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Nitrogen Fertilization of Rice in Arkansas

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Nitrogen (N) fertilizer is one of the most important investments in a successful rice crop. Because of the investment required, the goal is to apply the optimum rate to provide maximum returns. The amount of N required and management of the N varies depending on variety, soil conditions, cultural practices, crop rotations, and other factors.

DRY-SEEDED RICE

NITROGEN TIMING

Two recommended options, the ***three-way split*** or a ***single preflood***, are available for applying N fertilizer to rice produced under dry-seeded conditions. The traditional ***three-way split*** timing is recommended when one of the following criteria is met:

- poor pumping capacity (> 5 days to flood the field)
- poor water management abilities (fluctuating water level)
- a history of straighthead (or other reasons for draining during vegetative growth on light textured soils
- when tall varieties susceptible to lodging or with relatively low recommended N rates are being grown (Table 1).

The Rice Gauge (plant area board) should be used to monitor the plant N status at midseason to determine if adjustments need to be made in midseason N rates.

A ***single preflood*** application followed by monitoring the plant N status at midseason with the Rice Gauge (plant area board) is recommended if none of the above criteria are met. The amount of preflood N is critical for determining potential grain yield. (For more information on the Rice Gauge, see "Rice Plant Area", Fact Sheet 2122.) The number of panicles (heads) and the number of grains per panicle are determined by the preflood N application. Because the yield is determined prior to midseason on currently grown varieties, yield can no longer be recovered with N applications at joint movement. Also, the new varieties are generally shorter and have stiffer straw, thus, are less susceptible to lodging associated with excessive early N applications compared to the older varieties. Table 1 provides rates for both single preflood N applications and three-way split applications for the varieties that are suited for single preflood N applications. A "NR" in the single preflood column indicates that the single preflood N application is not recommended for this variety. It is best to utilize the single preflood application when possible as this method has been shown to consistently be the best method where management practices allow it. Also, it can potentially reduce the overall amount of N fertilizer needed.

Early N Application

The early N application (50 to 80% of the total N rate) should be applied at the 4 to 5 leaf growth stage onto dry soil immediately prior to flooding. Under no circumstances should the early N be applied into the floodwater. If the soil is not dry, delay N fertilizer application and flooding for 10 to 14 days after the scheduled application date on the DD50 printout. A study conducted by University of Arkansas scientists showed grain yields were not reduced when the preflood N and the flood were delayed (Table 2). If the soil has not dried by the end of this period, apply the N onto the muddy soil and flood immediately (field coverage within 5 days) to minimize N loss due to ammonia volatilization.

When a large amount of preflood N is required, "streaking" (uneven distribution) may be a problem. Streaking occurs when the amount of fertilizer applied is so great that even distribution becomes difficult to obtain with the airplane. This uneven distribution can cause grain yield reductions as great as 18%. To avoid this problem, two options are suggested. The best option is to divide the N rate and the "swath width" of the airplane in half. This increases overlap on the edges of the swath and allows the plane to distribute a more manageable amount of fertilizer. The other option is to split the early N into two applications. Apply about one-third of the recommended early N at the 2-3 leaf stage and the remainder immediately prior to flooding. Always flush the field following the first application to incorporate the N into the soil. This option is only recommended when the preflood N requirements are 90 lbs/A or greater because the possibility of N loss from nitrification-denitrification increases when the flood is not immediately applied. Pre-plant incorporated N applications are not recommended because the potential for extensive N loss. The highest yields have been obtained most consistently when all of the early N was applied immediately prior to flooding. This procedure provides the least amount of N loss, results in the greatest yield response, and should be used if possible.

Mid-Tillering N Applications

In some situations, it is beneficial to make an N application at mid-tillering (or "in-between" application). If an inadequate amount of preflood N was applied, the early N was not managed correctly, or if the soil is inherently low in fertility, an application may be beneficial at mid-tillering. While visual observations have been utilized in the past to decide about a mid-tillering application, the plant area board should now be used because it quantifies the visual observation. If the rice has visual symptoms such as reduced growth rate and is beginning to turn yellow, plant area measurements using the plant area board should be taken at the mid-tillering growth stage according to the DD50 printout.

