Midseason Nitrogen Fertilization Rate Decision Tool for Rice Using Remote Sensing Technology

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In drill-seeded, delayed flood rice production in the mid-southern United States, N fertilizer is most commonly applied using a two-way split application. The second application occurs at midseason near the panicle initiation stage of rice development where approximately one-third of the estimated N fertilizer requirement is applied. Midseason N rates are often adjusted either up or down by rice producers or crop consultants by visual assessment of the rice. In rice cropping systems such as these, instruments which could make in-season estimates of yield potential and available soil N would provide the initial framework to predict midseason N needs and greatly improve N fertilizer use efficiency in rice.

More time and research has been devoted to understanding N than any other nutrient. It is the most limiting nutrient in non-legume cropping systems and the least predictable. Mismanagement of N fertilizer can impact both economic and environmental aspects of crop production. Available soil N and yield level are determinants of a crop's N requirement and are essential parameters to quantify optimal N application rates. Making precise N prescriptions are difficult because tremendous variability exists for available soil N and yield across time and space.

Several destructive and non-destructive methods have been tested and established to assist in making midseason N fertilization rate decisions for rice. The chlorophyll meter and leaf color chart are among the tools that were developed to monitor rice N status (Peng et al., 1993; Stevens and Hefner, 1999). Nitrogen use efficiency was increased when in-season, sensor-based estimates of yield potential and crop responsiveness to N fertilization were used to determine midseason N rate for corn and wheat (Raun et al., 2002; Tubana et al., 2008). A study was initiated in 2008 at different sites in Louisiana and Mississippi to build a database required for the development of similar decision tool for rice. The database consists of grain yield and NDVI readings of three different rice varieties (Catahoula, Neptune, and CL151), which were collected at different growth stages from plots that received varying amounts of preflood N.

Spatial and Temporal Variability in Yield, Response to N, and Optimal N Requirement

Rice yield level and responsiveness to N fertilization (a function of available soil N) may, independently or in combination, affect optimal N requirement. Non-linear regression analysis was conducted on grain yield data with respect to preflood N rate to estimate optimal N rate for each site year. There were no distinct trends observed between percent increase in yield due to N and maximum yield level **(Figure 1)** nor with the estimated optimal N rate for each site from 2008 to 2010 **(Table 1)**. There were sites where maximum yield was similar over years, but had large differences in response to N fertilization, e.g. Rayville site in 2008 and 2009. Large differences in optimal N rates across site years were also observed **(Table 1)**. For example, the Crowley site in 2008 and 2010 maximized grain yield at 11,967 and 12,162 lb/A, respectively, with application rates of 138 and 126 lb N/A, but not in 2009 where 160 lb N/A yielded only 8,703 lb/A. Little benefit of N fertilization was observed at the Rayville site in 2009 (37%) which translated to an optimal N rate requirement of only 99 lb N/A. This is lower than the current state recommendation (120 to 160 lb N/A, Saichuk et al., 2009). The outcome of this analysis implies that prescribing N fertilizer on a need basis requires an estimation procedure for rice yield and rice response to N which are both in-season and on-site.

Collecting NDVI readings using a GreenSeeker handheld sensor at panical differentiation stage at LSU AgCenter Rice Research Station in Crowley, Louisiana.

Abbreviations and Notes: N = nitrogen; NDVI = normalized difference vegetation index; USD = U.S. dollar.

Midseason N Rate Decision Tool

Remote sensing technology offers a non-invasive method of obtaining crop information. Therefore, it can be used for in-season and on-site estimations of yield and rice response to N fertilization. However, this requires calibration of NDVI readings with yield (Raun et al., 2001; Teal et al., 2006) and in-season estimates of rice response to N (Mullen et al., 2003). In 2009, the components of the midseason N decision tool were established using the data collected in 2008 similar to the method by Raun et al. (2002). The initial version of the midseason N decision tool was evaluated using Catahoula variety as part of the experimental procedure in 2009 and is continually being refined as the collection of yearly data continues and the database becomes more robust. Contrast analysis for the effect of preflood N rate and N recommendation scheme on grain yield, N use efficiency (NUE), and net return to N was conducted. **Table 2** shows the mean rice grain yield, NUE, and net return to N at different preflood N rates and N recommendation schemes (fixed N vs. sensor-based) for each site year. The higher preflood N rates provided a significant increase in grain yield in 2010, but not in 2009 ($P<0.05$). With

