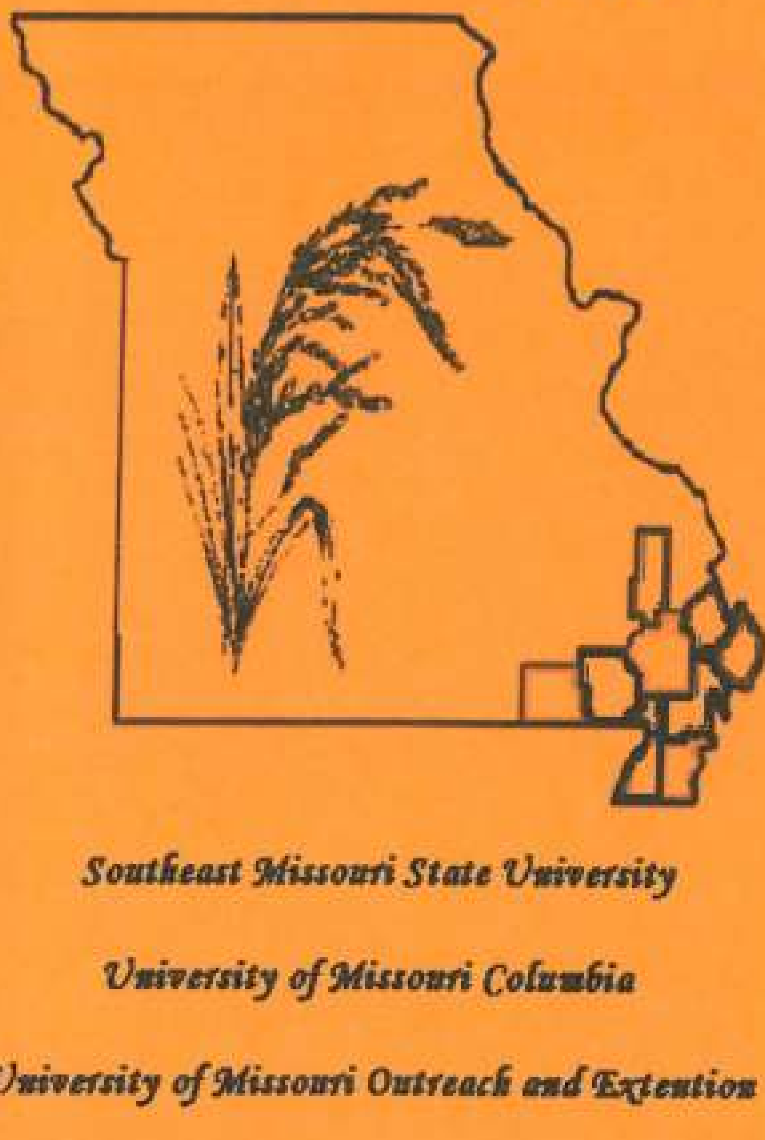
Missouri Rice Research Update 2013



Southeast Missouri State University

University of Missouri Columbia

University of Missouri Outreach and Extention

Special Report # 01-2013

February 2014

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, UM Fisher Delta Center Research Farm, and Southeast—Malden RiceLab. 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.

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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 Research and Producers Conference Program Agenda

February 25, 2014

Moderator: Sam Atwell MU Agronomy / Rice Specialist

7:30 am – Registration, coffee, doughnuts

8:00 am - Welcome

8:05 am – MU Rice Insect Program, - Dr. Moneen Jones MU Research Delta Center

8:20 am – Irrigation, Pumps & Wells – Joe Henggeler, MU Research Delta Center

8:50 am – Rice Issues – Dr. Michael Aide, SEMOU Research Cape Girardeau

9:20 am – Rice Varieties / Breeding – Dr. Donn Beighley, Southeast Missouri State University - Malden

9:50 am - Break

10:00 am – Rice Weed Control – Jim Heiser MU Research Delta Center.

10:30 am – Guest Speaker Possibly UAR?

11:00 am - Rice Production Research – Dr. Gene Stevens MU Research Delta Center.

11:20 am – Rice Market Outlook – David Reinbott, MU Extension Ag Business Specialist Scott Co.

11:40 am – US Rice Domestic & Foreign Markets –Greg Yielding, MO Rice Council / US Rice Producers Association

12:00 pm – Lunch

PLUS #

Industry Representatives are on hand to answer questions about their products.

University of Missouri Extension and MU Delta Research Center in partnership with MO Rice Council and Southeast Missouri State University want to thank:

Our Speakers, Eagles Club Mr. Bill Huechel, Rice Consultants and Special **THANK YOU** to our Company Sponsors

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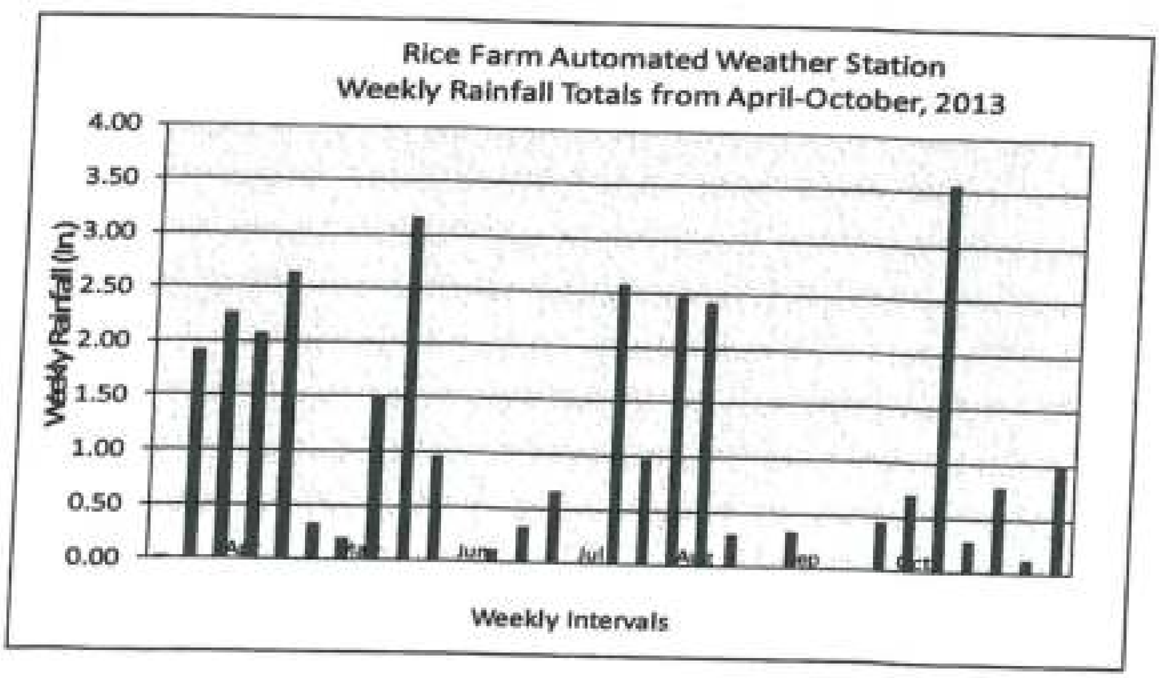
Extension Commercial Agriculture Automated Weather Station
Missouri Rice Farm, Glennonville, MO
2013 Monthly Weather Summary

	Temperature (°F)								Precipitation (In.)	
	Avg Max.	Avg Min.	Avg	Difference	Days ≥90°	Days ≥100°	Days ≤32°	Days ≤0°	Total	Difference
January	46.8	30.6	38.6	3.6	0	0	22	0	5.27	2.10
February	47.7	32.5	39.8	0.5	0	0	12	0	3.97	0.67
March	52.1	35.0	43.3	-4.9	0	0	14	0	2.07	-1.95
April	68.0	46.9	57.6	-1.1	0	0	1	0	6.28	1.83
May	77.6	58.3	67.7	-0.6	0	0	0	0	5.44	0.84
June	87.5	67.3	77.2	-0.1	13	0	0	0	3.82	0.56
July	86.7	66.7	76.3	-4.3	10	0	0	0	5.28	1.27
August	86.3	67.4	76.2	-3.0	10	0	0	0	4.17	1.66
September	83.7	61.9	72.3	0.9	7	0	0	0	1.49	-1.75
October	69.7	50.1	59.7	-0.2	0	0	1	0	5.78	2.20
November	54.0	35.2	44.5	-4.4	0	0	12	0	1.61	-2.75
December	44.4	28.6	36.2	-1.5	0	0	22	0	7.09	2.51
Year	67.0	48.4	57.5	-1.3	40	0	84	0	52.27	7.19



Cultivar	Sheath Blight	Blast	Straighthead	Bacterial Panicle Blight	Nar-row Brown Leaf Spot	Stem Rot	Kernel Smut	False Smut	Black Sheath Rot	Sheath Spot
Antonio	S	S		MS		S	S	MS		
Caffey	MS			S	R			MS		
Cheniere	S	VS	VS	VS	S	S	S	S	MS	
CL111	VS	MS	S	VS	VS	VS	S	S	S	
CL142-AR	MS	S	MS	S	S	S	S	S	S	
CL 151	S	VS	VS	VS	S	VS	S	S	S	
CL 152	S	VS	S	S	R		VS	S		
CL 162	VS	VS		VS	R		S	S		
CL 261	MS	VS	S	VS	S	VS	MS	S	MS	
Cocodrie	S	S	VS	S	S	VS	S	S	S	
Colorado	S	VS		S				S		
Della-2				S						
Francis	MS	VS	MR	VS	S	S	VS	S	S	
Jazzman	MS	S	S	MS	S	S	MS	S	MS	
Jazzman-2	VS	S		VS	MR		S	S		
JES	S	R	VS	S	R	VS	MS	MS	MR	
Jupiter	S	S	S	MR	MS	VS	MS	MS	MR	
Mermentau	S	S	VS	MS			S	S		
Neptune	MS	MS	VS	VS	MS	VS	MS	MS	MR	
Rex	S	S	S	S	MS	S	S	S	S	
Roy J	MS	S	S	S	MR	S	VS	S	MS	
RiceTec CL	MS	R	MS	MR	MS	S	MS	S	S	
RiceTec CL	S	R	R	MR	MS	S	MS	S	S	S
RiceTec CL	MS							S	S	
RiceTec XL723	MS	R	S	MR	MS	S	MS	S	S	
RiceTec XL753	MS			MR			MS	S	S	
RiceTec XL754	MS							S	S	S
Taggart	MS	MS	R	MS	MS	S	S	S	MS	
Templeton	MS	R	S	MS	S	MS	S	S	MS	
Wells	S	S	S	S	S	VS	S	S	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. Cart-

