Rice Nitrogen Management- Rates and Timing of Urea Fertilizer

Gene Stevens and David Dunn
University of Missouri-Delta Research Center

Managing nitrogen fertilization in rice fields can be challenging for producers. In drill-seeded rice, urea fertilizer is usually broadcast immediately before flooding. Depending on irrigation well pump capacity, field size, and weather conditions, urea can be lost by volatilization while a field is being flooded. Optimum N rates vary by rice variety, soil texture, and previous crop rotations. Nitrogen can also be lost by denitrification if the urea is converted to nitrate in the soil.

For many years, rice agronomists have tried to develop an accurate method of determining whether supplemental nitrogen is needed at internode elongation growth stage. The Plant Area Board has shown good correlation to rice yield response to mid-season N in experiments. However, few growers use it because it is time consuming and requires tedious calculations. Likewise, Minolta SPAD chlorophyll meters have been used successfully in N rice research projects but are too expensive for most growers and consultants.

Accomplishments in Year 1

<u>Yardstick N test</u>

In 2004, we developed and tested a new inexpensive method using an ordinary, wooden yardstick for monitoring rice plant N. The objective of the experiments was to develop critical threshold values using simple yardstick measurements that farmers can use to determine whether midseason N is needed on a rice field. Field tests were conducted at Glennonville, Missouri on a Crowley silt loam soil and Portageville, Missouri on a Sharkey clay soil. At each location, plots were drill seeded (7.5-in row spacing) with Francis and Cheniere varieties. A split-plot design was used with varieties in main plots and N treatments in subplots. Five pre-flood urea nitrogen rates were applied at 0, 35, 70, 105 and 140 lb N/acre. One half of the subplot treatments received mid-season N and one half did not receive additional N. Subplots with mid-season N received 30 lb urea N/acre at internode elongation plus 30 lb urea N/acre one week later. Plots were mechanically harvested with a combine. Rice yields for each pre-flood N rate subplot without midseason N were subtracted from yields in pre-flood N rate subplots with midseason N.

Visual observations with a yardstick were made at green ring growth stage. Two center rows from each plot were selected. A wooden yardstick was placed halfway between the rice rows on the surface of floodwater. (The yardstick was positioned parallel to the rows.) Standing between adjacent rows and leaning over the sampling rows, we counted the inch numbers showing on the yardstick (not hidden by rice leaves) out of the 36 places possible. Two digit inch numbers were counted as one place. When a rice leaf obstructed the view of either of two digit numbers, we did not count that place.

<u>Rice Yields</u> Averaged across varieties, soils, and years; rice yields were highest when 140 lb N/acre was applied before flooding with no midseason N applications (Table 1).

In seven out of eight (2 varieties X 2 soils X 2 years) field observations, midseason N reduced rice yields in main plots with 140 lb N/acre applied preflood. The one exception occurred on the Sharkey clay soil in 2004 when midseason N increased Francis rice yields at all preflood N rates. The greatest yield reduction (-61 bu/acre) occurred when midseason N was applied following the highest preflood N rate on freshly graded Sharkey clay in 2005. Poor harvesting efficiency from plant lodging contributed to the yield loss. Winds from the aftermath of Hurricane Katrina caused lodging in some plots at both locations. On the fresh cut field, lodging in plots with mid-season N following 140 lb urea N/acre preflood was 62% compared with only 3% in plots without mid-season N (Figure 1). For all environments, rice yield increases from midseason N applications following 0 and 30 lb urea N/acre pre-flood ranged with +9 to 23 bu/acre. In the mid-range of preflood N rates tested, rice yield responses from midseason N following 70 and 105 lb N/acre pre-flood varied by environment. Midseason N yield response in these treatments ranged from –37 to +16 bu/acre.

<u>Yardstick.</u> Yield response to mid-season N was correlated with yardstick observations made at green ring (Figures 1 and 2). In 2004 and 2005, 12 numbers showing on a yardstick was the critical level for applying midseason to Cheniere on Crowley silt loam soil (only 2005 results shown). In other words, when fewer than 12 digits were showing little or no positive yield response to midseason was found. Twelve was also the critical midseason yardstick value for Francis in 2004. However, since Francis grew taller than Cheniere, it was more prone to lodge from the 2005 winds resulting from hurricanes. In 2005 on the Crowley silt loam soil, Francis plot yields were increased from midseason only when greater than 18 numbers were showing on a yardstick. In 2005 on the freshly graded Sharkey clay soil, Francis and Cheniere yields were increased only when greater than 23 numbers were showing on a yardstick. Disturbing the Sharkey clay soil during the land grading process in the previous year, may have promoted above average N mineralization from soil organic matter in 2005 on the Sharkey clay, which would explain the lodging and lack of positive yield response to midseason N.

