19	0.39	0.11	0.53	0.63	0.53
Phosphorus						
Mean	0.09	0.22	0.11	0.35	0.35	0.38
Standard Deviation	0.03	0.04	0.03	0.17	0.15	0.18
Potassium						
Mean	1.60	2.28	1.60	0.38	0.45	0.49
Standard Deviation	0.26	0.68	0.35	0.18	0.21	0.26
Sulfur						
Mean	0.07	0.13	0.09	0.11	0.11	0.11
Standard Deviation	0.01	0.02	0.01	0.04	0.05	0.04
Calcium						
Mean	0.39	0.41	0.31	0.04	0.04	0.04
Standard Deviation	0.10	0.11	0.09	0.02	0.02	0.02
Magnesium						
Mean	0.13	0.35	0.16	0.14	0.16	0.06
Standard Deviation	0.02	0.07	0.02	0.07	0.07	0.08

Table 2. Micronutrient concentrations at harvest partitioned between grain and vegetative biomass

Nutrient	Vegetative Plant mass			-----------Seed--------		
	CL111	Hybrid	Wells	CL111	Hybrid	Wells
	---------------------------mg/kg----------------------					
Iron						
Mean	129	158	173	88	106	93
Standard Deviation	19	37	45	41	63	56
Manganese						
Mean	812	1055	1081	114	157	174
Standard Deviation	132	254	336	61	85	90
Boron						
Mean	4.6	4.8	3.8	2.2	2.4	2.4
Standard Deviation	0.5	1.5	0.4	1.0	1.1	1.4
Copper						
Mean	1.4	2.8	2.2	3.0	3.2	3.4
Standard Deviation	0.5	1.5	0.4	1.4	1.6	1.5
Zinc						
Mean	21.2	39.8	26.4	28.0	22.6	26.8
Standard Deviation	5.1	9.0	2.9	11.5	9.4	11.7
Arsenic						
Mean	1.7	1.3	1.3	0.11	0.12	0.12
Standard Deviation	0.3	0.3	0.4	0.05	0.05	0.05

CONCLUSION

In this field project, nitrogen promotes rice yields and the optimum nitrogen rates varied by variety from 90 to 120 lbs N/acre. At harvest, the harvest index demonstrated that the seed to leaf-stem dry weights were roughly equivalent. Nitrogen, phosphorus and copper were primarily partitioned into the seed, whereas potassium, calcium, magnesium, iron, manganese, boron and arsenic were not readily assimilated into seed and remained sequestered in the stem-leaf component. Arsenic showed the least tendency to be assimilated into the seed component. The total arsenic seed contents were not variety dependent; however the total arsenic biomass accumulation was greatest for the 'CL111' variety.

The 2012 Effect of Planting Date on Rice Varieties

Donn Beighley, Michael Kean, Travis Wagner, and Josh Weidenbenner

In southeast Missouri there are a smaller 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 late March 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.

Materials and Methods

The Date of Planting rice plots were established at the Missouri Rice Research Farm near Glennonville, MO on a Crowley silt loam. The plots were planted on: March 27, April 2, April 16, May 3, May 15, and May 26. At each planting date there were fifteen varieties that represent the major rice varieties grown in southeast Missouri as well as seven experimental varieties. The released varieties were: Francis, Mermentau, Jupiter, Roy J, Caffey, Taggart, Templeton, and Wells.

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.

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

The drill plots were planted with an Almaco no-till plot drill. For primary weed control, 12 oz. Command was applied post plant, 1 oz/A Permit, 3 qt/A RiceBeaux and ¾ lbs. Facet herbicides were applied prior to flooding. A pre-flood fertilizer was applied at a rate of 150 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.