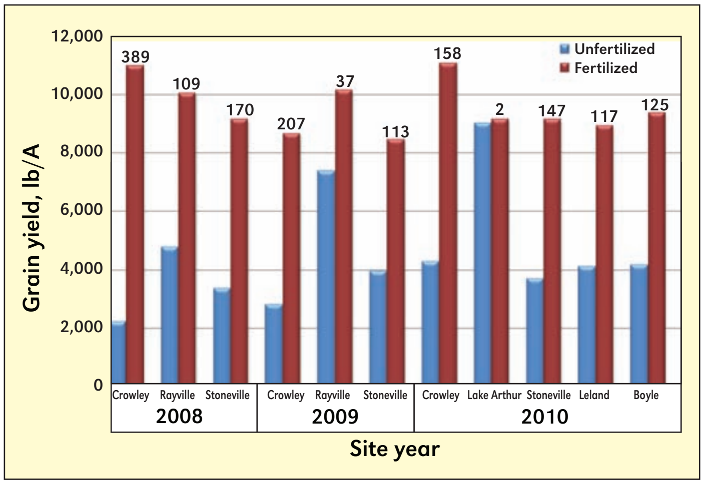

Figure 1. Mean rice grain yield of unfertilized and highest-yielding N-fertilized plots across sites in Louisiana and Mississippi, 2008-2010. Numerical values above the fertilized plot bar are percent increase in yield due to N.

Table 1. Maximum yield and optimal N rate from response trials conducted at different sites in Louisiana and Mississippi using the linear-plateau model, 2008-2010.

Year	Site	Maximum yield ------ lb/A ------ Actual†	Estimate§	Optimal N rate, lb/A	r^2
2008	Crowley	10,685	11,967	138	0.92
	Rayville	9,954	11,149	165	0.59
	Stoneville	8,965	10,041	210	0.88
2009	Crowley	7,771	8,703	160	0.50
	Rayville	10,049	11,255	99	0.33
	Stoneville	8,206	9,191	173	0.94
2010	Crowley	10,860	12,162	126	0.88
	Lake Arthur‡	8,940	-	-	-
	Stoneville	8,881	9,947	166	0.88
	Leland	9,094	10,185	159	0.84
	Boyle	9,220	10,326	134	0.91

Linear-plateau model level of significance, P<0.05.
‡No response to N fertilization.
†Actual – highest grain yield measured at harvest.
§Estimated maximum yield and optimal N rate using linear-plateau model.

the exception of the Boyle site, grain yield, NUE, and net return to N were statistically the same between sensor and fixed N rates (P<0.05), regardless of whether the sensor recommended higher or lower than the fixed 45 lb N/A. In cases where the sensor recommended a lower N rate, NUE values tended to be higher than the fixed N rate and also resulted in a higher net return at the Crowley and Rayville sites in 2009. At the Stoneville location across both years, the sensor recommended a higher N rate than the fixed 45 lb N/A. This resulted in similar NUE values between the fixed and sensor-based rates. However, the sensor-based rate resulted in a numerically higher net return to N fertilizer. On the other hand, the sensor demonstrated its limitation in 2010 where its recommendations did not result in gain in net return compared with fixed N rates, even though NUE was increased in most cases. The results of our preliminary evaluations demonstrate not only the potential of this midseason N decision tool to improve N fertilizer use efficiency in rice, but also highlight the potential areas where refinement should be made to ensure profitability for every unit of N invested. BC

Table 2. Grain yield, N use efficiency (NUE), and net return to N fertilizer as affected by preflood N rate and midseason application scheme, 2009 and 2010.