Cultivar	Year Released	Highlights
Antonio	2012 - Texas	A short season, semi-dwarf long-grain with very good yield potential and milling quality. Similar to Cocodrie for agronomic characteristics
Bowman	2007 - Missis-sippi	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 shealth blight and straighthead.
Caffey	2011 - Louisi-ana	A short season, semi-dwarf medium grain with excellent yield potential and milling quality. Susceptible to blast, sheath blight, and panicle blight.
Cheniere	2003 - Louisi-ana	A short season semi-dwarf long-grain with good yield potential and milling quality comparable to Cypress. Susceptible to sheath blight and blast.
Colorado	2012 - Texas	A short season, long-grain semi-dwarf with good yeild potential and good milling quality.
Della - 2	2012 - Louisi-ana	A semi-dwarf long-grain aromatic with good yield and very good grain quality. Improved lodging compared to Della.
Francis	2002 - Arkan-sas	A very short season, long-grain with excellent yield potential, susceptible to rice blast and very susceptible to kernal smut. It is the best long grain for high pH and salt soils bt should not be stressed for water due to blast con-
Jazzman	2009 - Louisi-	A Jasmine-type aromatic rice with good yield potential and milling quality.
Jazzman-2	2011 - Louisi-ana	A Jasmine-type aromatic rice with fair yield and good milling compared to Jazzman. Susceptible to sheath blight, bacterial panicle blight, and straighthead.
Jupiter	2006 - Louisi-ana	A short season, semi-dwarf, medium-grain with excellent yield potential and milling quality. It has a small grain size but has a moderate resistance to bacterial panicle blight.
Mermentau	2012 - Louisi-ana	A short season, semi-dwarf, long-grain variety with good yield potential and physical characteristics similar to Cocodrie, Cheniere, and Catahoula.
Rex	2010 - Missis-sippi	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.
Roy J	2010 - Arkan-sas	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 - Arkan-sas	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 - Arkan-sas	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 - Arkan-sas	A short-season, long grain with excellent yield potential, average to good milling quality, large kernal size similar to Lemont, but is [illegible]

Cultivar	Year Released &	Highlights
CL 111	2008 - BASF,	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	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 151	2007 - BASF, Horizon Ag	A mid-season, 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 152	2011 - BASF, Horizon Ag	A mid-season, semi-dwarf long-grain similar to CL 151 with good yield potential and high tolerence to Newpath herbicide. Improved lodging and chalk compared to CL 151.
CL 162	2011 - BASF, Horizon Ag	A short season, long-grain Clearfield variety with average yield potential and good milling quality. Susceptible to sheath blight, blast, and straighthead.
CL 261	2008 - BASF,	A short-season, medium-grain Clearfield variety similar to Bengal.
CL XL729	2007 - Rice-Tec, Inc.	A short-season, long grain Clearfield hybrid with excellent yield potential and moderately susceptible to sheath blight, and moderately resistant to blast.
CL XL745	2008 - Rice-Tec, Inc.	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 - Rice-Tec, Inc.	A mid-season, long-grain Clearfield hybrid with excellent good yield potential and average milling quality. Similar to CL XL729.
XL723	2005 - Rice-Tec, Inc.	A short-season long-grain hybrid with excellent yield potential, average milling quality; resistant to blast and moderately susceptible to sheath blight.
XL753	2011 - Rice-Tec, Inc.	A short-season long-grain hybrid with excellent yield potential.
XP754	2011 - Rice-Tec, Inc.	A mid-season long-grain hybrid with excellent yield potential and good milling quality.

Furrow Irrigated and Drill Seeded-Delayed Flood Irrigated Rice: Assessment of Rice Agronomic Performance and Arsenic Accumulation Rates

Michael Aide and Donn Beighley, and David Dunn

Grower interest in furrow irrigation of rice is increasing, largely attributed to reduced costs associated with water pumping and field preparation. This is the first of a two year study to determine the economic and agronomic efficiency of furrow irrigated rice compared to drill seeded-delayed flood irrigated rice. Two soil types (Sharkey clay and Crowley silt loam) were employed to assess soil differences. Yields of furrow irrigated rice were comparable to drill seeded-delayed flood rice. Difficulties of furrow irrigated rice include using the correct nitrogen fertility program and effective weed control.

Field Protocols

Rice (CL111) was grown in a field experiment at the Missouri Rice Research and Demonstration Farm (Dunklin County, Missouri, having plots devoted to furrow irrigated rice, flood rice, and drill-seeded delayed-flood rice. Nitrogen treatment consisted of urea, at120 lbs N/acre. No nitrogen was applied at internode elongation.

Rice was mid-May planted and the October harvest was by plot combine. Rice Tissue testing (N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn, B, Cu and As) and plant biomass accumulations were used to assess nutrient uptake patterns at pre-internodal elongation and at harvest. Rice samples for tissue testing included whole stem-leaf tissues prior to heading and stem, leaf and grain (paddy rice, brown rice and polished rice) sampling at harvest. Nitrogen P, K, Ca, Mg, S, Na, Al, Fe, Mn, Zn, B, and Cu were determined by inductively coupled plasma emission spectroscopy (ICP) after aqua-regia digestion, whereas arsenic, was determined by ICP-MS (mass spectroscopy). Total biomass and panicle weight sampling involved randomly selecting 20 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. Rice milling was accomplished using a Zaccaria PAZ 1 DTA milling machine.

A second field experiment was conducted in Stoddard County on a graded field having the Sharkey soil series. Rice (CL111) was cultured as row (furrow) irrigated rice on 30 inch centers. Nitrogen treatment consisted of 50 lbs/acre ammonium sulfate (10 lbs N/acre) at planting (16 May 2013) and 100 lbs ammonium sulfate (20 lbs N/acre) one week later lbs N/acre. One hundred lbs urea (46 lbs N/acre) was applied at the five leaf stage (10 June 2013). Nitrogen (100 lbs/acre urea or 46 lbs N/acre) was applied at 27

June 2013 and 65 lbs urea/acre (30 lbs N/acre) was applied at green ring (10 July 2013) internode elongation. Harvest was by combine. Rice Tissue testing, biomass assessment to assess nutrient uptake patterns at pre-internodal elongation and at harvest were as performed for the previous experiment. Harvest index was calculated as dry weight of paddy seed relative to dry weight of total plant above-ground biomass. Rice milling was accomplished using a Zaccaria PAZ 1 DTA milling machine.

RESULTS AND DISCUSSION

Soil Profile Distribution of Arsenic

The concentrations of soil As are considered normal for soil environments and there exists no evidence of anthropogenic transition metal addition. The Crowley pedon demonstrates that the sand separate has substantially greater concentrations of arsenic (Figure 1). The sand separate is composed primarily of glabules (indurated masses of Fe and Mn that differ from the soil matrix by the cohesiveness and color). The Sharkey pedon shows a modest arsenic concentration in the near-surface horizons (6 to 8 mg As/kg), whereas the subsurface horizons show smaller arsenic concentrations (3 to 5 mg As/kg) that do not vary appreciably with increasing soil profile depth (Figure 2).

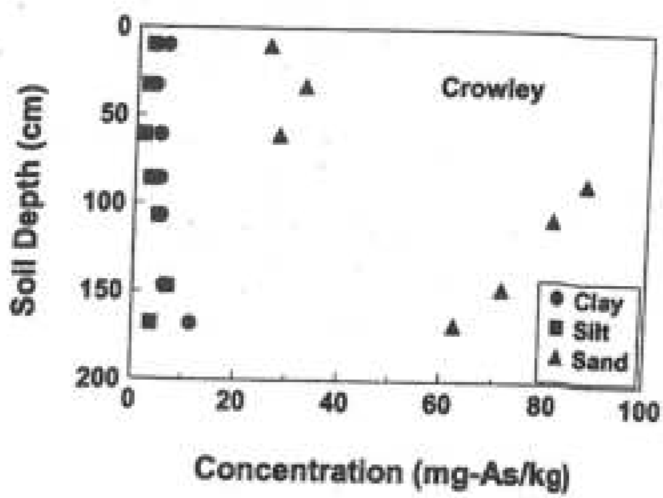


Figure 1. The distribution of arsenic in the Crowley pedon.

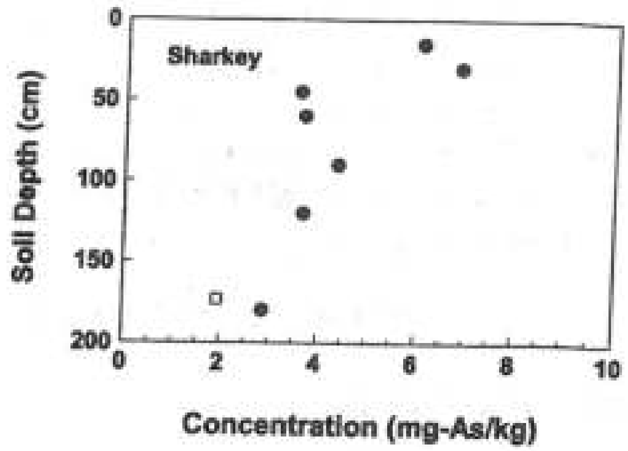


Figure 2. The distribution of arsenic in the Sharkey pedon.

Soil Nitrogen Distribution in the Sharkey Series

The distribution of nitrate and ammonium nitrogen in the Sharkey soil based on position in either the bed or in the furrow (interbed position) (Figure 3) shows differences, based partly on fertilization practices. Starter nitrogen fertilizer was applied as ammonium sulfate on 16 and 27 May 2013, whereas urea (46 lbs N/acre) was applied 10 June 2013 and again on 27 June 2013. Substantial rainfall occurred on 16 May 2013 (1.5 inches) and 10 June 2013 (1.5 to 2 inches). On 7 June 2013, soil sampling revealed that the ammonium and nitrate concentrations were low and little differentiation was observed between the bed and furrow position. On 21 June soil sampling (11 days after urea application) revealed appreciable nitrate concentrations in the bed and furrow positions, with substantially smaller corresponding ammonium concentrations in the bed and furrow positions. The substantial nitrate concentrations in both the bed and furrow positions infer that denitrification was not effective in reducing the nitrate concentrations and this nitrate was available for rice uptake.

On 11 July (1 day after 30 lbs N/acre and 14 days after 46 lbs N/acre application) the nitrate concentrations in the bed position were appreciable and the nitrate concentrations in the furrow position were non-existent. Ammonium concentrations in the bed and furrow positions were appreciable. Given the furrow irrigation in the furrow position, denitrification appears to have depleted the nitrate concentrations in the furrow position (anoxic soil), whereas the bed position was not sufficiently irrigated to permit denitrification (oxic or suboxic soil). On 26 July (8 and 15 days after 30 lbs N/acre application) soil testing showed appreciable nitrate and ammonium concentrations in the bed position and appreciable ammonium concentrations in the furrow position. The nitrate concentration in the furrow positions were depleted, presumably by denitrification from furrow irrigation. The risk of denitrification in furrow irrigated rice is apparent, especially in the furrow position. The key to furrow irrigated rice appears to be repeated ammonium sulfate starter applications followed by a series of urea applications.