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

In 2012 the March 27, April 2, April 16 planting dates were harvested for yield. The soil moisture conditions for the other planting dates were too wet to harvest. The late March planting had the highest yields at 127 Bu/A followed by the early April and mid-April planting dates. At the 27 March date the top yielding lines were Roy J, Mo02015035, Jupiter, Taggart, and Caffey. The 2 April date top yielding lines were Mo0125035, Roy J, Taggart, Caffey, and RU0002146. The 16 April top yielding lines were Roy J, Mo0215035, Taggart, Mo0318016, and RU0002146. The highest yielding variety across dates was the experimental Mo0215035 at 160 Bu/A followed by Roy J and Taggart. Tables 1and 2.

The percent whole rice yield values ranged from 69/59 on 2 April to 71/67 planted on 3 May. Table 1. Across varieties Mo0318001 (72/68) had the highest average milling quality and Caffey had the lowest average (69/57). The trend usually appears to be that the medium grain varieties have the highest milling values across all planting dates but not in 2012. Just the opposite was observed.

The number of days from planting to emergence ranged from 24 days at the March 27 planting date to 10 days at the 3 May planting date. Table 1.

Across planting dates the average number of days to 50% heading ranged from 91 days at 11 May up to 101 days planted 27 March (Table 1). A similar trend was observed within varieties. RoyJ had the longest average period between emergence and 50% heading date (97 days) while RU0002146 had the fewest (85 days). Table 2.

When averaged across all varieties the plant height did not change noticeably from one planting date to another, 38 inches Table 1. There was a similar trend for the individual varieties. Taggart was the tallest variety (44 inches) while Mo0302002 was the shortest variety (31 inches) when averaged across all planting dates. Table 2.

Lodging was higher than seen in most years ranging from 10 percent to 70 percent.

Summary

The late March / early April planting date continues to result in the higher yields and milling quality values. Roy J and Taggart both appear to be better yielding of the released rice varieties.

Across planting dates Roy J, Mo0215035, and Taggart were the most stable yielding lines across the three harvested dates. Mermentau and three experimental lines, RU0202195, Mo0302006, and Mo0318001 had the best average whole grain milling quality scores.

Table 1.

2012 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
Late March	24	101	38	20	127	72	66
Early April	21	98	---	---	111	69	59
Mid April	15	83	37	50	97	69	62
Early May	10	83	---	---	---	71	67

Table 2.

2012 Variety Averages Across Three Planting Dates						
Variety	Days to 50% Heading 4x	Plant Height Inches 2x	Percent Lodging 2x	Bu/A 3x	Percent Total Rice 6x	Percent Whole Rice 6x
Francis	91	38	64	90	71	65
Mermentau	91	37	69	104	71	67
Roy J	97	41	70	159	71	65
Taggart	96	44	67	132	70	62
Templeton	95	40	65	92	71	66
Wells	92	39	63	70	71	60
Jupiter	89	36	62	125	68	60
Caffey	91	34	63	126	69	57
RU0202195	89	38	66	100	71	67
Mo0318016	92	40	61	113	72	66
Mo0302006	90	31	64	88	71	67
Mo0302002	90	38	65	87	71	66
Mo0318001	92	38	61	104	72	68
RU0002146	85	37	62	122	69	60
Mo0215035	89	36	10	160	69	56

2012 Missouri Rice Variety Performance Trials

Donn Beighley, Michael Kean, Travis Wagner, Josh Weidenbenner,
Gene Stevens, Matt Rhine, and Jim Heiser

In 2012 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

Rice plots were established at two locations in 2012: 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 2 April, 17 May and 17 May, respectively on a Crowley silt loam. The plots at the Delta Center were drill seeded on 20 April on Sharkey clay and under the center pivot area on 20 April. The seed planted in the water seeded trial were treated with Apron-Maxim-Zinc for rice water weevils. The trial consisted of 33 public, private, and experimental varieties.

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.

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

Plots were planted with an Almaco no-till plot drill. Pre-flood fertilizer was applied at a rate of 150 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. RiceBeau 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 while a Kincaid plot combine only was used at the Delta Center. The grain from the plots was weighed and moisture was determined.

RESULTS

Due to complication only two of the 2012 Missouri Rice Variety Trials were taken to completion and due to spray drift another was partially harvested.