<u>Summary</u> One application of 140 lb urea N/acre applied before flooding produced the highest rice yields in this study. If a rice farmer suspects that significant preflood N has been loss in his field by urea volatilization, denitification, or water loss from a leaky levee, visually counting the numbers showing on a yardstick placed between rice rows at green ring may be helpful for making midseason N decisions. We found that the most consistent critical yardstick value for making midseason N decision was twelve. Zero or negative rice yield responses were found from midseason when fewer numbers were showing. However, if rice is grown on a freshly graded field or a field with a history of lodging, midseason N may not be beneficial to rice yields unless fewer than 18 to 23 digits are showing at green ring.

<u>Low population N test</u>
A field test was conducted at the Missouri Rice Research Farm in Glennonville, Missouri on a Crowley silt loam soil and the University of Missouri-Delta Center in Portageville, Missouri on a Sharkey clay soil and. The objective was to evaluate the yardstick method in sub-optimum rice plant densities in fields. The field was graded in the spring of 2004

and planted in soybeans. In 2005, rice plots were drill seeded (7.5-in row spacing) with Wells cultivar at seeding rates of 5, 15, 25, and 35 seeds ft^2. Three pre-flood nitrogen treatments were applied at 45, 90, and 135 lb urea N/acre. One half of the treatments received mid-season N while the other half received no mid-season applications. Plots with mid-season applications received 30 lb urea N/acre at internode elongation plus an additional 30 lb N/acre one week later. Plots were mechanically harvested with a combine.

Two methods of measuring leaf canopy were tested. For the first method, we used a macro developed at University of Arkansas for Sigma Scan™ image software to evaluate digital pictures based on the percentage of green leaf material in a given area. Digital photos were taken from each plot during the GR growth stage. A digital camera was positioned on 5-ft rod held at a 45-degree angle above the plot. Photos were taken at a downward angle over the rice rows. Photos were analyzed using Sigma Scan to determine the percentage of pixels in each picture that appeared green in color (near 510 nm in wavelength). For the second method, visual observations with a yardstick were also made at GR growth stage. The same procedure was used as in the "yardstick test" above.

<u>Rice yields</u>. Crop yield response to mid-season N decreased as pre-flood N rates increased. Averaged across seeding rates, midseason N increased yields 23 bu/acre at 45 lb N/acre pre-flood rates. However, at 135 lb N/ acre pre-flood, midseason N caused yields to decrease 10 bu/ acre. At the 5 seeds ft^2 seeding rate, plots with 45 lb N/acre pre-flood yielded significantly less than the 90 and 135 lb N/acre pre-flood N rates. At the 35 seeds ft^2 rate, no significant difference in yields was found between pre-flood nitrogen treatments. Also, no significant interaction between mid-season nitrogen applications and seeding rates was found. At the 90 and 135 lb N/acre preflood N application rates, lodging increased as seeding rates increased. Lodging was 25% at the 135 lb N/acre pre-flood compared to 7% at 90 lb N/ acre and 0% at 35 lb N/ acre.

<u>Yardstick.</u> In rice plots, numbers showing on the yardstick and leaf area percentages measured with digital photos processed in Sigma Scan were strongly correlated (R^2 = 0.998). This validated that the yardstick method was an accurate indicator of rice leaf canopy development at green ring growth stage. Averaged across N treatments, at the lowest seeding rate (5 seeds ft^2) percent leaf canopy at GR from digital photos was 40%. At higher seeding rates, percent canopy at GR was 65 to 80 %. The highest rice yields that we measured were when percent leaf canopy and yardstick numbers showing at GR were 60% and 15, respectively.

Objectives for Year 2

We will continue the rice nitrogen experiments in 2006 at the University of Missouri-Lee Farm and Missouri Rice Research Farm. In 2006, we will also study slow release urea N in rice-after-rice fields.