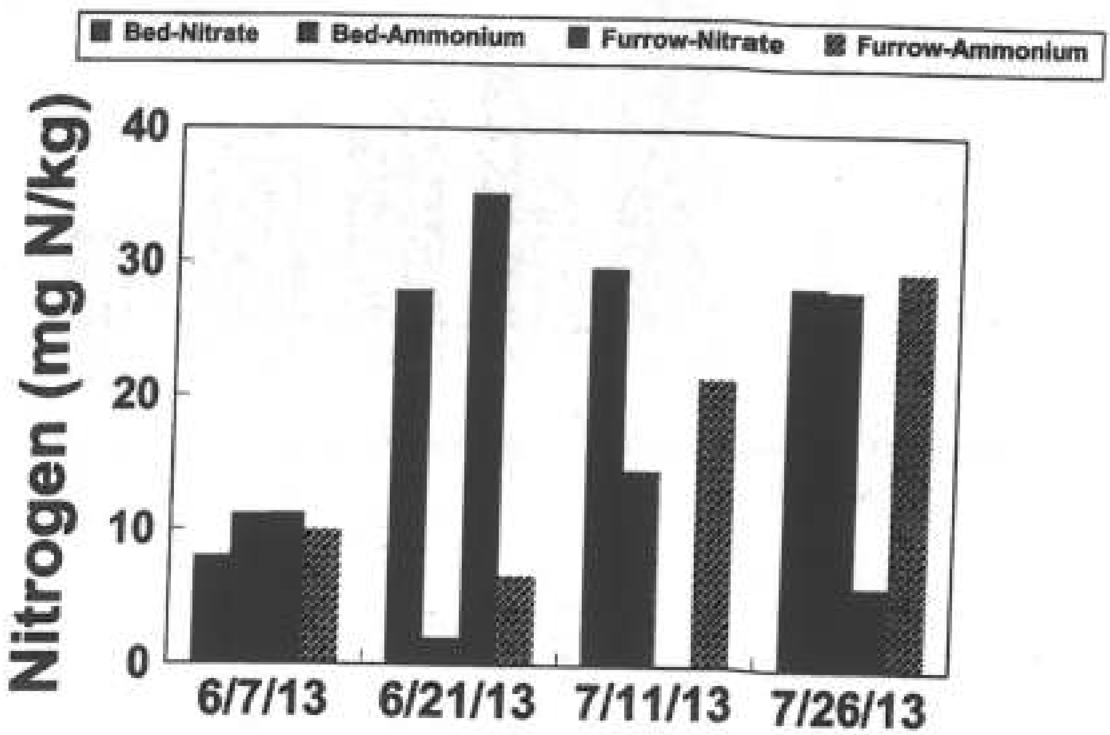


Figure 3. Distribution of nitrate and ammonium concentrations during the growing season for the Sharkey soil.

Rice Tissue Concentration from the Sharkey Furrow Irrigation

Plant tissue analysis demonstrates that the rice plant for the Sharkey series has received adequate nitrogen (Figure 4), phosphorus (Figure 5), and potassium (Figure 6) nutrition. The periodic decline in nitrogen concentrations during the growing season is consistent with normal rice plant development, as nitrogen is transferred to the developing panicles.

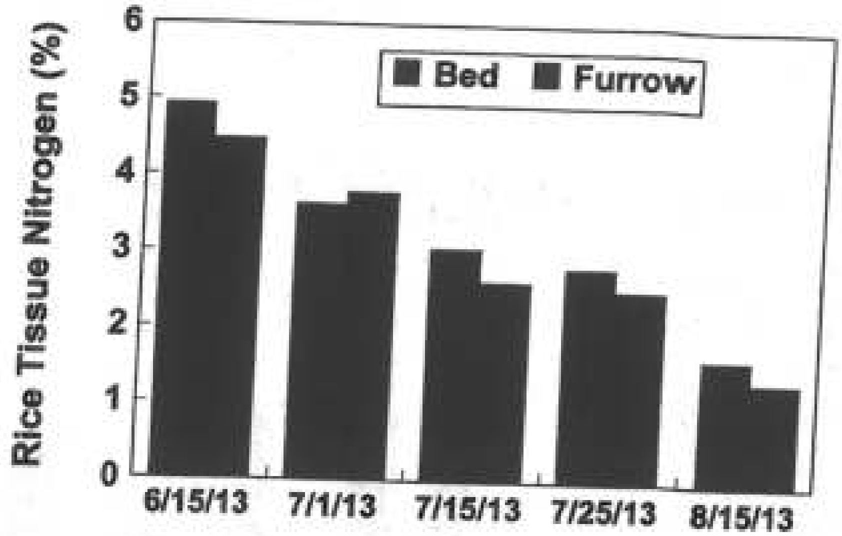


Figure 4. Distribution of rice tissue nitrogen concentrations during the growing season for the Sharkey soil

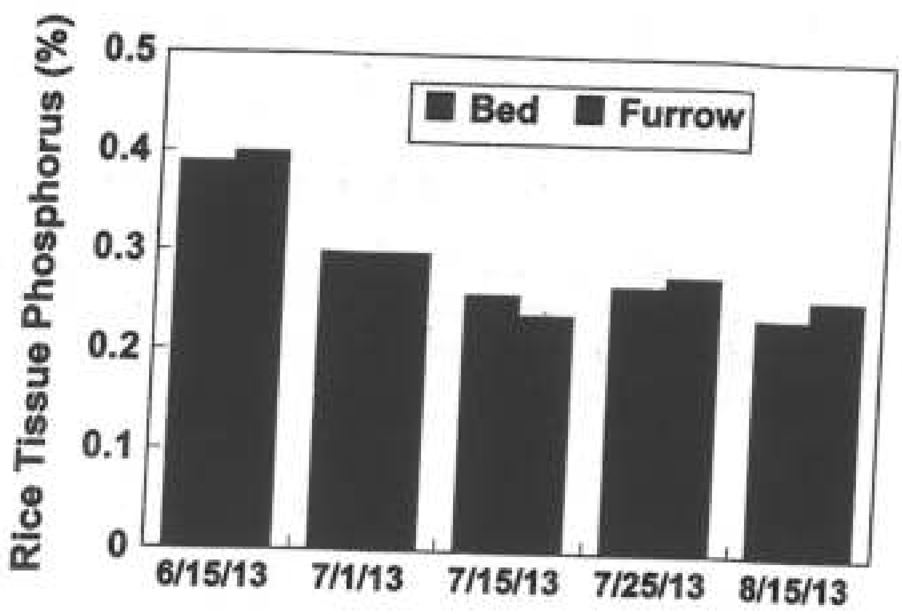


Figure 5. Distribution of rice tissue phosphorus concentrations during the growing season for the Sharkey soil

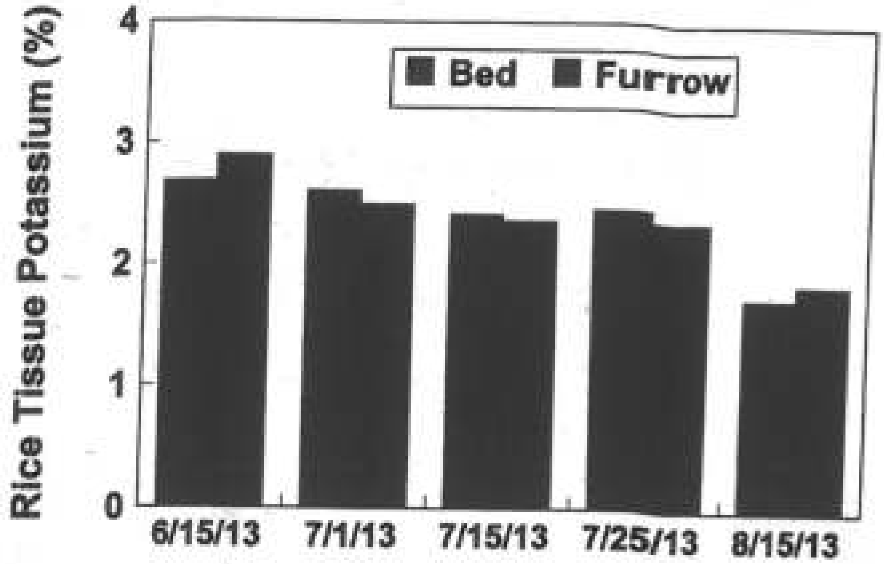


Figure 6. Distribution of rice tissue potassium concentrations during the growing season for the Sharkey soil

The plant tissue concentrations show a small extent of arsenic accumulation ((Figure 7). The higher arsenic concentrations on 15 June 2013 likely are attributed to smaller dry matter accumulation rates in the early portion of the growing season.

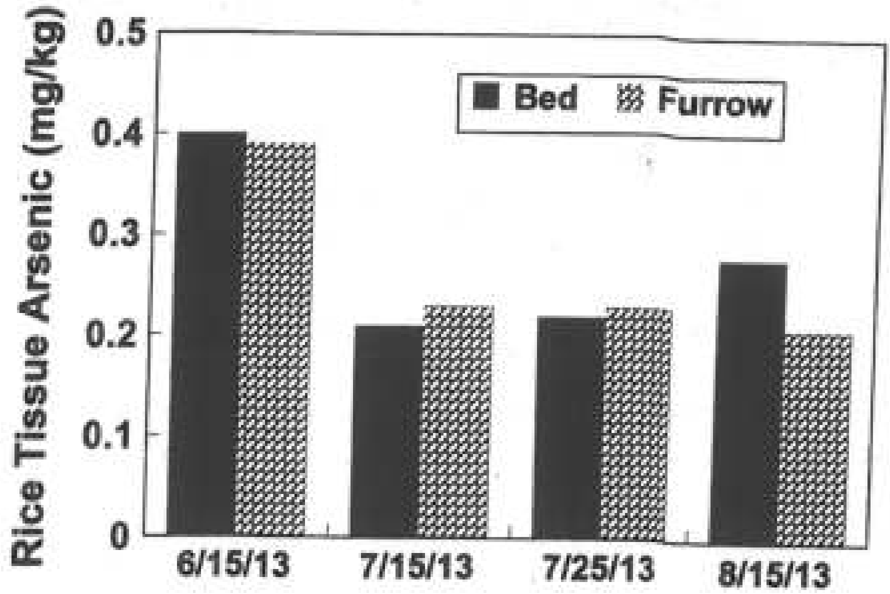


Figure 7. Distribution of rice tissue arsenic concentrations during the growing season for the Sharkey soil

Soil Nitrogen Distribution in the Crowley Delayed-Flood and Furrow Irrigation

The soil nitrate and ammonium concentrations for the drill-seeded delayed-flood and furrow irrigated rice systems on the Crowley series (Figure 8) are small (less than 12 mg N/kg) and likely represent nitrogen depleted systems.

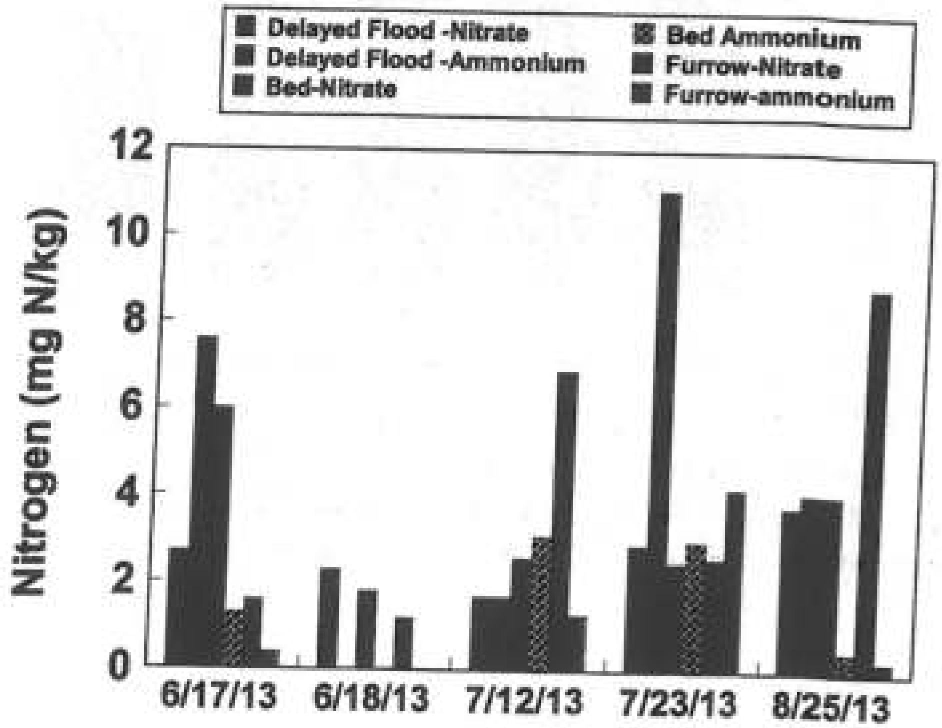


Figure 8. Distribution of rice tissue arsenic concentrations during the growing season for the Sharkey soil

Rice Tissue Concentration from the Crowley Delayed-Flood and Furrow Irrigation

The rice tissue nitrogen and potassium concentrations are low and likely represent mild nitrogen and potassium deficiencies (Figures 9 and 11). The phosphorus concentrations are sufficient and no phosphorus concentration differences attributed to the type of irrigation are evident (Figure 10).The nitrogen concentrations are not statistically different based on sampling date. The overall nitrogen concentrations decline during the growing season, which is consistent with increasing dry matter accumulation rates during the growing season. Rice tissue arsenic levels show substantial to excessive arsenic accumulation in rice vegetation associated with the flood irrigated rice, whereas the drill -seeded delayed-flood has arsenic concentrations near 1 mg As/kg (Figure 12). The furrow irrigated rice has substantially smaller arsenic levels, suggesting the furrow irrigated rice limits As uptake in rice.