RESULTS

Due to complication only two of the 2012 Missouri Rice Variety Trials (conventional drill-seeded and water-seeded) were taken to completion and due to spray drift another was partially harvested (center pivot).

The average yields were as follows: conventional drill test (MO Rice Farm) – 107 Bu/A and the water-seeded test (MO Rice Farm) - 139 Bu/A. The water-seeded trial yields were higher when compared to previous years.

Differences among long grain varieties were observed. The top yielding line across all trials was Roy J, CL152, Rondo, Taggart, JES, and Mo0318016. In the conventional drill-seeded trial at the Missouri Rice Farm Roy J (162 Bu/A) followed by Taggart, Rondo, CL152, and Mo0318016. The top yielding line in the water-seeded trial was Wells / Cheniere (152 Bu/A) followed by Charleston Gold, CL151, and JES. Table 3.

Across 2011-2012 at all locations RU0202195 (151 Bu/A) followed by Taggart, CL11, and CL152. Mo0318016 (140 Bu/A) was the highest yielding line across years at the Rice Farm followed by Rex, RU0202195, and CL152. Table 4.

The top yielding medium grain line across all trials was Mo0215035 (156 Bu/A) followed by Caffey and Jupiter. Caffey was the top line in the Missouri Rice Farm conventional drill-seeded trial (162 Bu/A) followed by Jupiter and Mo0215035. Mo0215035 (161 Bu/A) was the top line in the Missouri Rice Farm water-seeded trial followed by Jupiter and RU0002146. Table 1

Across years Mo0215035 (168 Bu/A) yielded the best followed by RU0002146 and Jupiter. On the Rice Farm Mo0215035 (156 Bu/A) was the best variety followed by Caffey and RU0002146. Table 2.

Among the aromatic rice varieties (Della-2, Jazzman, Jazzman 2, JES, and Charleston Gold) the top yielding aromatic line across all trials was JES (135 Bu/A) followed closely by Della-2. JES and Della-2 were the top two varieties in both the conventional drill-rice trial and water-seeded trial. Table 3.

The Louisiana hybrid rice line, LAH10 averaged 126 Bu/A across the two locations. Table 3.

In 2012 the number of days from planting to emergence for the water-seeded (10 days) and conventional drill-seeded emergence (19 days). The conventional drill-seeded emergence was similar to that observed in previous years. Table 1 & 3

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 77 days and 98 days for the conventional rice trial behind soybeans. Under both cultural practices these values are similar to previous years. The average number of days to 50% heading observed for the varieties in the combined trials ranged from 84 days for RU0002146 to 91 days for RoyJay and Rondo. Table 1 & 3.

The 2012 average plant heights across locations were 39 inches. Individual location plant heights were 48 inches for the MO Rice Farm and 38 inches for the water-seeded trial. Table 1 & 3

Lodging ranged from 10% (Jazzman) to 70% (Colorado) and averaged 40% on the conventional drill-seed trial and 10% in the water-seeded trial across all varieties. The winds observed in early September due to Hurricane Isaac were thought to cause the high levels of lodging. Table 1 & 3.

Average percent milling quality values across all trials was 71/66. The conventional rice trial had the highest at 70/65 and water-seeded averaged 72/67. In 2012 milling quality values were higher than observed in 2011. Table 1 & 3.

No significant disease symptoms were observed in 2012 other than the Brown Spot under the center pivot and some Straighthead in tests at the Rice Farm.

Summary

The bottom line is that there are **some** good varieties available for the Missouri rice producers. These include Roy J, Taggart, Francis, Wells, Cheniere, CL152, CL151, CL142 AR, CL111, CL261, Jupiter and Caffey. Across years the best released lines have been CL152, Francis, Wells, Taggart, and Roy J.

Growing conditions in Missouri continue to provide a good environment for high milling quality values.

Table 1.