Year	Site	Preflood N lb/A	Mid-season N ----- lb/A ----- Fixed^π (45)	Sensor	Grain Yield ----- lb/A ----- Fixed	Sensor	NUE ----- % ----- Fixed	Sensor	Net return§ ---- USD/A ---- Fixed	Sensor
2009	Crowley	75 a	*120*	*108 (43)*	6,976	7,106	41	46	546	568
		105 a	*150*	*139 (34)*	7,273	7,339	35	40	573	590
	Rayville	75 a	*120*	*125 (50)*	8,838	8,874	30	31	333	336
		105 a	*150*	*121 (16)*	8,878	8,765	21	37	313	332
	Stoneville	120 a	*165*	*178 (58)*	7,697	7,601	23	23	421	440
		150 a	*195*	*206 (56)*	7,645	7,817	23	21	425	481
2010	Crowley	75 b	*120*	*114 (39)*	9,314	9140	57	60	525	509
		105 a	*150*	*136 (31)*	10,509	10,040	60	61	640	596
	Stoneville	90 b	*135*	*148 (58)*	7,252	7,559	29	29	317	344
		120 ab	*165*	*172 (52)*	8,068	8,292	32	32	390	411
		150 a	*195*	*197 (47)*	8,608	8,745	31	32	434	448
	Leland	90 b	*135*	*158 (68)*	8,168	8,217	35	32	371	366
		120 ab	*165*	*179 (59)*	8,641	8,879	33	35	407	426
		150 a	*195*	*203 (53)*	9,255	9,472	32	33	459	448
	Boyle‡	90 c	*135*	*98 (8)*	8,894	8,175	39	42	443	384
		120 ab	*165*	*120 (0)*	9,561	8,887	37	46	500	450
		150 a	*195*	*150 (0)*	9,761	8,990	35	38	507	447

Different lower case letter within the preflood N for each site year indicates significant difference in grain yield (P<0.05).
†Values in parentheses are mid-season N rate applied based on sensor reading.
πFixed mid-season N rate of 45 lb N/A.
‡Site-year with significant difference in grain yield, NUE, and net return to N between fixed N and sensor-based N.
NUE – N use efficiency computed as = (grain N $uptake_{fertilized}$ – grain N $uptake_{check}$)/unit of N fertilizer x 100
§Net return to N fertilizer determined by subtracting the cost of fertilizer from the gross income (grain yield increase due to N application x price of grain) where price of N = USD 0.53 per lb for 2009 and USD 0.49 per lb for 2010, while rice grain = USD 0.14 per lb for 2009 and USD 0.12 per lb for 2010 (USDA-NASS, 2010).

(continued on next page)

Midseason N fertilization at panicle differentiation stage, LSU AgCenter Rice Research Station in Crowley, Louisiana.

Variety x N trial at the LSU AgCenter Rice Resarch Station, Crowley, Louisiana.

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Soil Test Levels in North America, 2010 Summary Update Publication/CD Available

With the cooperation of more than 60 public and private soil testing laboratories, IPNI has completed a summary of results of tests performed on approximately 4.4 million soil samples collected in the fall of 2009 and spring of 2010. The 2010 summary contains information about phosphorus (P), potassium (K), sulfur (S), magnesium (Mg), zinc (Zn), chloride (Cl^-), and pH.

"The summary can be viewed as an indicator of the nutrient supplying capacity or fertility of soils in the U.S. and Canada," notes Dr. Paul Fixen, IPNI Senior Vice President and Director of Research. He coordinated the efforts of IPNI North America staff and others in collecting the data and compiling the report. The 2010 summary is probably the most comprehensive evaluation of soil fertility ever conducted in North America.

The new summary offers a snapshot view of soil test levels in the U.S. and Canada in 2010, but also provides a comparison to the previous two summaries which were completed in 2005 and 2001. Since the 2010 summary is the third in which laboratories were asked to complete frequency distributions of soil test results, temporal changes in soil test level distributions can be viewed for the second time for states and provinces.

The 42-page publication (Item # 30-3110) is available for purchase for US$25.00. An accompanying CD-ROM contains a PDF file showing the pages of the report, a PowerPoint file of all figures and graphs in the report, and an Excel workbook of the major tables to facilitate construction of custom graphs for regions of interest.

The CD alone (Item # 82-3110) is available for US$10.00. The combination of the publication plus the CD (Item # 90-3110) is available for US$30.00. Shipping and handling costs are added.

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More information about the report is also available at this website: http://info.ipni.net/soiltestsummary