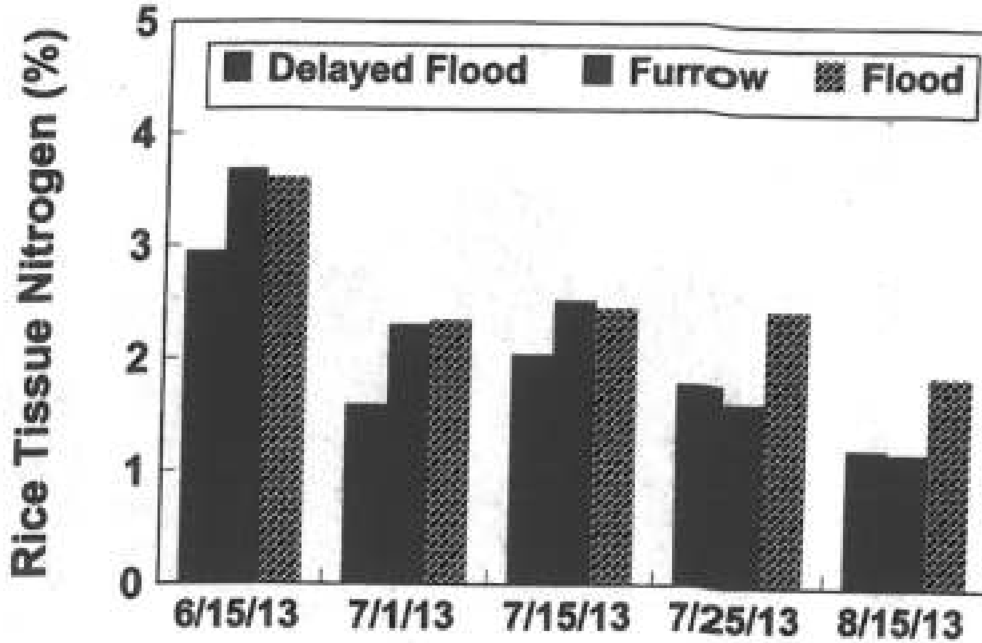


Figure 9. Distribution of rice tissue nitrogen concentrations during the growing season for the Crowley soil

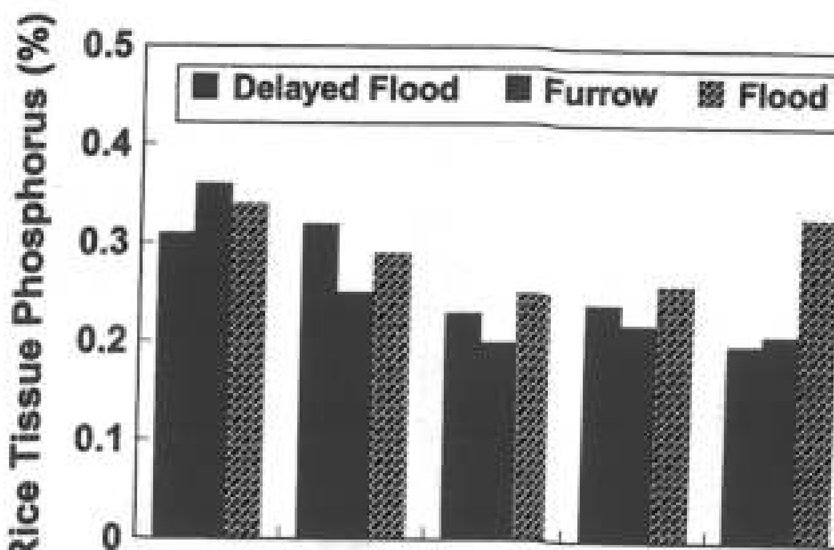


Figure 10. Distribution of rice tissue phosphorus concentrations during the growing season for the Crowley soil

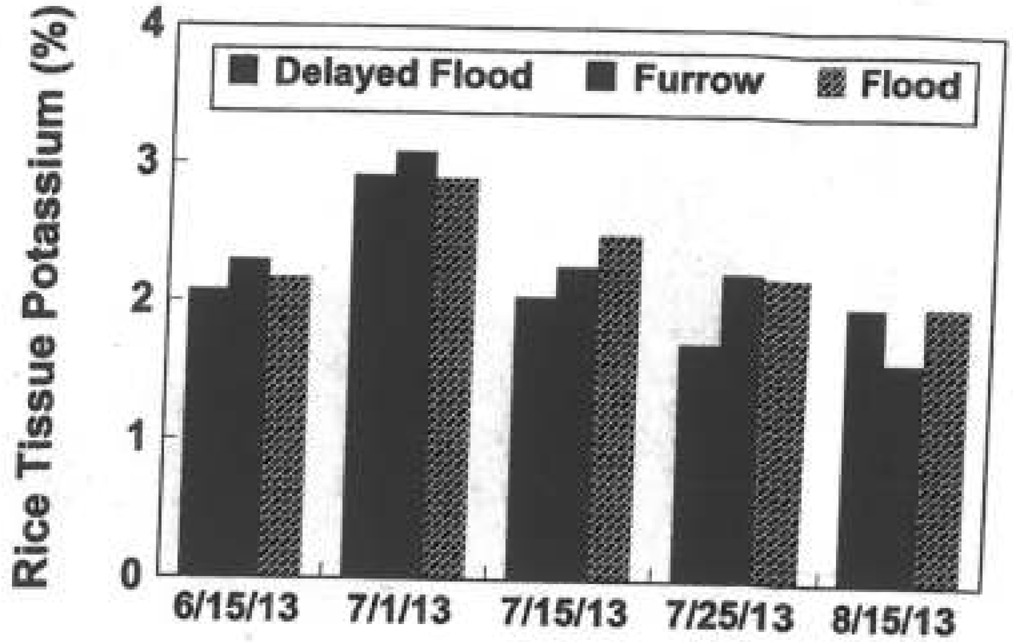


Figure 11. Distribution of rice tissue potassium concentrations during the growing season for the Crowley soil

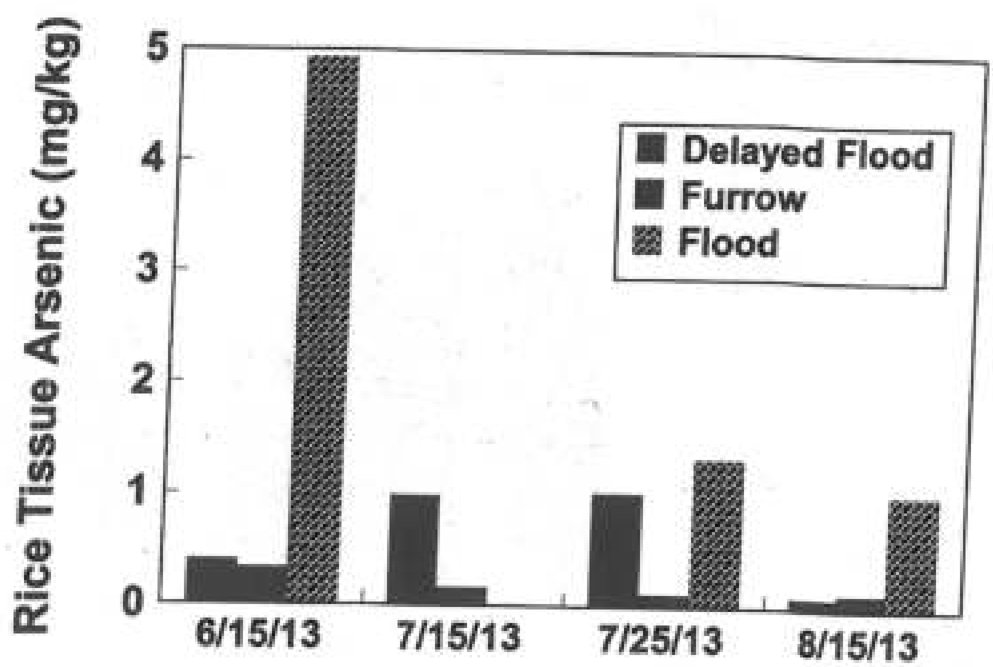


Figure 12. Distribution of rice tissue arsenic concentrations during the growing season for the Crowley soil (the zero value for flood irrigation on 7/15/13 represents no plant tissue sampling rather than zero mg As/kg).

Arsenic Partitioning in the Furrow Irrigation Sharkey Rice (Harvest)

The furrow irrigated rice associated with the Sharkey series exhibits low arsenic concentrations, with the leaf tissue concentrations less than 0.4 mg As/kg. Paddy rice arsenic concentrations were near 0.1 mg As/kg. Cadmium concentrations were greatest for stem material and least for the paddy rice.

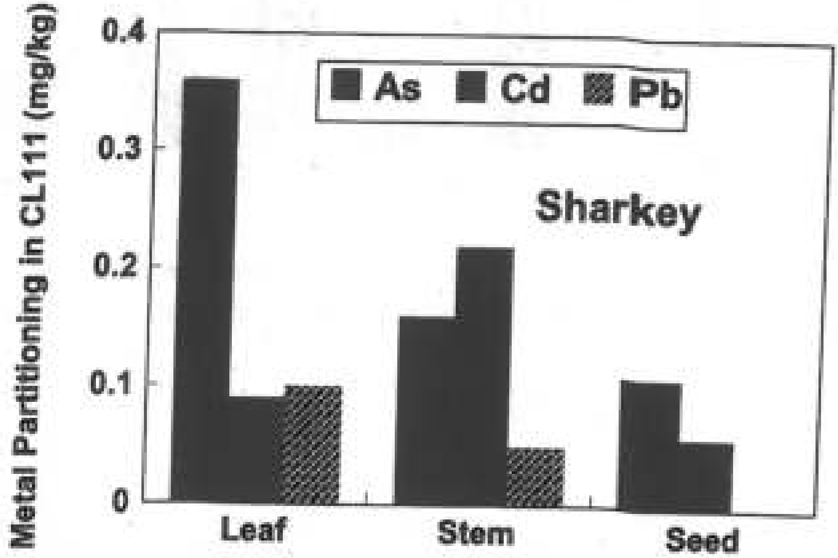


Figure 13. Distribution of metal partitioning of arsenic, cadmium and lead in rice leaf, stem and seed tissues for the Sharkey soil

Arsenic, Cadmium and Lead Partitioning in the Furrow and Delayed-Flood Irrigation on the Crowley Series (Harvest)

The furrow irrigated rice associated with the Crowley series exhibits moderate arsenic concentrations (Figure 14), with the leaf tissue concentrations near 1.3 mg As/kg. Paddy rice arsenic concentrations were near 0.25 mg As/kg (less than 0.1 to 0.40 mg As/kg). Cadmium concentrations were below detection limits. The drill-seeded delayed-flood irrigated rice associated with the Crowley series also exhibits moderate arsenic concentrations (Figure 29), with the leaf tissue concentrations near 1.5 mg As/kg. Paddy rice arsenic concentrations were near 0.4 mg As/kg, greater than the furrow irrigated rice. Cadmium concentrations for the drill-seeded delayed-flood rice were below detection limits.