2012 Rice Variety Trial Agronomic Data – Medium Grain

Variety	Days to 50% Heading 2x	Plant Height (Inches) 2x	Percent Lodge 2x	Avg Bu/A 2x	Lbs /A 2x	Percent Total Rice 2x	Percent Whole Rice 2x
Caffey	87	39	2	147	7345	70	67
Jupiter	86	40	2	153	7652	71	65
RU0002146	84	39	3	138	6907	70	66
Mo0215035	85	38	2	156	7799	70	63
CL261	86	40	3	124	6204	71	67
LAH10	89	42	2	126	6301	71	67

Table 2.

Missouri Multiple Year Yield Data (Bu/A) – Medium Grain

Variety	2012 Rice Farm	2012 Water-Seeded	2012 Two Location		2011-2012 Average		2011-2012 Rice Farm
Caffey	162	132	147		148		148
Jupiter	148	159	153		151		135
RU0002146	130	146	138		152		137
Mo0215035	151	161	156		168		156
CL261	126	122	124		125		111

Table 3.

2012 Rice Variety Trial Agronomic Data – Long Grain							
Variety	Days to 50% Heading 2x	Plant Height (Inches) 2x	Percent Lodge 2x	Avg Bu/A 2x	Lbs /A 2x	Percent Total Rice 2x	Percent Whole Rice 2x
Antonio	86	36	4	104	5189	73	68
Cheniere	85	38	3	110	5482	71	66
Colorado	86	41	4	106	5321	73	68
Francis	88	41	2	118	5924	73	70
Mermentau	88	37	3	104	5183	72	68
Rex	86	40	2	119	5970	70	65
Rondo	91	40	2	139	6973	69	63
RoyJay	91	40	2	153	7648	71	65
Rufipogon	89	37	3	125	6261	71	62
Taggart	89	42	2	137	6868	70	65
Templeton	89	41	4	114	5687	72	68
Wells	89	40	2	129	6442	71	67
RU0202195	87	40	3	125	6258	72	68
Mo0318016	89	40	2	133	6647	72	68
Mo0302006	90	39	3	123	6143	72	68
Mo0302002	89	41	3	121	6042	72	64
Mo0318001	89	39	2	122	6115	72	69
CL111	86	40	4	98	4878	72	67
CL142-AR	87	41	4	101	5050	71	65
CL151	87	39	4	109	5461	72	68
CL152	88	40	2	139	6966	72	69
CL162	89	39	3	105	5231	72	68
Della-2	89	40	2	131	6539	71	67
Jazzman	90	39	4	92	4621	72	67
Jazzman 2	90	39	2	107	5371	72	68
JES	89	36	3	135	6756	70	67
Charleston Gold	88	42	3	118	5893	70	65

Table 4.

Missouri Multiple Year Yield Data (Bu/A) – Long Grain

Variety	2012 Rice Farm	2012 Water-Seeded	2012 Two Location		2011-2012 Average		2011-2012 Rice Farm
Cheniere	67	152	110		129		101
Francis	105	132	118		129		132
Rex	115	124	119		132		139
Rondo	137	141	139		120		107
RoyJay	162	144	153		109		119
Rufipogon	106	145	125		124		115
Taggart	138	137	137		140		123
Templeton	93	135	114		95		113
Wells	106	152	129		137		126
RU0202195	117	133	125		151		139
Mo0318016	127	139	133		147		140
Mo0302006	108	138	123		147		131
CL111	60	135	98		143		107
CL142-AR	73	129	101		129		108
CL151	68	150	109		128		86
CL152	131	147	139		144		137
Jazzman	50	135	92		107		103
Jazzman 2	83	132	107		126		101
JES	124	146	135		95		88
Charleston Gold	85	151	118		93		73

Silicon as a Soil Amendment for Rice to Reduce Arsenic Levels in Grain

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

Consumer Reports magazine published a story in November 2012 showing arsenic (As) levels from 66 rice brands purchased in stores in New York City and online. Total As in most rice was several times higher than the EPA allowable levels in drinking water, 10 ppb. Television shows such as *The Doctors* and *Dr. Oz* picked up on the story. Within brands of rice tested, brown rice was higher in As than milled white rice because the bran contains most of the nutrients in the grain. However, total As values in rice can be misleading. Organic As is easily passed through the digestive system without causing harm. On the other hand, inorganic As is a carcinogen which has been linked to bladder and lung cancer. Ironically, Asian people who eat rice three times per day have the lowest incidence of these types of cancers.