Table 1. Rice yields as affected by urea preflood and midseason nitrogen rates at the University of Missouri-Lee Farm at Portageville, Missouri on a Sharkey clay soil.

		Francis				Cheniere			
Nitrogen applications		2004		2005		2004		2005	
Preflood	Mid-season	total	change	total	change	total	change	total	change
-----lb N acre^{-1}-----		---bu acre^{-1}---							
0	0	113	+12	169	+11	110	+20	175	7
0	30+30	125		180		130		182	
35	0	110	+9	191	+7	129	+19	194	-7
35	30+30	119		199		148		187	
70	0	118	+10	212	-12	134	+11	200	-19
70	30+30	128		200		145		181	
105	0	125	+12	208	-24	138	+5	205	-37
105	30+30	137		184		143		168	
140	0	138	+5	202	-18	145	-15	185	-61
140	30+30	143		184		130		124	

Table 2. Rice yields as affected by urea preflood and midseason nitrogen rates at the Missouri Rice Research Farm at Glennonville, Missouri on a Crowley silt loam soil.

		Francis				Cheniere			
Nitrogen applications		2004		2005		2004		2005	
Preflood	Mid-season	total	change	total	change	total	change	total	change
-----lb N acre^{-1}-----		---bu acre^{-1}---							
0	0	142	+22	125	+26	141	+23	134	+29
0	30+30	164		150		164		163	
35	0	172	+19	148	+24	151	+22	146	+35
35	30+30	191		172		173		181	
70	0	185	+16	172	+25	175	+4	165	+24
70	30+30	201		197		179		190	
105	0	202	+2	186	-12	182	-7	169	+29
105	30+30	204		174		175		198	
140	0	211	-17	207	-4	175	-13	194	-17
140	30+30	194		203		162		177	

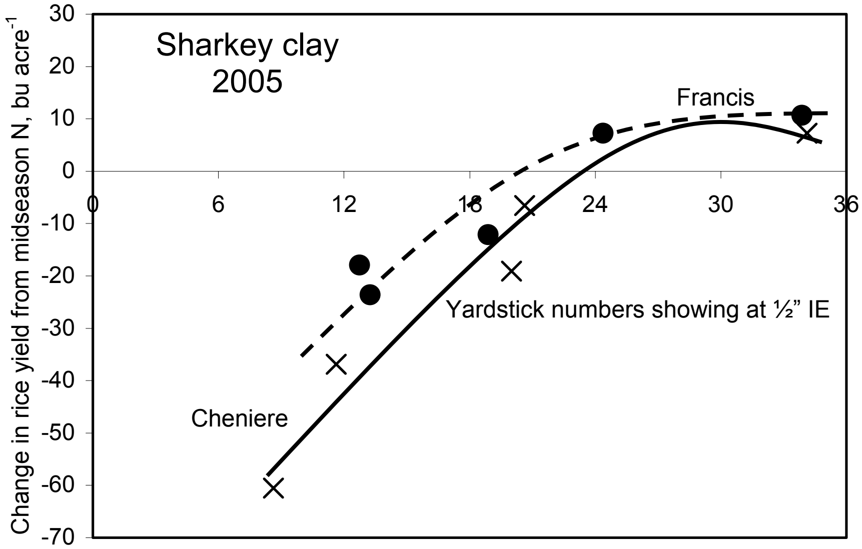

Figure 1. Change in rice yields (+ and -) from applying 30 lb N acre^{-1} at IE followed by 30 lb N acre^{-1} one week later as correlated to numbers visible on a yardstick placed between drill rows at green ring on a Sharkey clay loam soil in 2005 at Portageville, Missouri. Significant lodging was observed at high N rates and average rice yields were 186 bu acre^{-1}.