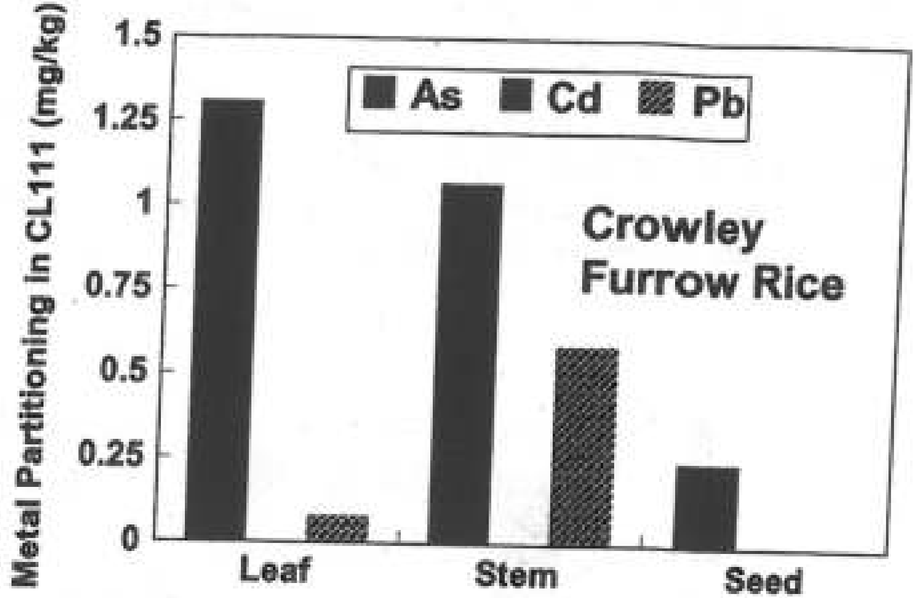


Figure 14. Distribution of metal partitioning of arsenic, cadmium and lead in rice leaf, stem and seed tissues for the Sharkey soil (Furrow irrigated rice)

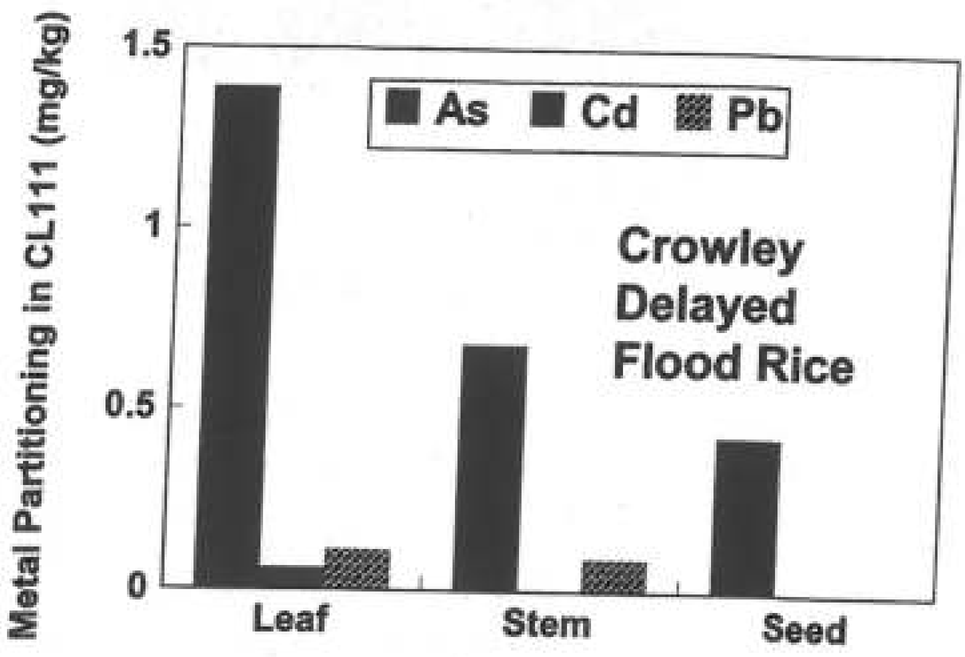


Figure 15. Distribution of metal partitioning of arsenic, cadmium and lead in rice leaf, stem and seed tissues for the Sharkey soil (Drill-seeded, Delayed flood irrigated rice)

Nutrient Distribution between Brown and Polished Rice

The nitrogen (Figure 16), phosphorus, and potassium concentrations in brown and polished rice show little differences attributed to milling for nitrogen and substantial reductions in phosphorus and potassium in polished rice.

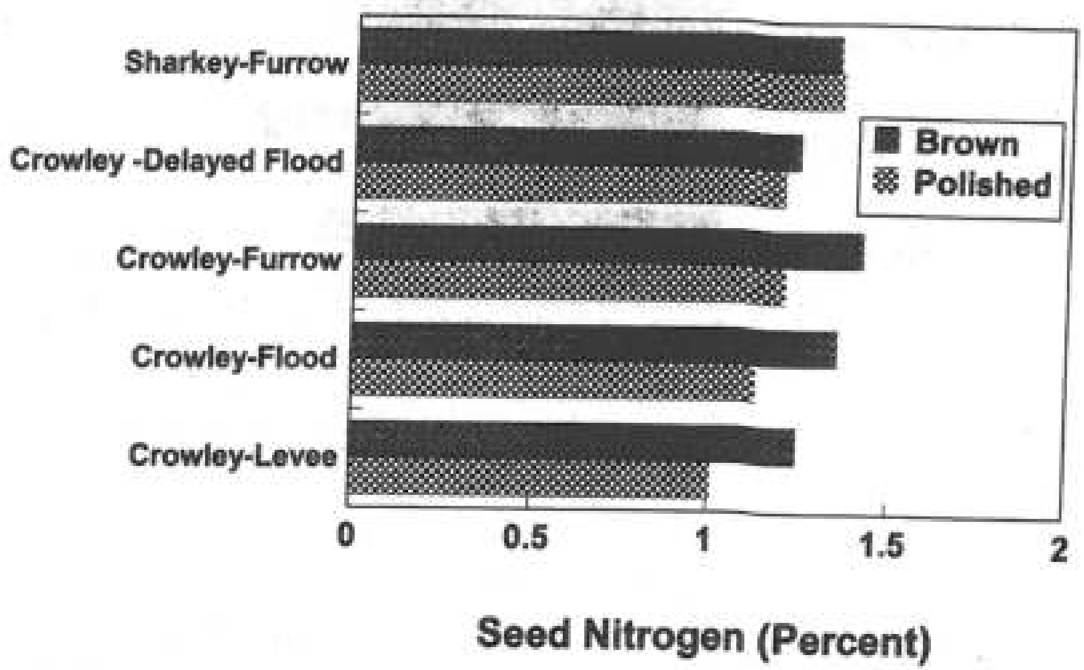


Figure 16. Distribution of nitrogen between brown and polished rice

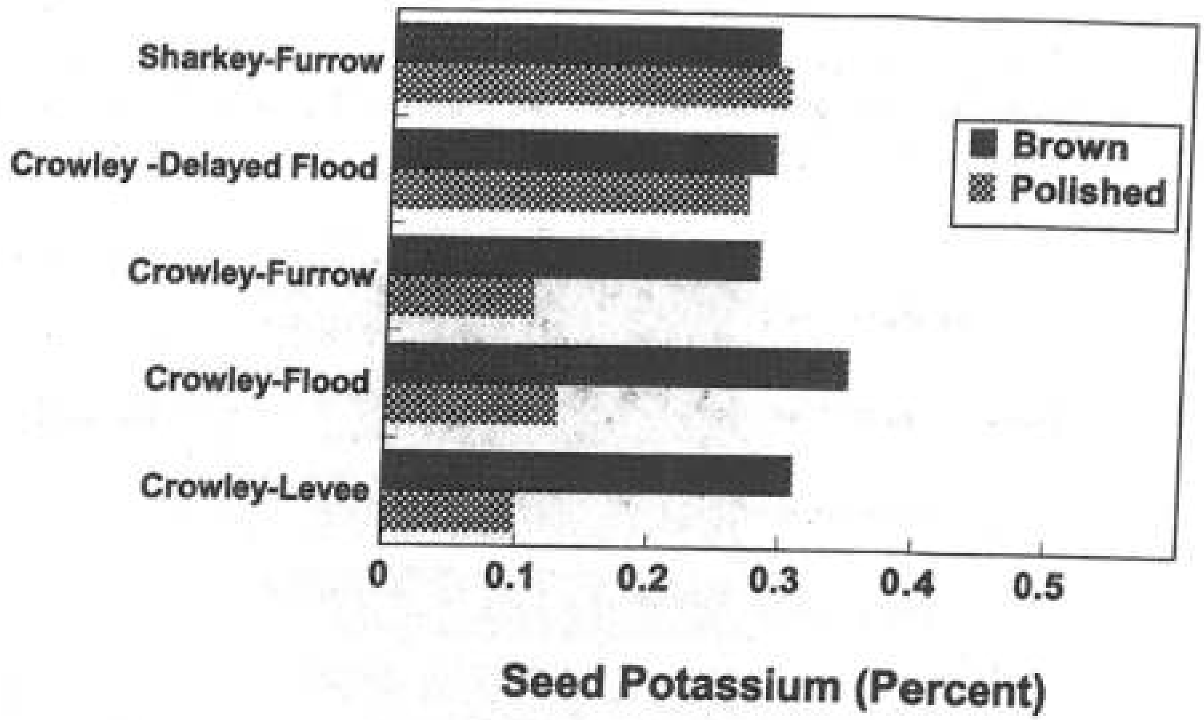


Figure 17. Distribution of potassium between brown and polished rice

Arsenic concentrations for dehulled rice (brown and polished (white)) rice (Figure 18) exhibit significant differences between furrow irrigated and delayed flood irrigated rice systems. The Crowley and Sharkey soils both exhibit more than 0.2 mg As/kg) for both brown and polished rice. Conversely, furrow irrigated rice demonstrates As concentrations below detection limits (less than 0.1 mg As/kg). Cadmium concentrations for the delayed flood systems were below detection limits (0.05 mg Cd/kg), whereas Cd concentrations for the furrow irrigated systems were 0.8 mg Cd/kg for the Sharkey series and below detection limits for the Crowley series.