Arsenic and silicon (Si) behave similarly in soil. In drained fields, arsenate, As [V], and silica ions are adsorbed on oxidized iron particles. When fields are flooded for rice, ferric iron +3 is reduced to the ferrous iron +2, which releases As and Si into solution where they can be taken up by rice roots. Recent research showed that As in rice grain was reduced by applying soluble silica fertilizer. Si competes with As ions for root entry points. Liming can help depending on what species of As is present. Raising soil pH decreases arsenate adsorption by iron but increases arsenite adsorption, which is more prominent in flooded soils. Lime and calcium silicate from steel mill slag have shown to reduce As in radishes grown in contaminated soil.

Silicon is good for rice yields while As is bad. Tissue Si and As content are usually higher in rice than crops such as corn and wheat. In rice, Si promotes disease resistance and helps plants withstand stresses such as salinity and dry soil. Conversely, As in rice tissue reduces yield by producing panicles without grain called straight heads. Breeders are working to identify varieties with lower As content in grain, but fungal diseases may increase due to lower tissue Si. Molecules of arsenite, 4.11 angstroms, and silica, 4.38, are similar in diameter and shape. Since arsenite is slightly smaller, blocking As from passing through root membranes to the xylem also inhibits Si uptake. Two proven methods to significantly reduce As in rice grain are silica fertilization and growing rice without flooding.

In 2012, we sampled rice straw from Missouri fields that were under both flood and center pivot irrigation regimes. The University of Florida (UFL) has developed methods for testing soil and rice straw Si concentrations. The lab procedures were developed for the Everglades area where Si deficiency is common in rice fields. Based on rice straw, 960 lb Si/acre is recommended by UFL for fields testing less than 3.4% Si. Missouri soil samples from graded rice fields with deep cuts averaged 22 lb Si/acre. Fields with sandy areas tested 3.4 lb Si/acre. Based on this recommendation, Si fertilization could significantly benefit rice production on Missouri soils, not only as competition for As uptake, but for increased stress resistances and yield. More research is planned to determine Si recommendations for the state of Missouri, as well as its relationship to As accumulation in rice.

Additives for Increasing Nitrogen Efficiency in Rice

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Introduction

Rice needs supplemental nitrogen fertilizer additions to achieve maximum yields. In the standard dry seeded, delayed flood rice production system, the bulk of the nitrogen is supplied as urea. Then a permanent flood is immediately established. However, in real farm situations the establishment of the permanent flood can be delayed for several days. During the time period between fertilizer application and flood establishment the applied urea is subject to losses by several pathways. These include volatilization of urea and conversion of urea to nitrate followed by subsequent leaching and denitrification. Several products are commercially available to control these losses. This study compares several products in their ability to achieve rice yields in a dry seeded, delayed flood production system.

Methods and Materials

In 2012 this evaluation was conducted on a Crowley silt loam soil located at the Missouri Rice Research Farm, Qulin, Missouri. A small plot evaluation with a randomized complete block design employing four replications was conducted. Rice was cultivated using the standard methods of P and K fertilization, water management, and weed & insect control for dry-seeded, delayed flood rice in Southeast Missouri. Three pre-plant N rates (70, 105, and 140 lbs N/a) were compared to an untreated check. No additional N was applied at mid-season. The following products: urea, urea + Agrotain®(Koch Agronomic Services, LLC, Wichita, KS) urea + NutriSphere-N® (N-N®, Specialty Fertilizer Products, Leawood, KS), urea + NZONE™ (AgXplore International, Parma, MO), and urea + N-FIXX® (The Helena Chemical Company, Collierville, TN). The following rates were used for each additive: Agrotain® 4 qt/ ton urea, N-N® 0.25% w/w, NZONE™ 2 qt/ ton urea, and N-FIXX 4 qt/ton. These N fertilizer treatments were applied to dry soil on May 18, 2012, 11 days prior to flood establishment. An additional set of urea treatments (70, 105, and 140 lbs N/a) applied one day before flood establishment. On May 29, 2012 a permanent flood was established and maintained until the rice reached maturity. Relavent weather data for the site prior to flood establishment is given as Table 1. At season's end each plot was harvested and the resulting rice yield was measured.

