Starter Fertilizer for Delayed-Flood Rice — Agronomic Effects

By Tim Walker, Rick Norman, Brian Ottis, and Jason Bond

Results from this study indicate that starter N applications when applied to semi-dwarf cultivars planted on clay soils in the Mississippi River Alluvial Flood Plain can increase seedling plant height and moderately increase rice grain yield.

In recent years, the *sd1* semidwarf gene has been used extensively in U.S.A. public rice (*Oryza sativa* L.) breeding programs largely because the semidwarf plant type allows for greater yields through higher N fertilization rates while reducing the susceptibility to lodging (McClung, 2003). Because of these characteristics, semidwarf cultivars have increased in popularity in the southern U.S.A. rice-growing region, are planted on a large percentage of the acreage, and have contributed to increased grain yield in the last 20 years (**Figure 1**). Because of their shorter mesocotyls, emergence and seedling growth rates of semidwarf cultivars can be lower compared to taller cultivars (Turner et al., 1982). This difference can be further exacerbated when rice is planted on alluvial clay soils, which represent the majority of rice acreage in Mississippi and a growing percentage of acreage in Arkansas and Missouri. Clay soils have less N-supplying capacity compared to coarser-textured soils such as silt loams (Trostle et al., 1998).

Nutrient availability and uptake, as well as weed control, are facilitated by the flooded soil environment (Norman et al., 2003; Kendig et al., 2003). In addition, thermal time (degree days) greatly determines rice plant development (Moldenhauer and Gibbons, 2003). Therefore, practices that encourage biomass production in the seedling and early vegetative stages are needed so that rice is grown in an upland environment for a minimum number of days.

Starter fertilizer sources have proven to be beneficial in increasing early-season vegetation and sometimes yield in corn, cotton, and soybean (Vetsch and Randall, 2000; Bednarz et al., 2000; Osborne and Riedell, 2006). Therefore, studies

Rice plot harvest using a small-plot combine at the Delta Research and Extension Center near Stoneville, Mississippi.

to investigate starter fertilizer in rice were warranted. The specific objective of this study was to determine the potential for using starter N fertilizer to increase seedling rice growth and grain yield for semidwarf cultivars planted in clay soils in the southern U.S.A. rice production area.

An experiment was conducted in 2005 and in 2006 at the Delta Research and Extension Center in Stoneville, Mississippi, and at the Northeast Research and Extension Center in Keiser, Arkansas, and in 2006 at the University of Missouri-Columbia Lee Farm, near Portageville. Sharkey clay (very-fine, smectitic, thermic Chromic Epiaquerts) soil was present at each location and specific soil chemical properties are listed in **Table 1**. Twelve total treatments that consisted of combinations of starter N source and preflood N rate were evaluated. The starter N sources…AMS, 21% N; DAP, 18% N; and urea, 46% N…were applied to 2-leaf Cocodrie rice cultivar at the

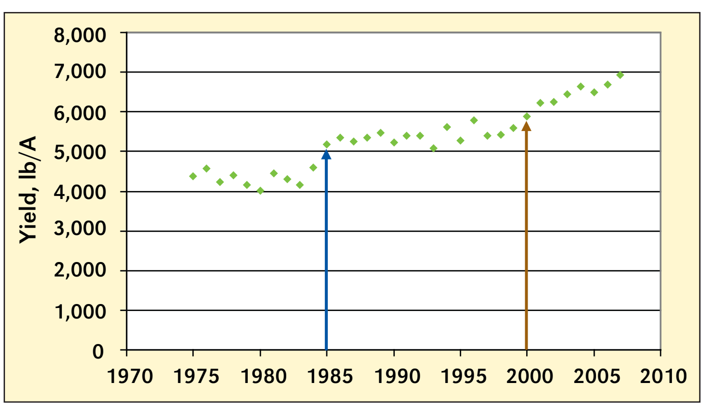

Figure 1. Rice grain yield by year from 1975 to 2007 for southern U.S.A. rice-producing states, including Arkansas, Louisiana, Mississippi, Missouri, and Texas. 'Lemont', released by Texas in 1985, was one of the first semidwarf cultivars planted across large acreages in the south. Since its release in 2000, Cocodrie has been one of the most popular semidwarf cultivars planted in the southern U.S.A. rice-producing area.