If a mid-tillering application is called for by the Rice Gauge (see "Rice Plant Area", Fact Sheet 2122), apply 30 lbs N/A immediately. At the mid-tillering growth stage, the rice plant is still developing its root system. Because the roots are generally not developed well enough to fully utilize N rapidly, ammonia volatilization becomes a problem if the N is applied into the floodwater. Therefore, the best results will be obtained by draining the field, applying the N fertilizer onto the muddy soil, and re-flooding as quickly as possible. This procedure incorporates the N into the soil. Limitations may be present that will not allow the use of this technique. If water management, weed control, insect control, or other problems exist that discourages draining the field, the only option is to apply the N into the floodwater. However, research studies have shown that rice does not respond as well to this treatment as application onto dry or muddy soil surface followed by flooding.

Midseason N Applications
The midseason N rates for the three-way split method for each variety are shown in Table 1. Adjustments in the rates should be determined based on the plant area measurements made with the Rice Gauge at the beginning internode elogation growth stage listed on the DD50 printout. Because natural fertility is variable among soils, the amount of N that the rice plant derives from the soil is also variable (Table 3). At the Northeast Research and Extension Center (NEREC) and the Southeast Research and Extension Center, grain yields for unfertilized 'Kaybonnet' were very low compared to the fertilized plots (Table 3). At the Pine Tree Experiment Station (PTES), grain yield for the unfertilized 'Kaybonnet' was higher compared to the other locations, yet, the fertilized plots were very similar to the other locations. The soils at PTES were capable of contributing more N to the rice crop than at NEREC or SEREC. Also, optimum yields were obtained with lower N rates at PTES compared to NEREC or SEREC. In other words, some soils contribute very little N to the rice crop while other soils contribute a significant amount of N. A soil test procedure is not available to measure the amount of available N for the rice. The plant area board can be used to determine how much, if any, midseason N is needed to optimize grain yields.

Recent studies conducted jointly by the University of Arkansas and Louisiana State University demonstrated that the midseason N application can be made in either one or two applications. When they compared one application of 60 lbs N/acre at **2**" internode elongation (IE) to two applications of 30 lbs N/acre each, the yields were not significantly different. Subsequently, you may be able to reduce application costs with only one application. Also in this study, they demonstrated that applying the first mid-season N at "green ring"(5-7 days prior to **2**"IE) was just as effective as applying the N at **2**"IE, which has been recommended by the University of Arkansas. Thus, a window of opportunity exists for applying the first mid-season N application.

NITROGEN RATES
The recommended N rates for most of the varieties grown in Arkansas are listed in Table 1. The recommendations are based on the following conditions: 1) silt loam or lighter textured soils; 2) rice following soybean in rotation; 3) the soil pH is less than 6.5; and 4) optimum stand density. If the N is applied in three split applications and one or more of these conditions does not apply, adjustments should be made to the preflood N rate to achieve the optimum N fertilizer rate for the particular situation. The adjustments are needed because the residues from the previous crop influences the amount of soil N available for the rice. The recommended adjustments in the early N rate are listed below with the conditions needed to make the adjustment.

NOTE 1: The adjustments are additive to a maximum increase of 30 lbs N/A. The adjustments are additive if more than one situation applies. For example, increase the early N rate by 30 lbs/A if the rice follows grain sorghum (+10 lbs N/A) on a clay soil (+20 lbs N/A). Likewise, the preflood N rate would be increased by only 30 lbs N/A if rice follows rice (+20 lbs/A) on clay soils (+20 lbs/A).

NOTE 2: Use the N rate adjustment rules for both ***single preflood*** and ***three-way split*** application methods.

I. Increase the early N rate by 20 lbs/A if:
- i) rice is grown on clay soils
- ii) rice follows RICE or COTTON in rotation
- iii) the stand density is less than 10 plants per sq ft

II. Increase the early N rate by 10 lbs/A if:
- i) rice follows GRAIN SORGHUM, WHEAT, or CORN in rotation
- ii) the soil pH is 6.5 or greater

III. Decrease the early N rate by 10 lbs/A if:
- i) rice follows SETASIDE or FALLOW

IV. Do not apply early N if rice follows FISH, LONG TERM PASTURE, or the first year after land clearing.

V. Adjust midseason N rates by measuring plant area with the Rice Gauge. Measurements should be taken at beginning internode elongation as listed in the DD50 printout.