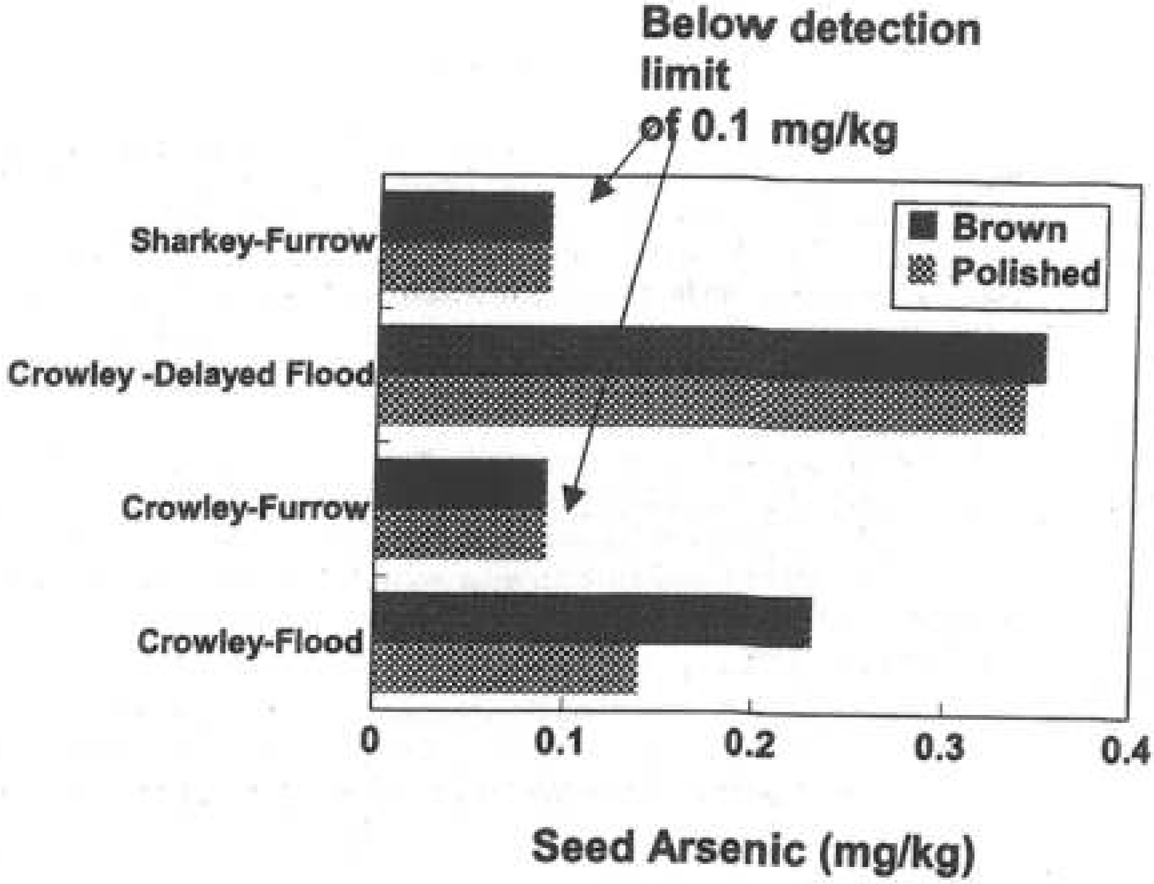


Figure 18. Distribution of arsenic between brown and polished rice

SUMMARY

- Furrow irrigated rice yielded (field combine average of 162 Bu/A on Sharkey clay) similar to the Crowley drill seeded delayed flood irrigation system,
- Furrow irrigated rice requires a new look at nitrogen fertilization in terms of fertilizer timing, sources (ammonium sulfate versus urea, and amounts) to minimize nitrogen losses attributed to denitrification.
- Furrow irrigated rice has the potential to dramatically reduce arsenic uptake relative to drill seeded, delayed flood irrigation.

The 2013 Effect of Planting Date on Rice Varieties
Donn Beighley

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: April 5, April 10, May 2, May 10, and June 5. At each planting date there were 12 varieties that represent the major rice varieties grown in southeast Missouri as well as seven experimental varieties. The released varieties were: Bowman, Cheniere, CL152, Francis, Jupiter, Presidio, Roy J, Taggart, and four experimental lines.

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, Tim Walker – MSU, Stoneville, MS, Dante Tabian – TAMU, Beaumont, TX, 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. The fertilizer was applied at a rate of 90 lbs N preflood with 40 lbs N midseason application. The flood was maintained throughout the growing season. There was an application of Karate Z was made for a stinkbug infestation. 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 2013 all of the planting dates were harvested for yield; however the May 10 planting date experienced stand problems due to untimely rainfall and bird predation. The early April planting had the highest yields at 213 Bu/A followed by the mid-April, early May, and early June planting dates. At the April 5 date the top yielding lines were Taggart, Jupiter, and Francis. The April 10 date top yielding lines were Roy J, Mo0125035, and Jupiter. The May 2 top yielding lines were RU0002146, Roy J, and Jupiter. The June 5 date top yielding lines were Mo0125035, RU0202195, and Mo0302002. The highest yielding variety across dates was the experimental Mo0215035 at 216 Bu/A followed by Jupiter and Roy J. Tables 1and 2.

The percent whole rice yield values ranged from 75 / 69 on April 5 to 73 / 66 planted on May 2. Table 1. Across varieties CL152 (75 / 70) had the highest average milling quality and Mo0125035 had the lowest average (72 / 64). The trend usually appears to be that the medium grain varieties have the highest milling values across all planting dates but not in 2013. This was observed in 2012 also.

The number of days from planting to emergence ranged from 22 days at the April 5 planting date to 7 days at the June 5 planting date. Table 1.

Across planting dates the average number of days to 50% heading ranged from 82 days at June 5 up to 102 days planted April 5 (Table 1). A similar trend was observed within varieties. RoyJ had the longest average period between emergence and 50% heading date (101 days) while Cheniere had the fewest (92 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 low with most all plots having less than 10 percent.

Summary

The early April planting date continues to result in the higher yields and milling quality values. Roy J and Jupiter both appear to be better yielding released rice varieties. Roy J has performed well across years.

Across planting dates Jupiter, Mo0215035, and Roy J were the most stable yielding lines across the four harvested dates. Francis, Taggart, and Roy J had the best average whole grain milling quality scores.

Table 1

2012 Planting Date Agronomic Trait Averages							
Planting Date	Days to Emer-gence	Days to 50% Head-ing	Plant Height (Inches)	Lodg-ing (Percent)	Bush-els / Acre	Per-cent Total Rice	Per-cent Whole Rice
Early April	22	102	40	1	213	75	69
Mid April	20	96	38	1	202	74	67
Early May	13	86	38	1	183	73	66
Early June	7	82	36	1	159	74	67
Across Planting Dates	16	91	38	1	189	74	67

Table 2

2013 Variety Trait Averages Across Three Planting Dates								
Entry	GT	Days to Emer-gence	Days to 50% Head-	Plant Height (Inches)	Lodging (Percent)	Bu / A	Percent Total Rice	Percent Whole Rice
Bowman	L	19	95	37	1	152	74	65
Cheniere	L	19	92	36	1	167	75	68
CL152	L	18	97	37	1	173	75	70
Francis	L	18	96	37	1	185	75	68
Jupiter	M	20	92	35	1	210	71	66
Presidio	L	17	92	36	1	174	75	66
Roy J	L	18	101	40	1	203	74	67
Taggart	L	18	99	32	1	194	75	68
Mo0215035	M	19	94	36	1	216	72	64
Mo0302002	L	17	95	36	1	193	75	69
RU0002146	M	21	95	37	1	203	73	66
RU0202195	L	17	94	37	1	200	75	69

2013 Missouri Rice Variety Performance Trials

Donn Beighley, Gene Stevens, Matt Rhine, Jim Heiser, and Nathan Goldschmidt

In 2013 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.

Methodology

Rice plots were planted at five locations in 2013: the Missouri Rice Research Farm near Glennonville, MO, at the UM Delta Center Farm at Portageville, MO, and the Campbell Farm near Qulin, 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 April 10, May 20 and May 20, respectively on a Crowley silt loam. The plots at the UM Delta Center were drill seeded on May 16 on Sharkey clay and under the center pivot area on May 8. The trial planted at Campbell Farms was planted on May 15. The trial consisted of 32 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 three replications. Plots at the MO Rice Farm were planted with an Almaco no-till plot drill at the Missouri Rice Farm. The plots at the Delta Center (Sharkey clay and center pivot) were 16 feet long and planted with a Hege planter. The Campbell Farm plots were 12 feet long and planted with a Hege planter. The water seeded plot size was 12 foot long by 4.4 feet wide and seeded by hand.

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; Tim Walker – MSU, Stoneville, MS, and Horizon Ag.

Pre-flood fertilizer was applied at a rate of 90 lbs N with 40 lbs N applied midseason on the drill seeded at the MO Rice Farm. 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 was an application of Karate Z was made for a stinkbug infestation. 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.

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. 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 Southeast - Malden

Results

All of the 2013 Missouri Rice Variety Trials were taken to completion though due to high variability of the data the water-seeded and center pivot data were not included in this report.

The average yields were as follows: (MO Rice Farm) conventional drill test– 202 Bu/A, continuous drill seeded – 155 Bu/A; Campbell Farms – 180 Bu/A, UM Delta Center clay – 187 Bu/A.

Differences among long grain varieties were observed. The top yielding line across all trials was CL151 (212 Bu/A), Roy J, and Mo0302002. In the conventional drill-seeded trial at the Missouri Rice Farm – RU0801081 (238 Bu/A) followed by CL151 and Taggart. The top yielding line in the continuous rice drill seeded trial was CL151 (235 Bu/A) followed by CL111 and Roy J. The top yielding line on the Campbell Farm was Roy J (260 Bu/A) followed by RU0801081 and Taggart. The top yielding line on the UM Delta Center clay was Antonio (215 Bu/A) followed by Mo0302002 and MoLA260490. Table 1.

Across 2011-2013 at all locations Francis (161 Bu/A) followed by Mo0318016 and RU0202195. Table 3.

The top yielding medium grain line across all trials was Mo0215035 (202 Bu/A) followed by RU0902162, and Caffey. RU0902162 (237 Bu/A) was the top line in the Missouri Rice Farm conventional drill-seeded trial followed by Caffey and Mo0215035. Mo0215035 (161 Bu/A) was the top line in the Missouri Rice Farm continuous rice drill seeded trial followed by RU0902162 and Jupiter. Caffey (214 Bu/A) was the top yielding line on the Campbell Farm followed by Jupiter and RU0902162. Mo0215035 (184 Bu/A) was the top yielding line on the UM Delta Center clay followed by RU0002146 and Jupiter. Table 2.

Across years Mo0215035 (175 Bu/A) yielded the best followed by Jupiter and RU0002146. Table 3.

Among the aromatic rice varieties (Della-2 and Jazzman 2) there were no yield differences observed (144 Bu/A). Table 1.

Days to 50% heading was taken at the MO Rice Farm trials and Campbell Farms. In the water-seeded trial (69 days), conventional drill seeded (98 days), continuous rice drill seeded (98 days), and Campbell Farms (79 days). The average number of days to 50% heading observed for the varieties in the combined trials ranged from 81 days for Colorado to 91 days for Taggart. Table 1 & 2.

The 2012 average plant heights across locations were 37 inches. Individual location plant heights were: Water-seeded (34 inches), continuous rice drill seeded (37 inches), conventional drill seeded (37 inches), UM Delta Center clay (40 inches) and Campbell Farms (37 inches). Table 1 & 2.

There was very little lodging at any of the locations.

Average percent milling quality values across all trials was 72 /62. The conventional drill seeded trial (70 / 63), water-seeded averaged (72 / 58), continuous drill seeded (69 / 52), UM Delta Center clay (74/65), and Campbell Farms (73 / 66). Table 1 & 2.

Rice Disease Data

No significant disease symptoms were observed in 2013 other than the Brown Spot under the center pivot and some smut in other tests.

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, CL111, Jupiter and Caffey. In recent years the best released lines have been CL151, Roy J, and Jupiter.