Bluebonnet is a tall cultivar released by Texas in 1944.

Abbreviations and notes for this article: N = nitrogen; AMS = ammonium sulfate; DAP = diammonium phosphate; PF = preflood; PE = panicle emergence; OM = organic matter; TDM = total dry matter; TNU = total N uptake.

Table 1. Selected soil chemical properties (pH, organic matter, and clay content) and pertinent agronomic dates for studies conducted in Arkansas, Missouri, and Mississippi.

State	Year	Soil pH[†]	OM, %	Clay	Planting date	Starter N application date	Preflood N application date	Harvest date
Arkansas	2005	6.5	1.6	53	20 Apr	17 May	8 Jun	22 Sep
	2006				24 Apr	16 May	15 Jun	15 Sep
Missouri	2006	6.0	3.4	58	23 Apr	15 May	5 Jun	6 Sep
Mississippi	2005	8.0	2.2	60	3 May	18 May	6 Jun	15 Sep
	2006				9 May	31 May	10 Jun	20 Sep

Soil pH measured in a 1:2 soil/water ratio.

Dr. Tim Walker collects plot notes (heading dates) in rice grown at Delta Research and extension Center near Stoneville, Mississippi.

rate of 20 lb N/A. A control treatment receiving no starter N was also included. Plots were flush-irrigated to incorporate fertilizer treatments within 3 days after application. Preflood N rates (90, 120, and 150 lb N/A) as urea were applied to 5-leaf rice within 3 days prior to flood establishment. Prior to the N application PF at the 5-leaf growth stage, plant heights were measured from 5 individual plants randomly selected from each plot, including the no-starter treatment. Additionally, total aboveground biomass was harvested from 3 linear feet of row, dried at 140°F for 72 hours, weighed for total dry matter (TDM), and then processed and analyzed for total N content. Total dry matter and total N content were also determined at panicle emergence as previously described. Plots were threshed when grain moisture reached 16 to 20%, and grain yields were standardized to 12% moisture content. Response variables are reported as the means of the 5 site-years.

Plant height measured at the 5-leaf growth stage was affected by starter N source. Ammonium sulfate and DAP produced plant heights that were approximately 14% greater than when no starter was applied (**Table 2**). Though not significant, TNU and TDM tended to be greater when 20 lb N/A was applied as a starter (**Table 2**). Starter N did not affect TDM and TNU when measured at PE. However, rice grain yield was affected by starter N source. Modest grain yield increases were observed when AMS and DAP were applied as a starter compared to when no starter was applied (**Table 3**).

Total dry matter, TNU, and grain yield were all affected by PF N rate. Yield and TDM were greatest when at least 120 lb N/A was applied PF, whereas TNU increased with increasing PF N rate (**Table 4**).

These data suggest that plant height at the 5-leaf stage can be increased with an AMS or DAP application on 2-leaf rice at a rate of 20 lb N/A. This plant height increase can have positive management implications. First of all, greater plant height will allow for earlier flood establishment. The flood provides growers the opportunity to potentially decrease the number of herbicide applications. Furthermore, flooding earlier increases the number of days rice vegetative growth occurs in a flooded environment which has positive implications on nutrient availability and uptake. Starter N in the form of AMS and DAP also increased grain yields when compared to no starter application. Future research should address starter fertilizer rates, combinations, and placement as research in

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Table 4. Total dry matter and total N uptake at panicle emergence, and grain yield as affected by preflood N rate averaged across starter N sources.