**Note the new recommendation for increasing the preflood N rate on clay soils. Research has shown that optimum N rates are consistently higher on clay soils compared to silt loam soils (Table 3).

WATER-SEEDED RICE

Due to increased red rice pressure, many Arkansas farmers are making a transition to a water-seeding system which has been used successfully in Louisiana and California for several years. Nitrogen management under water-seeded conditions is similar to dry-seed systems in some respects. The primary difference between N management for water-seeded rice and dry-seeded rice is the time and duration of the flood. All of the recommended N can be applied pre-plant incorporated (ppi) for water-seeded rice with newer varieties that have good straw strength, such as 'Cypress' or 'LaGrue', because the soil remains saturated throughout the growing season. The N should be broadcast and incorporated 2 to 4 inches into the soil prior to flooding. It is important to mechanically incorporate the N because the floodwater does not incorporate the N deep enough to prevent volatilization losses of the N prior to the obtaining sufficient size to utilize the N. The flood should be applied as soon after application of the N fertilizer as possible to prevent nitrification of the ammonium. Since the field is flooded, or at least the soil is saturated, for the entire growing season, loss of N by nitrification - denitrification is not a problem. It is important that the soil not be allowed to crust when the field is drained for seedling peg-down. If the soil dries, the N will be converted from the ammonium form to the nitrate form and will be lost by denitrification after the flood is re-established. Plant area measurements should be taken with the Rice Gauge at the midseason growth stage listed in the DD50 printout to determine the amount of N needed at midseason.

If varieties are grown that are susceptible to lodging, a split application should be used. Apply the early N rate listed in Table 1 ppi and use the Rice Gauge to determine the correct rate needed at midseason. The most important aspect of N management under a water-seeding system is to maintain the flood for the duration of the season. If the soil is allowed to dry, N losses will occur and N efficiency will be reduced.

Nitrogen efficiency is typically reduced with a single pre-plant application to a ***no-till water seeded* system**. The water does not appear to be adequately incorporating the N as it does with a preflood application in a dry-seeded system. Research is currently underway to determine the best method of applying the N in a no-till water-seeded system. Current recommendations are to apply the N in split applications using the early N rate pre-plant (Table 1) or on the muddy soil after peg-down and then use the Rice Gauge at midseason to determine the amount of midseason N needed.

NITROGEN SOURCES

Due to the flooded conditions associated with rice production, it is necessary to use ammonium N sources instead of using nitrates. The reason is that nitrates are lost by denitrification under the flooded conditions. Table 4 gives a brief comparison of some of the major N fertilizer materials. The most common N source used for rice production is urea. This fertilizer is an ammonium N source that is widely available, relatively inexpensive, and has a large percentage of N per pound of fertilizer. Ammonium sulfate is another ammonium N source, but is generally more expensive and has less N content per pound of fertilizer than does urea, which also increases application costs. Liquid N solutions (liquid combinations of urea and ammonium nitrate) are sometimes used in rice production. One problem with N solutions is that they contain approximately 25% nitrates which will result in their loss due to denitrification when applied to the rice crop. If N solutions are used for the early N requirement, denitrification losses are substantial (Table 5). The rice plant has not developed sufficiently to utilize the fertilizer fast enough to prevent losses. If N solutions are used at mid-season, ammonia volatilization of the urea which adheres to the rice leaves is the major problem. While the plant can use the fertilizer rapidly at midseason, liquid urea is not taken up as efficiently as urea granules in the flood water. Research data shows that since granular urea falls into the floodwater, it is taken up more efficiently than the liquid urea which adheres to the rice leaves (Table 5).

If you need further information, refer to the "Rice Production Handbook" (MP-192), "Rice Plant Area" (Fact Sheet 2122), or contact you local County Extension Agent.

Table 1. Nitrogen rates and distribution for varieties grown in Arkansas.