Results

Yield results from 2012 are given in Table 2. The 140 lbs N rate produced the greatest yields when averaged for all products (112 Bu/acre). The urea 11 days pre-flood produced the lowest yields when averaged for all N rates (96 Bu/acre). When yield results were averaged for all N rates the urea + NZONE™ treatments produced the numerically greatest yield (114 Bu/acre). However the greatest yields for an individual treatment were produced with urea + N-N® at the 140 lbs N rate (119 Bu/acre).

When average yields for all N rates of urea applied one day before flooding are compared to those applied 11 days before flooding the loss resulting from flood delay amounts to 8 bu/acre.

As the fertilizer treatments were applied to dry soil little loss of N due to volitization would be predicted. This is supported by granules of urea being visible on the soil surface two days following application. The rainfall event on the evening of May 20, 2012 (0.44 inches) was sufficient to move the applied urea below the soil surface. This event may have also served to convert urea to ammonia and subsequently to nitrate. The nitrate is then liable for loss via denitrification. Two of the products evaluated, Agrotain and N-FIXX are marketed as strictly volitization inhibitors. The other two products, NutriSphere-N® and NZONE™, are marketed as inhibiting both volitization and denitrification. This may explain the relatively better yield performance of these last two products. The environmental conditions found in 2012 may or may not be typical for Southeast Missouri. More study is needed before definitive conclusions are drawn. Rice producers should exercise caution before extending these results in to future years.

Acknowledgement:

This research was made possible by the support of the Missouri Rice Research and Merchandising Council, Agrotain International, St Louis, MO, Specialty Fertilizer Products, Leawood, KS, AgXplore International, Parma, MO, and The Helena Chemical Company, Collierville, TN. Use of trade or product names is for identification purposes only and does not constitute an endorsement or recommendation by the University of Missouri.

Date	Total Precip (inches)	Average Temp (degrees f)	Max wind speed (mph)
5/15	0.00	70	18
5/16	0.00	72	17
5/17	0.00	71	17
5/18	0.00	76	17
5/19	0.00	79	21
5/20	0.44	77	36
5/21	0.00	69	20
5/22	0.00	66	23
5/23	0.00	70	17
5/24	0.00	79	35
5/25	0.00	81	20
5/26	0.00	82	22
5/27	0.00	82	20
5/28	0.00	84	22
5/29	0.00	82	21

Table 2. Average rice yields in bu/a for N treatments for a silt loam soil located at the Missouri Rice Research Farm, Qulin, MO, 2012

N Rate	Urea 1 day pre-flood	Urea 11 day pre-flood	Urea + Agrotain® 11 day pre-flood	Urea + N-N® 11 day pre-flood	Urea + NZONE™ 11 day pre-flood	Urea + N-FIXX 11 day pre-flood	Average all products
0	88						
70	97	88	103	107	115	102	102
105	105	94	108	109	114	113	107
140	109	106	111	119	114	115	112
Avg for N rates	104	96	107	112	114	110	

Lsd 0.05 = 9.2 bu/acre, CV% = 6.5

Effect of Potassium Nitrate Applications on Rice Grain Yields, Milling Quality, Lodging and Stalk Strength