Rate, lb N/A	TDM[1], lb/A	TNU, lb N/A	Yield, lb/A
90	9,035 b	134 c	7,583 b
120	9,803 a	153 b	8,102 a
150	10,105 a	176 a	8,340 a

[1]Means in the same column followed by a different letter are different at $p \leq 0.05$.

Table 2. Plant height, total N uptake, and total dry matter measured at the 5-leaf stage as affected by starter N fertilizer source.

Starter	Height,[1] in.	TNU, lb N/A	Biomass, lb/A
AMS	9.3 a	6.7	168
DAP	9.4 a	6.6	165
Urea	8.9 ab	6.2	163
None	8.1 b	5.4	136
		NS	NS

[1]Means in the same column followed by a different letter are different at $p \leq 0.05$.

Table 3. Grain yield as affected by starter N source averaged across preflood N rates.

Starter	Yield,[1] lb/A
AMS	8,117 a
DAP	8,076 ab
Urea	7,941 bc
None	7,899 c

[1]Means in the same column followed by a different letter are different at $p \leq 0.05$.

Cocodrie is a semidwarf cultivar released by Louisiana in 2000.

Table 2. Fertility effects on soybean yield, and whole plant tissue P and K concentration at full-bloom, 2004-2007 (average over row spacing and plant population).

Treatments	Yield, bu/A	Whole plant P	Whole plant K
		----------- % -----------	
Check	50.3	0.222	2.61
Low P	68.8	0.245	2.59
Low P-Low K	77.8	0.248	2.99
Low P-High K	80.4	0.246	3.41
High P-Low K	84.7	0.292	2.97
High P-High K	84.8	0.300	3.39
N-P-K	84.9	0.294	3.42
LSD (0.05)	4.1	0.019	0.13
CV%*	4.2	5.1	4.9

* Coefficient of variation.

In 2 of the 3 years Mn was applied, average yield increase was 4.9 bu/A.

Table 3. Fertility effects on soybean yield components and plant height, 2004-2007 (average over row spacing and plant population).

Treatments	Seed number per $ft.^2$	Seed per pod, number	Seed size, grams/100 seed	Plant height, in
Check	390	1.6	10.9	23.7
Low P	485	2.2	11.4	27.2
Low P-Low K	570	2.8	12.3	28.3
Low P-High K	614	2.9	13.5	28.4
High P-Low K	660	2.9	13.6	29.3
High P-High K	661	2.9	13.2	29.6
N-P-K	660	2.9	13.8	29.9
LSD (0.05)	23	0.9	0.5	1.1
CV%	12	8.1	4.3	2.6

* Coefficient of variation.

actually reduced yield. When averaged over all 4 years of the experiment, row spacing or plant population did not affect yield of soybean, nor was there a significant interaction among the three factors in the experiment

Soybean yield did respond to fertilizer application. Addition of 30 lb P_2O_5/A resulted in a 4-year average yield increase of over 18 bu/A (**Table 2**). Applying 80 lb P_2O_5 with 60 lb/A K_2O increased yield by 34 bu/A over the unfertilized check plot. Applying additional K or adding N to the mix did not increase yields. Addition of P and K fertilizer significantly increased soybean tissue nutrient concentration at the full bloom stage of growth. Addition of fertilizer increased the number of seed, number of seed per pod, and weight of seed as well as plant height (**Table 3**). Direct application of P and K fertilizer is crucial in maximizing performance and yield of irrigated soybean.

In 2 of the 3 years that the Mn treatment was included in the experiment, Mn applied with N, P, and K resulted in an increase in soybean yield over the same treatment without Mn. Average yield increase was 4.9 bu/A in those 2 years. Manganese application can fit in a fertility program designed for maximum soybean yield. BC

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other crops suggest that lower N rates can be used and still obtain increased early-season vegetative growth and grain yield (Vetsch and Randall, 2000; Kaiser et al., 2005). Finally, the recovery efficiency of starter N in rice is not well understood. Therefore, research is needed to address the dynamics of recovery of starter N applications in a delayed-flood rice production system. BC

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