Growing conditions in Missouri continue to provide an environment for high milling quality.

Table 1.

2013 Rice Variety Trial Agronomic Data - Long Grain

Variety	Days to 50% Heading	Plant Height (Inches)	Lodging (Percent)	Bushels Per Acre	Pounds Per Acre	Percent Total Rice	Percent Whole Rice
Antonio	84	37	1	172	7718	74	66
Bowman	89	37	1	170	7644	71	60
Cheniere	84	36	1	170	7643	71	59
CL111	82	37	1	154	6941	71	57
CL151	83	36	1	190	8551	71	62
CL152	84	37	1	144	6464	72	62
Colorado	81	37	1	143	6450	71	56
Francis	85	39	1	172	7760	72	60
Mermentau	85	37	1	174	7837	72	62
Presidio	84	33	1	145	6535	73	60
Roy J	90	40	1	186	8356	73	62
Taggart	91	40	1	176	7938	71	57
Templeton	89	41	1	160	7196	71	57
Wells	88	39	1	159	7160	71	49
RU0202195	85	36	1	169	7620	73	64
Mo0318016	87	39	1	165	7418	72	62
Mo0302002	85	37	1	174	7843	72	62
Mo-LA260490	83	33	1	146	6579	73	60
Mo-LA281519	88	36	1	149	6683	72	62
Mo0238681	85	36	1	150	6757	72	61
Mo0239718	86	37	1	150	6737	72	62
Mo-LA249469	81	35	1	154	6949	72	62
RU0903190	88	38	1	165	7405	72	59
RU1004157	86	37	1	157	7053	71	58
RU0801081	85	39	1	174	7837	73	60
Della-2	87	37	1	144	6478	70	59
Jazzman 2	87	40	1	144	6484	71	60

Table 2.

2013 Rice Variety Trial Agronomic Data - Medium Grain

Variety	Days to 50% Head-ing	Plant Height (Inches)	Lodg-ing (Percent)	Bushels Per Acre	Pounds Per Acre	Percent Total Rice	Percent Whole Rice
Caffey	87	38	1	175	7869	70	60
Jupiter	86	38	1	184	8277	69	62
RU0002146	88	40	1	169	7612	71	64
Mo0215035	86	37	1	180	8100	70	65
RU0902162	87	36	1	176	7935	71	59

Table 3

Missouri Multiple Year Yield Data (Bu/A)

Entry	2011	2012	2013	2012-2013	2011-2013
Cheniere	134	152	187	169	157
CL111	154	135	171	153	153
CL151	104	150	212	181	156
CL152	143	147	162	155	151
Francis	159	132	192	162	161
Roy J	76	144	205	175	142
Taggart	108	137	195	166	147
Templeton	134	135	178	156	149
Wells	147	152	176	164	158
RU0202195	161	133	184	159	159
Mo0318016	154	139	187	163	160
Caffey	134	132	191	161	152
Jupiter	122	159	198	178	159
RU0002146	144	146	182	164	157
Mo0215035	161	161	202	182	175

Variable Nitrogen Rate Trial

Donn Beighley

In 2013 the Variable Nitrogen Rate Trial (VNRT) was initiated to deter the best nitrogen rates for rice varieties being released by the Missouri Rice Breeding Program. The experimental rice lines included those also planted in the Missouri Rice Variety Trial (MORVT) as well as two released lines – Roy J and Jupiter. The goal was determine the best nitrogen practices for each experimental line testing both a pre-flood treatment at various N rates and a pre-flood treatment at the various N rates plus a midseason N application. The pre-flood treatments were 90 lbs N, 120 lbs N, 150 lbs N, and 180 lbs N. The midseason N application was 30 lbs N.

Methodology

Urea was the fertilizer used in this trial. The pre-flood treatment was applied using a Gandy drop fertilizer cart calibrated to either a 90 lbs, 120 lbs, 150 lbs, or 180 lbs N rate. The midseason treatment was applied using a handheld broadcast spreader into which was added a previously weighed N sample for each individual plot. This method was used to increase the accuracy of the N applied in this manner.

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 Table 1.

Yield

When evaluating the average yield across all varieties results indicate the optimum fertilizer rate was 150 lbs N pre-flood plus 30 lbs N applied midseason (150+ lbs N) followed by 150 lbs N only. In only one case was the optimum fertilizer rate similar to the 150 + lbs N – Roy J with 120 lbs N pre-flood with 0 lbs N midseason. It was observed that applying the midseason N did not increase yields except at the 150 lbs treatment. It was observed that yields did decrease significantly past the 150 lbs treatments by an average of 35 Bu/A.

Days to 50% Heading

It is commonly thought that increasing N rates has a tendency to delay days to 50% heading. In this trial it was observed that there was a one day increase in days to 50% heading when the N rate increased from 120 lbs N treatments to 150 lbs N treatments. And that in some cases there was a decrease in days to 50% heading with an increase from 150 lbs N treatment to 180 lbs N treatment.

Percent Whole Rice

With percent whole rice being a factor in the price of rice, both percent total rice and percent whole rice milling quality values were determined. The best percent whole rice was at 90 lbs N pre-flood and 120+ lbs N midseason. There was not much difference in percent whole rice values until one looks at the 180 lbs N treatment results; at that rate there was a three percent decrease in whole rice across all treatments to include the pre-flood and the midseason applications.

Lodging

A concern by many rice producers is that as they increase N rates the potential for lodging increases. In this case it was not observed to be the case except for RU0002146, which did have higher rates of lodging as the N rates increased.

Conclusion:

The application of 150 lbs N pre-flood plus 30 lbs N midseason appears to be the optimum N fertilizer rate across six rice varieties. Further testing will be conducted to confirm these results.

Table 1.

Variable Nitrogen Rate Trial

Bushels Per Acre	90 lbs N	120 lbs N	150 lbs N	180 lbs N
Test Avg.	243	268	293	258
Pre-Flood Avg.	244	269	289	256
Pre-Flood + Midseason Avg.	243	267	297	260

Days to 50% Heading	90 lbs N	120 lbs N	150 lbs N	180 lbs N
Test Avg.	99	99	100	100
Pre-Flood Avg.	99	99	100	100
Pre-flood + Midseason Avg.	99	99	100	99

Percent Whole Rice	90 lbs N	120 lbs N	150 lbs N	180 lbs N
Test Avg.	63	63	62	59
Pre-Flood Avg.	64	62	63	58
Pre-flood + Midseason Avg.	62	65	61	59

Percent Lodging	90 lbs N	120 lbs N	150 lbs N	180 lbs N
Test Avg.	4	3	10	14
Pre-Flood Avg.	4	1	11	14
Pre-flood + Midseason Avg.	4	4	9	14

The Effect of Silicate Amendments on Rice Yield Performance

Donn Beighley

Due the interest in determining ways to reduce rice grain arsenic levels using silicate compounds and the purported effect of silica on yield in other crops; a study was undertaken to determine the effect of silica on rice yields. These are the preliminary results of this study.

Methods:

This study was conducted at two locations: The Missouri Rice Research Farm (Dubbs silt loam) and the UM Delta Center Pivot (Tiptonville silt loam). Nine rice lines were tested – RU1305001, RU1305178, RU1305187, RU1305155, CL111, CL151, CL152, CL142AR, and Wells.

The Missouri Rice Research Farm trial was planted on April 10. Fertilization included a pre-flood application of N (90 lbs per acre) plus a midseason application of N (30 lbs per acre) and a midseason application of calcium silicate (445 lbs per acre) to half of the yield trial plots. The plots were harvested using an Almaco plot combine.

The UM Center Pivot location was planted on May 8. Fertilization included a first tiller application of N at 151 lbs per acre and calcium silicate application at 455 lbs per acre. The plots were harvested using a Kincaid combine.

Agronomic traits data were taken throughout the growing season to include emergence date, 50% heading date, plant height (inches), lodging percent, and yield (Bu/A). In addition milling quality – percent total rice and percent whole rice were determined at the Southeast – Malden Rice Lab.

Results:

At the Missouri Rice Farm it was observed that the addition of the calcium silicate at midseason resulted in a seven bushel per acre increase across varieties. The fertilization with calcium silicate at planting at the UM Delta Center Pivot trial resulted in a 14 bushel per acre decrease in yield across varieties.

The effect of the calcium silicate fertilizer on days to 50% heading was negligible across varieties at the Missouri Rice Farm however in the UM Delta Center Pivot location it was observed an average of five additional days necessary to reach 50% heading.

There were no measureable differences in plant height between a calcium silicate application and no calcium silicate application at both locations.

The milling quality results for percent whole rice showed a decrease of two percent from silicate to no silicate application at the Missouri Rice Farm. At the UM Delta Center Pivot trial there was no observable difference across rice varieties.

Table 1.

Agronomic Trait	Missouri Rice Farm Silica	Missouri Rice Farm No Silica	Missouri Rice Farm Difference	UM Center Pivot Silica	UM Center Pivot No Silica	UM Center Pivot Difference
Bushels Per Acre	256	248	7	162	176	-14
Days to 50% Heading	97	98	-1	98	93	5
Plant Height (Inches)	40	41	-1	32	33	-1
Percent Whole Rice	68	69	-2	68	68	0

New Technologies and Options in Rice Weed Control

Jim Heiser

New Technology on the Horizon

As compared to other crops, rice trails behind in the development of new technologies and herbicide options. This is because of the limited number of producers to which to sell a new product and few acres to apply new products. In other words, there is less to be gained from developing a rice only product than development of a technology that benefits corn growers. However, two new products may prove to be very beneficial and worth the wait for rice growers.

Pending testing and approval, benzobicyclon, an HPPD inhibitor from Gowan may be available as early as 2015. This would be a new mode of action, and the first HPPD inhibitor, for use in rice. In LSU studies, this product has shown excellent control of aquatic weeds such as ducksalad, on yellow nutsedge, hemp sesbania, and Indian jointvetch. Control of barnyardgrass is fair and sprangletop control looks promising in limited Missouri research. Control can be slow especially on hemp sesbania. The depth of flood also plays an important role in the activity of this compound. Greenhouse studies showed virtually no control when applied to dry soil. Control was better when a flood was applied soon afterward. Control generally increased as the flood was increased in depth from 2 to 6 inches (McKnight, et al. 2012). For this reason, this product will probably be marketed toward water seeded rice growers or as an early post-flood option to control aquatics, sedges and sprangletop. Testing of benzobicyclon in Missouri has targeted smallflower umbrella sedge and Amazon sprangletop.

Additional smallflower umbrellasedge control studies in Missouri during the 2013 season were inconclusive as cultural practices provided very good control of a population that proved difficult to manage in 2012. These studies focused on currently available herbicides. We plan to continue evaluations in 2014 as some of the cultural practices employed for control may not be achievable during wetter growing seasons. We will be working with the Missouri Rice Research and Merchandising Council and Gowan Company to determine the best practices for utilizing this potential new tool and combating this difficult weed.

A second technology which is just beginning the testing process is Provisia® rice from BASF. This is a non-GMO herbicide tolerant rice similar to Clearfield® but will be utilizing ACCase inhibitors for the control of grass weeds only. At this time, it is unclear what herbicide(s) will be utilized with this system. Launch is expected toward the end of the decade.

Upcoming Research

We plan to conduct several trials with the MRRMC this year. Our focus will be to continue looking for control options with experimental and current herbicides for the control of smallflower umbrellasedge, amazon sprangletop, and Pennsylvania smart-weed. We are also looking at carryover injury potential of fomesafen (Reflex, Flexstar, etc.) on rice following application in soybeans the previous year. Additionally, we plan to conduct several industry trials to evaluate potential new products and uses for older products to help you combat weed problems.