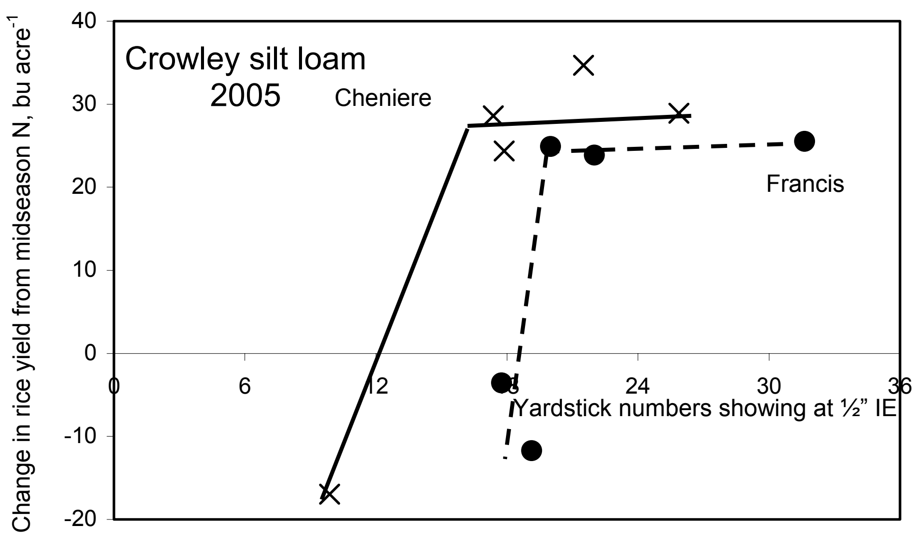

Figure 2. Change in rice yields (+ and -) from applying 30 lb N acre^{-1} at IE followed by 30 lb N acre^{-1} one week later as correlated to numbers visible on a yardstick placed between drill rows at green ring on a Crowley silt loam soil in 2005 at Glennonville, Missouri. No lodging was observed and average rice yields were 172 bu acre^{-1}.

Table 3. Effect of rice seeding rate, preflood N and mid-season on lodging, leaf canopy at green ring growth stage and rice yields at the MU Delta Research Center in 2005.

	Mid-	Plant			Green ring		
Preflood	season	seed	Lodging	Ht	Yardstick	Leaf	Bu/a
lb N/acre	applied	$\#/ft^2$	%	in	showing	Canopy[1]	
45	no	5	0	24	27	36%	119
45	yes	5	0	24	29	30%	130
90	no	5	0	24	21	41%	155
90	yes	5	0	26	20	42%	157
135	no	5	0	24	26	44%	151
135	yes	5	0	24	25	37%	134
45	no	15	0	25	23	51%	172
45	yes	15	0	26	19	66%	180
90	no	15	0	26	17	67%	171
90	yes	15	3	26	14	69%	175
135	no	15	31	28	14	73%	153
135	yes	15	60	27	11	73%	130
45	no	25	0	24	24	62%	143
45	yes	25	0	26	18	64%	187
90	no	25	0	26	18	64%	168
90	yes	25	3	27	14	72%	190
135	no	25	61	29	8	83%	149
135	yes	25	46	28	9	79%	152
45	no	35	0	26	19	68%	166
45	yes	35	0	26	16	74%	196
90	no	35	13	26	11	84%	169
90	yes	35	38	28	8	83%	175
135	no	35	5	29	12	84%	169
135	yes	35	3	27	10	80%	166

1. Measured from digital photo and analyzed with Sigma Scan software.

Table 4. Effect of rice seeding rate, preflood N and mid-season on lodging, leaf canopy at green ring growth stage and rice yields at the Missouri Rice Research Farm in 2005.

Preflood	Mid-season	Plant seed	Ht	Green ring yardstick	Yield
lb N/acre	applied	$\#/ft^2$	in	showing	bu/acre
45	no	5	23	36	15
45	yes	5	23	35	21
90	no	5	24	35	28
90	yes	5	18	36	29
135	no	5	24	36	25
135	yes	5	24	36	34
45	no	15	26	25	148
45	yes	15	28	21	200
90	no	15	30	21	163
90	yes	15	27	20	229
135	no	15	31	19	207
135	yes	15	28	21	216
45	no	25	28	24	192
45	yes	25	28	22	208
90	no	25	32	9	215
90	yes	25	32	10	245
135	no	25	32	13	248
135	yes	25	33	12	239
45	no	35	28	15	201
45	yes	35	29	18	222
90	no	35	31	15	221
90	yes	35	31	18	237
135	no	35	34	13	227
135	yes	35	32	11	245

Proposed budget:

Expenses	2005	2006	2007
Res. Specialist salary (0.4)	$11,200	$11,648	$12,114
Fringe benefits	$2,800	$2,912	$3,028
Supplies	$1,500	$1,560	$1,622
Travel	$2,000	$2,080	$2,163
Total	$17,500	$18,200	$18,928