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Introduction

Proper potassium (K) nutrition is critical for maximizing rice grain yields. Potassium deficiency in rice can reduce grain yields and increase lodging. Visual symptoms of K deficiency in rice first appear in older leaves. These symptoms include a yellowing of leaf tips, decreased disease resistance, and reduced yields. In K deficient rice there is decreased accumulation of starch in the rice stem. This suggests a close correlation between K content of the stem and the breaking strength of the stalk. Accordingly, increased stalk strength and decreased lodging are associated with proper K nutrition. Foliar feeding of rice represents an opportunity for producers to correct nutrient deficiencies during the growing season. In the past we have looked at using foliar solutions of potassium nitrate (KNO_3) to increase grain yields. These evaluations were conducted on a potash deficient soil. It was demonstrated that foliar KNO_3 could increase grain yields if the plants were deficient in K. We also found evidence of non-yield benefits. These benefits included increased stalk strength, decrease lodging, and greater disease resistance. These benefits may or may not be directly translated into yield. This raised the question "Could foliar KNO_3 benefit rice grown on a soil where K was adequate?" In 2010, with support from the Potassium Nitrate Association, we began a 3-year study which investigated the effect of foliar applied potassium nitrate on grain yields, stalk breaking strength and lodging in rice production.

Methods and Materials

A three-year rice experiment was performed in 2010, 2011 and 2012 on a Crowley silt loam soil located at the Missouri Rice Research Farm at Qulin, MO. Different research areas were used each year. In 2010 and 2012 the initial soil test K levels at this location was 92 and 94 lbs K/a respectively. In 2011 the initial soil test K levels at this location was 230 lbs K/a For all three years all other soil test parameters were found to be adequate for drill seeded delayed flood rice production in Southeast Missouri. The University of Missouri recommended rates for K in 2010 and 2012 was 60 lb K_2O/acre. In 2011 the recommendation was for a maintenance application consisting of 20 lb K_2O/acre. Each year research plots were established with 0, 30, 45, or 60 K_2O/acre (0, 50, 75, or 100% of the 2010 and 2012 recommended rate) as a pre-plant application of KCl. Subsequently each plot received either did or did not receive in-season foliar KNO_3 applications. Those plots that did were treated three times: pre-flood, inter-node elongation, and 10% heading. These foliar treatments were applied using a CO_2 back pack sprayer. Each application consisted of 10 lbs of KNO_3 or 4.6 lb K/acre. The experimental design was a randomized complete block six replications. In this evaluation rice was cultivated under the standard methods for producing rice in a dry seeded delayed flood production system in Missouri. At season's end each plot was harvested and grain yield determined. A representative sample of grain was collected from each plot for milling quality testing. Lodging % of each plot was also determined at this time. Following harvest 12 inch long basal stalk samples were collected from each plot. These samples were evaluated for breaking strength by progressively adding weights to a cup suspended by a string from the stalk. The weight at which each stalk failed was recorded. The data collected was first analyzed for each individual year using ARM. These individual year results were then averaged over the 3-years for each treatment.

Results and Discussion

The yield and milling quality results for from this experiment are presented as Table 1. Additions of K either as soil applied KCl or foliar applied KNO_3 increased rice grain yields. In all three years of the study the lowest yielding treatment was the untreated check. The greatest yielding treatment was 60lb of KCl pre-plant + foliar KNO_3. A linear relationship was found between rice yields and pre-plant K rates with no foliar additions of KNO_3. This indicates that low soil K fertility conditions may have been limiting rice yields. When yields for all rates of pre-plant KCl were averaged for all three years additions of foliar KNO_3 increased rice yields by10 Bu/acre. For both years that data is available milling quality was increased by foliar KNO_3 applications. The largest increases were found when no pre-plant KCl was applied. In 2010 and 2012 lodging was reduced by foliar KNO_3 applications, while in 2011 no lodging was encountered (Table 2). The effects on lodging and subsequent grain shatter of Hurricane Isaac are most dramatic. Here additions of foliar KNO_3 consistently reduced lodging. For both years that data is available stalk strength was increased by foliar KNO_3 applications.

Foliar KNO_3 applications positively affected rice grain yields and reduced lodging even when soil K levels were found to be optimal (2011). Producers should closely monitored the K status of their rice fields and consider foliar KNO_3 consider applications.