Silicon and Lime as Amendments to Reduce Arsenic in Rice Grain

Gene Stevens, David Dunn, and Matthew Rhine

Introduction

Arsenic (As) and silicon (Si) react almost identically in the 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 form +2 releasing As and Si into solution where they can be taken up by rice roots (Smith et al, 1998). For this reason, tissue Si and As content are usually higher in rice than crops such as corn and wheat.

Silicon promotes rice yield while arsenic is detrimental. In rice, Si promotes disease resistance and helps plants withstand stresses such as salinity and dry soil (Matoh et al., 1985; Nolla et al., 2012). Conversely, arsenic 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 (Ma et al., 2008).

Two proven methods to significantly reduce As in rice grain are silica fertilization and growing rice without flooding (Seyfferth and Fendorf, 2012; Li et al., 2009; Spanu et al., 2012; Norton et al., 2009). Recent research showed that As in rice grain was reduced by applying soluble silica fertilizer. Si competes with As ions for root entry points (Seyfferth and Fendorf, 2012). Liming can help depending on what species of As is present. Raising soil pH decreases arsenate adsorption by iron but increases arsenite, As[III], adsorption (Mahimairaja et al., 2005). Lime and calcium silicate from steel mill slag reduced As in radishes grown in contaminated soil (Gutierrez et al., 2010).

At the Delta Center Soil Lab, low yielding rice grown in 2012 with center pivot was Si deficient. In 2013, we began a study to evaluate available silicon fertilizer sources. The objective of this project is to evaluate the effect of irrigation treatments (aerobic and continuous flooding) and soil amendments of calcium silicate (CaSi) fertilizers on yield and arsenic content of rice grain in Southeast Missouri.

Materials and Methods

These experiments were conducted at three locations: a Tiptonville silt loam (Fine-silty, mixed, superactive, thermic Oxyaquic Argiudolls) in Portageville, MO, a Dubbs silt loam (Fine-silty, mixed, active, thermic Typic Hapludalfs) at Qulin, MO, and a Sharkey clay (Very-fine, smectitic, thermic Chromic Epiaquerts) at Hayward, MO. RiceTec hybrid CLXL745 was planted at 28 kg ha^{-1} at all three locations, with two additional cultivars (Jupiter and CL151) planted at 100 kg ha^{-1} in Hayward, MO to determine if any cultivar differences could be found for As uptake.

At planting, fertilizer treatments including three rates of calcitic lime, three rates of dolomitic lime, and five rates of calcium silicate were applied to bare soil. Nitrogen was applied at first tiller at a rate of 170 kg ha^{-1}. Irrigation treatments varied by location. The Portageville location was sprinkler irrigated, while the Qulin location was flood irrigated at first tiller. The Hayward location had separate flood and flushed (aerobic) treatments. Three additional treatments of potassium silicate were applied at rice boot stage. Pre-harvest whole plant samples were taken and separated for analysis of arsenic (grain) and silicon (leaves and stem) concentrations. Silicon was analyzed using the University of methodology (Elliott and Snyder, 1991), while As was measured using ICP-MS analysis. Plots were harvested at the end of the season for crop yield.

Results

Silicon samples of aerobic rice at Portageville, MO showed an increase in tissue Si as CaSi rate increased (R2 = 0.8666; Figure 1). Silicon concentrations in flooded rice were much higher than aerobic treatments, ranging from 62750 to 73375 mg Si Kg^{-1}. However, silicon content of flooded rice tissue was not significantly different among treatments compared to the untreated check. University of Florida recommends Si fertilization for tissue samples with less than 34,000 mg Si kg^{-1} (10), which explains why significant differences could be found on aerobic rice, which was deficient of Si, but not flooded rice.

In Qulin, MO, arsenic concentrations of flooded brown rice were significantly reduced following applications of 1000 and 2000 kg Si ha^{-1} compared to untreated checks (P = 0.05; Table 1). Grain As was not reduced from applications of 500 or 1500 kg ha^{-1} on this soil.

Grain As was significantly lower in aerobic rice grown at Portageville, MO compared to flooded rice. However, no significant differences in grain As could be found due to silicon fertilization.

In Hayward, MO, As concentrations of flooded rice were significantly lower than flooded rice at Qulin, MO. Analysis of three cultivars showed no significant difference in grain As, although cultivar CL151 showed numerically reduced As concentrations (Table 2). No significant difference was found due to silicon fertilization in either irrigation system (Table 3).

No significant differences in grain yield could be found among treatment application rates for any location (Table 4). Grain yield of aerobic rice at Portageville, MO was found to be numerically higher with all fertilizer amendments compared to the untreated check. Yield increases ranged from 107 to 1965 kg ha^{-1}. Grain yield of rice in Qulin, MO showed no significant increase from fertilizer amendments. Given that tissue samples on untreated flood rice were found to have sufficient Si, increases in yield were not expected. Also, these fertilizer amendments take time to break down in the soil, meaning that plots may not have fully utilized the applications. These plots will be maintained for two more years to see if any subsequent differences can be found.

When averaged across fertilizer rates, significant differences in grain yield were found at both Qulin and the flooded Hayward location due to the type of fertilizer applied (Table 5). In both cases, the highest yielding treatment came from the addition of dolomitic lime. On the aerobic site at Portageville, MO, the addition of CaSi improved yields by 1109 kg ha^{-1}, although this increase was not statistically significant.

Conclusions

Although these fertilizer amendments did not significantly increase grain yield, their potential effect on As concentrations may prove to have merit on flooded fields. When grain As concentrations were high, as seen at the Qulin location, reductions in As content could be found with applications of CaSi. Applications of CaSi also proved to increase stalk Si content on aerobic fields. However, flooded fields were found to have sufficient levels of Si, so increases in uptake were found. On flooded fields, grain yield was highest with applications of dolomitic lime. This may prove to be a better choice than calcitic lime when additions need to be made during a rice production year.

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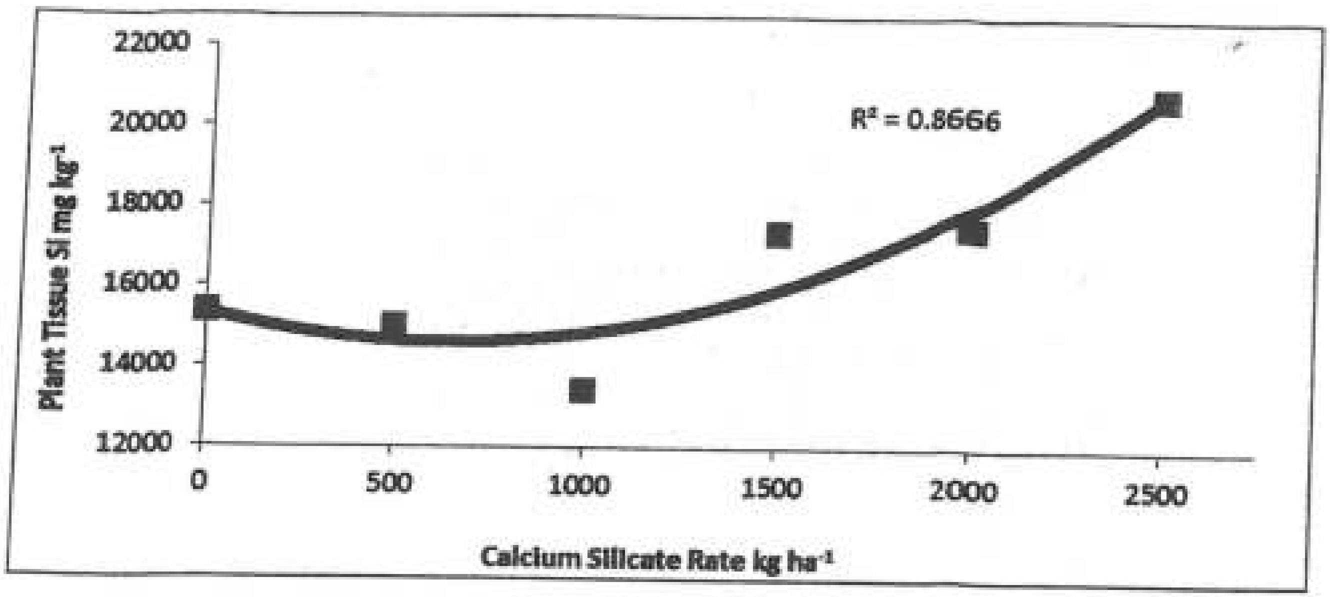

Figure 1. Effect of silicon fertilization rate on rice tissue silicon concentrations from aerobic rice grown under sprinkler irrigation at Portageville, MO.

Table 1. Effect of irrigation and silicon fertilization on arsenic concentrations of brown rice (CLXL745) grown at Qulin and Portageville, MO in 2013.

	Qulin, MO	Portageville, MO
Si Fertilizer	**Flood**	**Aerobic**
kg ha-1	--------Grain As content, ppb--------	
0	205 a	15.8 a
500	202 ab	15.3 a
1000	175 bc	14.0 a
1500	208 a	14.0 a
2000	169 c	15.8 a
2500	190 abc	16.5 a

Table 2. Effect of irrigation and cultivar on arsenic concentrations of brown rice grown at Hayward, MO in 2013.

	Hayward, MO	
	Flood	**Aerobic**
Cultivar	-----Grain As content, ppb-----	
CLXL745	60.4 a	26.8 a
Jupiter	58.5 a	26.8 a
CL151	46.8 a	18.1 a

Table 3. Effect of irrigation and silicon fertilization on arsenic concentrations of brown rice grown at Hayward, MO in 2013.

	Hayward, MO	
Si Fertilizer	Flood	Aerobic
kg ha^{-1}	-----Grain As content, ppb-----	
0	53.8 a	21.5 a
1000	55.6 a	27.3 a
2000	56.3 a	22.8 a

Table 4. Effect of silicon fertilization on rice grain yield across locations in Southeast Missouri in 2013.

		Portageville, MO	Qulin, MO	Hayward, MO	Hayward, MO
	Rate	Aerobic	Flood	Flood	Flush (Aero)
Amend-ment	kg ha^{-1}	---------------------kg ha-1---------------------			
None	0	6379	16312	10548	10127
Cal Lime	840	6761	14765	10129	9942
Cal Lime	1680	7051	15450	10415	9173
Cal Lime	2520	7691	16456	10337	9385
Dol Lime	840	6895	16158	11632	10322
Dol Lime	1680	7139	17213	10852	9650
Dol Lime	2520	7091	16406	10713	10603
CaSi	500	8344	15901	10104	9910
CaSi	1000	7037	16483	10218	9639
Casi	1500	7424	16080	10264	8957
CaSi	2000	7288	16476	9912	10581
CaSi	2500	7347	17014	10247	10646
KSi	0.20	6486	16318	11221	10441
KSi	0.24	7518	16091	10637	9282
KSi	0.28	6633	16016	10563	9520

Table 5. Effect of amendment type on grain yield across locations in Southeast Missouri in 2013.

	Portageville, MO	Qulin, MO	Hayward, MO	Hayward, MO
	Aerobic	Flood	Flood	Flush (Aero)
Amendment	-------------------kg ha^{-1}------------------			
None	6379	16312 ab	10548 abc	10127
Cal Lime	7168	15557 b	10293 bc	9500
Dol Lime	7041	16592 a	11066 a	10192
CaSi	7488	16391 a	10149 c	9947
KSi	6879	16142 ab	10807 ab	9747