Variety	Single Preflood Nitrogen Rate[2]	N Rates for Three-Way Split Application[1]			
		Nitrogen Distribution			Total N Rate
		Early N[3]	Panicle Differentiation	PD + 7-10 days	
	--------------------------------------lbs N/acre---------------------------------------				
Lebonnet[4]	NR	45	45	0	90
Della Mars Rico Skybonnet[4] Tebonnet	NR	50	30	30	110
Adair Jasmine 85 Nortai	NR	60	30	30	120
Katy	NR	75	30	30	135
Alan Drew Jackson Jodon Kaybonnet Lagrue Litton L202 Maybelle Millie Newbonnet Orion Priscilla RT 7015	95	75	30	30	135
Cocodrie Cypress Bengal Jefferson Lacassine Lafitte	110	90	30	30	150
Dellmont Gulfmont Lemont Madison Rexmont Rosemont	140	120	30	30	180

1 Nitrogen rate for rice following soybean in rotation on silt loam soils. Rates may need to be adjusted for soil factors, other crop rotations and stand establishment.
2 Single preflood N rates not recommended for: varieties marked "NR", poor water management ability, >5 days to flood the field, or history of straighthead.
3 Early nitrogen should be applied immediately prior to flooding or a portion can be flushed in at the 2-3 leaf growth stage.
4 Apply the first midseason N at 3/4" IE for Lebonnet and Skybonnet.

Table 2. Influence of delaying the flood and preflood nitrogen application on dry-seeded rice.

N Application and Flood Date[1]	GRAIN YIELD	
	RREC[2]	SEBES
days	bushels/A	
0	172	170
7	--	172
14	160	171
21	164	176
LSD	NS[3]	NS

[1]Days after the fourth to fifth leaf stage
[2]RREC = Rice Research and Extension Center, Stuttgart, AR; SEBES = Southeast Branch Experiment Station, Rohwer, AR.
[3] NS = Not significantly different.
Source: Norman, R.J., R.S. Helms, and B.R. Wells. 1992. Fert. Res. 32:55-59.

Table 3. Grain yield of 'Kaybonnet' rice as influenced by nitrogen fertilization.

N Rate	GRAIN YIELDS			
	CLAY SOILS		SILT LOAM SOILS	
	NEREC	SEREC	PTES	RREC
lbs/A	bushels/A			
0	73	27	107	72
90	153	130	173	172
120	170	160	177	173
150	182	166	178	150
180	191	157	172	136
LSD(0.05)	16	24	10	18

[1]NEREC = Northeast Research and Extension Center, Keiser, AR; SEREC = Southeast Research and Extension Center, Rowher, AR; PTES = Pine Tree Experiment Station, Pine Tree, AR; RREC = Rice Research and Extension Center, Stuttgart, AR
Source: Norman,R.J, B.R. Wells, R.S. Helms, D.C. Wolf, and C.A. Beyrouty. 1993. Ark. Rice Res. Studies 1992. Ark. Agr. Exp. Sta. Res. Ser. 431:110-118.

Table 4. Characteristics of nitrogen fertilizer sources available for rice production.

Nitrogen Fertilizer Source (In order of Preference)	Advantages	Disadvantages
Urea -- 46% N	High N percentage, widely available,	Even distribution is difficult to obtain at high rates
Ammonium Sulfate -- 21% N, 24% S	Provides sulfur fertilizer, reduces soil pH	Low N percentage, expensive
Nitrogen Solutions (UAN solution) -- 32% N	Good distribution at high rates	Very high N loss by denitrification due to nitrates, Volatilization loss is greater than urea when applied at midseason.

Table 5. Comparison of Fertilizer N Uptake and Grain yields of granular urea and UAN solution.

	TIME OF FERTILIZER N APPLICATION			GRAIN YIELD
	Preflood	Internode Elongation (IE)	IE + 10 days	
	% of N Fertilizer			lbs/A
Urea	65.6 a[1]	77.1 a	81.6 a	6209 a
UAN Solution	40.7 b	64.3 b	64.9 b	5397 b

[1] Means within a column followed by the same letter are not significantly different at the 5% level of probability.
Source: Wilson, C.E.,Jr., B.R. Wells, and R.J. Norman. 1994. Soil Sci. Soc. Am. J. 58:1825-1828.