Acknowledgement

This research was made possible by the support of the Missouri Rice Research and Merchandising Council and the Potassium Nitrate Association. Use of trade or product names is for identification purposes only and does not constitute an endorsement or recommendation by the University of Missouri.

Table 1. Average rice grain yields and milling quality for pre-plant potassium chloride and foliar potassium nitrate fertilizer treatments Qulin, MO 2010, 2011, and 2012.

Pre-plant K_2O/ acre	Foliar KNO_3	Yield (bu/a)			Milling Quality (head % / total %)		
		2010	2011	2012	2010	2011	2012*
0	No	111	125	80	50 / 61	66 / 75	----
0	Yes	131	129	80	57 / 63	69 / 76	----
30	No	136	133	90	55 / 62	68 / 75	----
30	Yes	151	136	101	57 / 63	69 / 76	----
45	No	160	134	90	56 / 63	69 / 75	----
45	Yes	157	141	115	58 / 64	69 / 76	----
60	No	167	141	99	57 / 63	70 / 76	----
60	Yes	170	146	121	57 / 63	69 / 76	----
LSD 0.05		18.9	7.5	11.8	2.0 / 1.9	1.2 / 0.8	
CV%		10.8	4.7	10.4	3.0 / 2.6	1.5 / 0.9	

*Data analysis not complete at this time

Table 2. Average rice lodging and stalk breaking strength for pre-plant potassium chloride and foliar potassium nitrate fertilizer treatments Qulin, MO 2010, 2011, and 2012.

Pre-plant K_2O/ acre	Foliar KNO_3	Lodging (%)			Stalk breaking strength (gm/ stalk)		
		2010	2011	2012	2010	2011	2012*
0	No	23	0	61	186	83	----
0	Yes	25	0	24	258	110	----
30	No	23	0	19	230	105	----
30	Yes	20	0	4	211	145	----
45	No	37	0	12	206	131	----
45	Yes	17	0	0	250	161	----
60	No	32	0	10	193	125	----
60	Yes	23	0	1	298	195	----
LSD 0.05		14	----	14	83	24	
CV%		49.0	----	75.5	30.9	15.6	

Herbicide Resistant Small Flower Umbrella Sedge

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Small flower umbrella sedge (*Cyperus difformis*), is an annual sedge that reproduces by seeds, unlike the more familiar yellow nutsedge (*Cyperus escuelentus*), which mainly reproduces by tubers (nutlets) which form on the end of underground rhizomes. Other similar species, rice flatsedge (*Cyperus iria*), and Green Kyllinga (*Kyllinga brevifolia*), can be differentiated from small flower umbrella sedge in several ways. Rice flatsedge has a distinctive "christmas tree" smell, and loose, spreading inflorescence in contrast to umbrella sedge's tight ball-like seed head. Green Kyllinga has a seed head similar to umbrella sedge, but will have rhizomes. All are smaller than yellow nutsedge and will generally be less than 24" tall.

Populations of small flower umbrella sedge with confirmed resistance to Acetolactate Synthase (ALS) herbicides have been documented in California (1993) and in several areas outside the U.S. since 1994. Most recently, resistance has been documented in Arkansas (2010) and a second mode of action in California (2012). A suspected ALS resistant population was found in 2005 near Portageville, Mo. Testing at that time was inconclusive, but did show that the use of non-ALS herbicides including basagran and propanil could provide some control of small flower umbrella sedge. More recently, however, another possible resistant population has been reported. Testing will tentatively be performed this growing season to determine if this is a resistant population.

Non-herbicide resistant small flower umbrella sedge is generally easy to control and may go unnoticed until resistance and a resulting increased population has developed. Research on populations from California, Italy and Spain showed that cross resistance (resistance to an herbicide that had never been applied to a population but was closely related to one that had been applied) was not always present. While this could potentially allow for the use of Permit after a population had displayed resistant to Londax, it would be wise to utilize other herbicide modes of action, weed control techniques, or crop rotations to prevent problematic populations. These developments require an extensive evaluation of the herbicides we can use in Missouri to successfully control small flower umbrella sedge.